جامعة نيويورك أبوظبي
NYU ABU DHABI

14TH AIMS CONFERENCE

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ABSTRACTS

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Special Sessions

Special Session 1	Analysis of parabolic models for chemotaxis
Special Session 2	Recent advances in nonlinear Schrodinger systems
Special Session 3	Recent Mathematical Progress in Boundary Layer Problems
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Abstracts for Thematic Sessions

Thematic Session 1 : Reaction-diffusion equations and aggregation, chemotaxis and nonlocal dispersal

Introduction:

Parabolic systems with cross-diffusion: global existence versus finite time blowup

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Schedule:

Piotr Biler
University of Wroclaw
Poland

Abstract:
Two toy models, both consisting of parabolic systems with nonlinear cross-diffusion terms, obtained after a slight modification of the nonlinearity of the usual doubly parabolic Keller--Segel system

$$u_t = \Delta u - \nabla \cdot (u \nabla \varphi),$$

$$\tau \varphi_t = \Delta \varphi + u,$$

are studied. For these toy models, with the same structure of steady states as is for the nonlinear heat equation $u_t = \Delta u + u^2$, we establish that for data which are, in a suitable sense, smaller than the diffusion parameter τ in the equation for the chemoattractant, global solutions exist. For data larger than τ, a finite time blowup occurs. In this way, we check that our size condition for the global existence is sharp for large τ. Results are based on papers in collaboration with Grzegorz Karch, Dominika Pilarczyk, Hiroshi Wakui. and in particular on this with Alexandre Boritchev (Lanar), Lorenzo Brandolese, {\it Sharp well-posedness and blowup results for parabolic systems of the Keller--Segel type}, Methods and Applications of Analysis {\bf 30} (2023), 53--76.

Nonlocal Aggregation-Diffusion Equations: fast diffusion and partial concentration

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Schedule: December 19 17:00-17:45 Conference Hall A

Jose A Carrillo
University of Oxford
England

Abstract:
We will discuss several recent results for aggregation-diffusion equations related to partial concentration of the density of particles. Nonlinear diffusions with homogeneous kernels will be reviewed quickly in the case of degenerate diffusions to have a full picture of the problem. Most of the talk will be devoted to discuss the less explored case of fast diffusion with homogeneous kernels with positive powers. We will first concentrate in the case of stationary solutions by looking at minimisers of the associated free energy showing that the minimiser must consist of a regular smooth solution with singularity at the origin plus possibly a partial concentration of the mass at the origin. We will give necessary conditions for this partial mass concentration to and not to happen. We will then look at the related evolution problem and show that for a given confinement potential this concentration happens in infinite time under certain conditions. We will briefly discuss the latest developments when we introduce the aggregation term. This talk is based on a series of works in collaboration with M. Delgadino, J. Dolbeault, A. Fernandez, R. Frank, D. Gomez-Castro, F. Hoffmann, M. Lewin, and J. L, Vazquez.

A delay-induced nonlocal problem with free boundary

Schedule: December 19 15:00-15:45 Conference Hall A

Jian Fang
Harbin Institute of Technology
Peoples Rep of China

Co-Author(s): Yihong Du, Ningkui Sun

Abstract:
Incorporating time delay and Stefan type free boundary into reaction-diffusion equation yields a compatible condition, which guarantees the well-posedness of the initial value problem. Further, under a KPP type setting we establish a dichotomy on propagation or vanishing. When propagation happens, the spreading speed is shown to exist and it is determined nonlinearly by a delay-induced nonlocal elliptic problem in half line.

Global existence and spatial spreading speeds in chemotaxis systems with logistic source on $\mathbb{R}^N$

Schedule: December 19 15:45-16:30 Conference Hall A

Wenxian Shen

USA

Co-Author(s): Zulaihat Hassan, Rachidi Salako, Shuwen Xue, Yuming Paul Zhang

Abstract:
This talk is concerned with the global existence and spatial spreading speeds in three primary chemotaxis systems with logistic source on the whole space $\mathbb{R}^N$. First, I will present a unified proof demonstrating global existence of positive classical solutions of these systems can be deduced from their uniform boundedness in $L^p_{\text{loc}}(\mathbb{R}^N)$ for some $p > \max\{1, \frac{n}{2}\}$. I will then provide sufficient conditions in terms of the parameters in the systems for the global existence and boundedness of classical solutions. Next, I will discuss the spatial spreading speeds of positive solutions with compactly supported or front-like initial functions. Special attention will be given to influence of the chemotaxis sensitivity on the propagation speeds of such solutions. It will be shown that chemotaxis does not slow down the spatial spreading no matter it is positive taxis or negative taxis. Some discussion will also be given on whether chemotaxis speeds up the spatial spreading.

Facets of complexity in chemotactic aggregation

Schedule: December 19 14:00-14:45 Conference Hall A

Michael Winkler
University of Paderborn
Germany

Abstract:
Keller-Segel type cross-diffusion systems have been playing an outstanding role in the understanding of various patterning phenomena in biology. Concentrating on issues of predominant application relevance, the description of taxis-driven explosions has been among the most challenging topics in their analysis, and a natural focus of the literature in this regard is on the characterization of solution behavior near collapse. The presentation aims at reporting both on classical and on some recent developments, with a particular focus on the identification of circumstances under which solutions either must blow up at single points only, or alternatively may form singularities throughout larger regions in space.

Basic Reproduction Numbers for Reaction-Diffusion Population Models

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Schedule: December 19 17:45-18:30 Conference Hall A

Xiao-Qiang Zhao

Canada

Co-Author(s): Xiao-Qiang Zhao

Abstract:
The basic reproduction number (or ratio) R0 is an important concept in population biology. As a threshold quantity for population dynamics, it is unquestionably one of the most valuable mathematical ideas brought to theoretical ecology and epidemiology. In this talk, I first review the definition, stability equivalence, numerical computation of R0 for reaction-diffusion systems with compartmental structure. Then I introduce a spatial model of Zika virus transmission with seasonality and establish a threshold type result on the global stability in terms of R0. Finally, I present numerical simulations for the Zika transmission in Rio de Janeiro Municipality, Brazil and briefly discuss the effects of some model parameters on R0.

Thematic Session 2 : Monge-Ampere type equations and their applications

Introduction:

Singularities in optimal transport

Schedule: December 18 13:45-14:30 Conference Hall A

Shibing Chen

Peoples Rep of China

Co-Author(s): Yuanyuan Li, Jiakun Liu

Abstract:
In the optimal transport problem, singularities may arise when the target domain is non-convex. In this talk, we will discuss some recent results concerning the structure of singularities. In particular, we will show that the singular set is locally a smooth curve away from a finite number of points, provided the target domain is a non-convex polygon. This is based on joint work with Yuanyuan Li and Jiakun Liu.

Long time regularity of the Gauss Curvature flow with flat sides

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Schedule: December 18 17:45-18:30 Conference Hall A

Genggeng Huang

Peoples Rep of China

Abstract:
In this talk, we talk about the long time regularity of the interface in the $p-$Gauss curvature flow with flat sides in higher dimensions with $p > \frac{1}{n}$. This is a joint work with Prof. Wang Xu-Jia and Zhou Yang.

Interior C^2 estimate for Hessian quotient equations

Schedule: December 18 15:45-16:30 Conference Hall A

Siyuan Lu

Canada

Abstract:
In this talk, I will first review the history of interior C^2 estimate for fully nonlinear equations. I will then discuss my recent work on interior C^2 estimate for Hessian quotient equations and the main idea behind the proof.

Optimal transport maps of non-convex domains

Schedule: December 18 13:00-13:45 Conference Hall A

Connor Mooney

USA

Abstract:
Optimal transport plays a central role in economics, meteorology, and geometry. The regularity theory of optimal transport maps is delicate, and for the most part has focused on the case that the source and target domains are convex. I will discuss some sharp regularity results for optimal transport maps of planar domains with concave boundary portions. This is joint work with A. Rakshit.

Lagrangian mean curvature PDEs

Schedule: December 18 15:00-15:45 Conference Hall A

Ravi Shankar

USA

Abstract:
We discuss recent developments in the analysis of PDEs which arise from the study of mean curvature of Lagrangian graphs.

On variational problems with a convexity constraint

Schedule: December 18 17:00-17:45 Conference Hall A

Bin Zhou
Peking University
Peoples Rep of China

Abstract:
In this talk, I will report the recent progress on variational problems with a convexity constraint, including the interior regularity of minimizers and the approximation by singular Abreu equations. The results apply to many problems which contains the principal-agent problems studied by Figalli-Kim-McCann. In particular, the famous Rochet-Chone mode is included.

Thematic Session 3 : Recent advances in singularity analysis in nonlinear elliptic and parabolic equations

Introduction:

Delaunay-type compact equilibria in the liquid drop model

Schedule: December 17 13:00-13:45 Conference Hall A

Manuel del Pino

England

Abstract:
We deal with the {\em liquid drop model}, introduced by Gamow (1930) and Bohr-Wheeler (1939) in nuclear physics to describe the structure of atomic nuclei. The problem consists of finding a surface $\Sigma = \partial\Omega$ in $\mathbb{R}^3$ that is critical for the following energy of regions $\Omega \subset \mathbb{R}^3$:

$$\mathcal{E}(\Omega) = \mathrm{Per}\ (\Omega) + \frac{1}{2}\int_{\Omega\times\Omega} \frac{dxdy}{|x-y|}$$

under the volume constraint $|\Omega| = m$. The associated Euler-Lagrange equation is

$$H\Sigma(x) + \int_{\Omega} \frac{dy}{|x-y|} = \lambda \quad \forall x \in \Sigma, \quad |\Omega| = m,$$

where λ is a constant Lagrange multiplier. Round spheres enclosing balls of volume m are always solutions. They are minimizers for sufficiently small m. Since the two terms in the energy compete, finding non-minimizing solutions can be challenging. We find a new class of solutions with large volumes, consisting of ``pearl collars with an axis located on a large circle, with a shape close to a Delaunay`s unduloid surface with constant mean curvature. This is joint work with Monica Musso and Andr\`es Z\`u\~niga.

On the KPP equation with nonlocal diffusion and free boundaries

Schedule: December 17 13:45-14:30 Conference Hall A

Yihong Du
University of New England
Australia

Co-Author(s): Wenjie Ni

Abstract:
A new phenomenon in nonlocal diffusion models is that accelerated propagation may happen, that is, the propagation speed could be infinite, which never occurs in the corresponding local diffusion model with compactly supported initial data. In this talk, we will first briefly review the history of the KPP model used to describe the propagation of biological/chemical species, and then look at some very recent results on the KPP equation with nonlocal diffusion and free boundaries. For several natural classes of kernel functions appearing in the nonlocal diffusion term, we will show how the exact rate of acceleration can be determined. The talk is based on joint works with Dr Wenjie Ni.

Recent developments on type II singularities for dispersive PDE

Schedule: December 17 15:45-16:30 Conference Hall A

Joachim Krieger

Switzerland

Abstract:
I will discuss recent results on various type II singularity formations for different dispersive PDE, illustrating some apparently universal mechanisms. These results are sometimes in stark contrast to the parabolic counterparts of these equations.

On some overdetermined boundary value problems and the Schiffer conjecture.

Schedule: December 17 15:00-15:45 Conference Hall A

Mouhamed Moustapha Fall

Senagal

Abstract:
Second order elliptic equations on a domain in which both Dirichlet and Neumann conditions are prescribed at the boundary of the domains constitute a class of overdetermined problems. To deal with these problems, we are led to find two unknowns: solution and the domain. They appear in many physical questions such as fluid and solid mechanics. In addition, they appear when minimizing domain-dependent energy functionals such as Sobolev norms and eigenvalues. While a lot of progress is being made, there still remains challenging open problems, e.g. the Schiffer conjecture: which states that if a nontrivial eigenfunction of the Neumann eigenvalue problem, on a bounded domain, has a constant Dirichlet boundary condition then the domain must be a ball. In this talk, we provide an overview on recent results on overdetermined and discuss new results on the Schiffer problem on some manifolds.

Long time behavior for vortex dynamics in the 2 dimensional Euler equations

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Schedule: December 17 17:00-17:45 Conference Hall A

Monica Musso
University of Bath
England

Abstract:
The evolution of a two-dimensional incompressible ideal fluid with smooth initial vorticity concentrated in small regions is well understood over finite time intervals: as these regions shrink to zero, the vorticity converges to a superposition of Dirac deltas centered on collision-free solutions of the point vortex system. Although the point vortex system exhibits globally smooth solutions for generic initial conditions, the long-term behavior of the fluid vorticity remains much less understood. We consider two scenarios: the case of two vortex pairs traveling in opposite directions and that of an expanding self-similar configuration of vortices. Using gluing methods we describe the global dynamics of this configuration. This work is in collaboration with J Davila, M. del Pino and S. Parmeshwar.

On some properties of Steklov eigenfunctions

Schedule: December 17 17:45-18:30 Conference Hall A

Angela Pistoia
Sapienza University of Roma
Italy

Abstract:
I will focus on a couple of properties of the eigenfunctions of Steklov problem on a compact Riemannian manifold with boundary. First, we give a precise count of the interior critical points of a Steklov eigenfunction in terms of the Euler characteristic of the manifold and of the number of its sign changes the boundary. Based on a joint work with Luca Battaglia (University of Roma Tre) and Luigi Provenzano (Sapienza University of Roma) Next, we disprove the conjectured validity of Courant`s theorem for the traces of Steklov eigenfunctions building a Riemannian metric for which the n-th eigenfunction has an arbitrary number of nodal domains on the boundary. Based on a joint work with Alberto Enciso (ICMAT Madrid) and Luigi Provenzano (Sapienza University of Roma) .

Thematic Session 4 : Recent progress on the numerical solution of partial differential equations

Introduction:

Convergent finite element approximations of surface evolution with artificial tangential motion

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Schedule: December 18 13:00-13:45 Capital Suite 7

Buyang Li
The Hong Kong Polytechnic University
Hong Kong

Abstract:
The finite element approximation of surface evolution under external velocity field is studied. A tangential motion is designed, by using harmonic map heat flow from a reference surface onto the evolving surface, to improve the mesh quality of the numerically computed surface. The convergence of evolving finite element approximations to the surface evolution driven by a specified vector field with the proposed tangential motion is proved for finite elements of degree $k \geq 3$. Numerical examples are provided to demonstrate the convergence of the algorithm and its effectiveness for improving the mesh quality of the numerically computed evolving surface.

Speeding up gradient flows on probability measure space

Schedule: December 18 13:45-14:30 Capital Suite 7

Qin Li
UW-Madison
USA

Co-Author(s): Shi Chen, Oliver Tse, Steve Wright

Abstract:
In the past decade, there has been a significant shift in the types of mathematical objects under investigation, moving from vectors and matrices in the Euclidean spaces to functions residing in Hilbert spaces, and ultimately extending to probability measures within the probability measure space. Many questions that were originally posed in the context of linear function spaces are now being revisited in the realm of probability measures. One such question is to the efficiently find a probability measure that minimizes a given objective functional. In Euclidean space, we devised optimization techniques such as gradient descent and introduced momentum-based methods to accelerate its convergence. Now, the question arises: Can we employ analogous strategies to expedite convergence within the probability measure space? In this presentation, we provide an affirmative answer to this question. Specifically, we present a series of momentum-inspired acceleration method under the framework of Hamiltonian flow, and we prove the new class of method can achieve arbitrary high-order of convergence. This opens the door of developing methods beyond standard gradient flow.

Half-Closed Discontinuous Galerkin Discretisations

Schedule: December 18 15:00-15:45 Capital Suite 7

Per-Olof Persson
University of California, Berkeley
USA

Co-Author(s): P.-O. Persson and Y. Pan

Abstract:
We introduce the concept of half-closed nodes for nodal Discontinuous Galerkin (DG) discretisations. This is in contrast to more commonly used closed nodes in DG where in each element nodes are placed on every boundary. Half-closed nodes relax this constraint by only requiring nodes on a subset of the boundaries in each element, with this extra freedom in node placement allowing for increased efficiency in the assembly of DG operators. To determine which element boundaries half-closed nodes are placed on we outline a simple procedure based on switch functions. We examine the effect on operator sparsity from using the different types of nodes and show that in particular for the Laplace operator for there to be no difference in the sparsity from using half-closed or closed nodes. We also discuss in this work some linear solver techniques commonly used for Finite Element or Discontinuous Galerkin methods such as static condensation and block-based methods, and how they can be applied to half-closed DG discretisations. Finally we demonstrate its use on a range of test problems including in CFD, and benchmark its performance on these numerical examples.

Some topics on gradient flow approach and its applications to various fields

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Schedule: December 18 15:45-16:30 Capital Suite 7

Xiaofeng Yang

USA

Abstract:
Developing efficient numerical algorithms for highly nonlinear and coupled Partial Differential Equation (PDE) systems has been a longstanding challenge, prompting numerous efforts in this field over many years. We aim to construct a framework approach to address major weaknesses in nearly all existing numerical algorithms designed for solving coupled nonlinear gradient flow systems. These methods have been applied to some well-known systems, such as the anisotropic phase-field dendritic crystal growth model, yielding efficient numerical schemes characterized by linearity, a fully decoupled structure, unconditional energy stability, and second-order time accuracy. These features showcase the algorithms` considerable potential for practical applications.

Construction of Solution Landscape for Complex Systems

Schedule: December 18 17:00-17:45 Capital Suite 7

Lei Zhang
Peking University
Peoples Rep of China

Abstract:
Energy landscape has been widely applied to many physical and biological systems. A long standing problem in computational mathematics and physics is how to search for the entire family tree of possible stationary states on the energy landscape without unwanted random guesses? Here we introduce a novel concept Solution Landscape, which is a pathway map consisting of all stationary points and their connections. We develop a generic and efficient saddle dynamics method to construct the solution landscape, which not only identifies all possible minima, but also advances our understanding of how a complex system moves on the energy landscape. We then apply the solution landscape approach to target several problems, including the defect landscapes of nematic liquid crystals, the transition pathways connecting crystalline and quasicrystalline phases, and the excited states of rotational Bose-Einstein condensates.

Thematic Session 5 : Mathematical analysis of fluid mechanics

Introduction:

Some aspects of the long-time behavior of 2d Euler flows

Schedule: December 16 13:45-14:30 Conference Hall A

Tarek Elgindi

Abstract:
We will discuss some issues related to the long-time behavior of solutions to the 2d incompressible Euler equation. In particular, we will discuss some results of rigidity and flexibility for steady Euler flows. We will then move to discuss their stability properties and how they can be used to establish some non-trivial dynamical behavior, such as filamentation, for unsteady solutions. In particular, we will discuss the concept of twisting, its stability, and various consequences thereof. This is based on joint works with several co-authors, including M. Coti-Zelati, T. Drivas, Y. Huang, I. Jeong, A. Said, K. Widmayer, and C. Xie.

Boundary layer separation

Schedule: December 16 17:00-17:45 Conference Hall A

Tej-eddine Ghoul

United Arab Emirates

Abstract:
I will present results obtained on shock formation for transport model and how it can be applied to describe boundary layer separation notably for the prandtl system.

On the desingularization of time-periodic vortex motion in bounded domains

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Schedule: December 16 15:00-15:45 Conference Hall A

Zineb Hassainia
New York University at Abu Dhabi
United Arab Emirates

Abstract:
In this talk, we will discuss vortex motions for Euler equations in planar domains. In this setting, the dynamics of a single vortex is governed by a Hamiltonian system, with most of its energy levels corresponding to time-periodic motion. We show that, under certain non-degeneracy conditions, it is possible to desingularize most of these trajectories into time-periodic concentrated vortex patches. The proof uses a Nash-Moser scheme and KAM techniques combined with complex geometry tools. Additionally, we will present a vortex duplication mechanism to generate synchronized time-periodic motion of multiple vortices. This is a joint work with Taoufik Hmidi and Emeric Roulley.setting, the dynamics of a single vortex is governed by a Hamiltonian system, with most of its energy levels corresponding to time-periodic motion. We show that, under certain

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Uniform Inviscid Damping and Inviscid Limit of 2D Navier-Stokes with Navier Boundary Conditions

Schedule: December 16 13:00-13:45 Conference Hall A

Sameer Iyer

Abstract:
We present a recent series of works, joint with J. Bedrossian, S. He, F. Wang, in which we prove nonlinear inviscid damping, enhanced dissipation, and inviscid limit for the 2D Navier-Stokes equations near Couette. The domain is the periodic channel, \mathbb{T} \times [-1,1], and Navier Boundary Conditions are prescribed vertically.

Global WP of Current-Vortex Sheets in 2D Ideal Incompressible MHD

Schedule: December 16 17:45-18:30 Conference Hall A

Zhen Lei
Fudan University
Peoples Rep of China

Co-Author(s): Zhen Lei

Abstract:
I will talk about our recent work on the Global well-posedness of Current-Vortex Sheets in 2D Ideal Incompressible MHD. This is a joint work with Prof. Yuan Cai from Fudan University.

Blow-up for the supercritical defocusing nonlinear wave equation

Schedule: December 16 15:45-16:30 Conference Hall A

Zhifei Zhang
Peking University
Peoples Rep of China

Abstract:
In this talk, we introduce our recent result on the finite time blow-up for the supercritical defocusing nonlinear wave equation(NLW) in $R^{d+1}, d \geq 4$. The proof of this result is based on a surprising connection between complex-valued NLW and relativistic Euler equations, and the construction of self-similar imploding solutions of the relativistic Euler equations.

Abstracts for Special Sessions

Special Session 1 : Analysis of parabolic models for chemotaxis

Introduction: Parabolic models for chemotaxis processes have continuously been attracting considerable interest throughout the past decades. Refinements and further developments of approaches have facilitated not only a noticeably deep understanding of simple prototypical systems of Keller-Segel type, but also insightful exploration of models at increasing levels of complexity. The investigation of key issues related to the occurrence or the absence of singularity formation has been providing answers to core questions of application relevance, and has beyond this independently been stimulating the analysis of parabolic systems in more general. The purpose of the proposed special session is to discuss recent results in the analysis of chemotaxis systems, and to showcase methodological advances in this area. By including both application-oriented and theoretical aspects, and by bringing together both young and experienced researchers, it is intended to stimulate and newly initiate expedient future developments in this active field of study at the borderline between mathematics and science.

Solution behaviors in chemotaxis-consumption systems with Dirichlet boundary conditions

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Schedule: December 19 8:00-8:30 Capital Suite 7

Jaewook Ahn
Dongguk University
Korea

Abstract:
Bacillus subtilis swim toward oxygen-rich air-water interfaces in water droplets and form large clusters near the boundary. To describe such pattern formation, chemotaxis systems with signal consumption have been proposed, which in numerical studies have exhibited various patterns similar to those observed in actual experiments. In this talk, I will present related analytical results on chemotaxis-consumption systems, particularly those with Dirichlet boundary conditions for the signal. One of our findings shows that bacteria populations under certain initial conditions tend to aggregate near the boundary, where signals have been prescribed. On the other hand, for the system of chemorepulsive counterpart, it is shown that a finite time blowup can be observed whenever the diffusion effect on bacteria populations is slightly weakened. Some results on the existence of bounded solutions will also be discussed.

Boundedness of classical solutions to a chemotaxis consumption model with signal dependent motility

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Schedule: December 20 8:00-8:30 Capital Suite 7

Khadijeh Baghaei
Pasargad Institute for Advanced Innovative Solutions
Iran

Co-Author(s): Ali Khelghati

Abstract:
My goal in this talk is to present our recent results for a chemotaxis consumption model with signal dependent motility and logistic source. For this model, we have proved that there exists a unique global classical solution which is uniformly in time bounded. This result is obtained for small initial data without any restriction on the coefficient of the logistic term. This is a joint project with Ali Khelghati.

Boundedness in a class of Keller--Segel models with dissipative gradient terms

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Schedule: December 19 15:15-15:45 Capital Suite 7

Alessandro Columbu
Universit\`a degli Studi di Cagliari
Italy

Co-Author(s): Tongxing Li; Daniel Acosta Soba; Giuseppe Viglialoro;

Abstract:
We study a class of zero-flux attraction-repulsion chemotaxis models, characterized by nonlinearities laws for the diffusion of the cell density, the chemosensitivities and the production rates of the chemoattractant and the chemorepellent. Additionally, a source involving also the gradient of the biological distribution is incorporated. In this talk we will see a sketch of the proof for the existence of solutions and we will find a condition for the boundedness.

Some results on Keller-Segel(-Navier)-Stokes model with indirect signal production

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Schedule: December 19 14:30-15:00 Capital Suite 7

Feng Dai
Huazhong University of Science and Technology
Peoples Rep of China

Co-Author(s): Bin Liu

Abstract:
In this talk, we consider the Keller-Segel(-Navier)-Stokes model with indirect signal production in a bounded domain with smooth boundary. Under appropriate regularity assumptions on initial data, the global solvability and asymptotic stabilization to the associated initial-boundary value problem are obtained. In comparison with the existing results for the case of direct signal production, our results reveal the regularizing effect of the indirect signal production mechanism on the Keller-Segel(-Navier)-Stokes system.

Quantitative analysis and its applications for Keller-Segel type systems

Schedule: December 20 16:45-17:15 Capital Suite 7

Mengyao Ding
Institute for Advanced Study in Mathematics of HIT
Peoples Rep of China

Co-Author(s): Yuzhou Fang; Chao Zhang

Abstract:
In this work, to address the asymptotic stability of chemotaxis systems incorporating various mechanisms, we employ the De Giorgi iteration method to quantitatively analyze the upper bound of solutions. The refined upper bound estimate obtained in the present paper illustrates how various factors influence the upper bound, which can then be used to determine the large-time behaviours of solutions. To show the wide applicability of our findings, we investigate the asymptotic stability of a chemotaxis model with nonlinear signal production and a chemotaxis-Navier-Stokes model with a logistic source. Additionally, within the context of p-Laplacian diffusion, we establish H\"{o}lder continuity for a chemotaxis-haptotaxis model and a chemotaxis-Stokes model.

On a chemotaxis model with nonlinear diffusion modelling multiple sclerosis

Schedule: December 18 9:00-9:30 Capital Suite 7

Simone Fagioli
University of L`Aquila
Italy

Co-Author(s): M. Kamath, E. Radici, L. Romagnoli

Abstract:
We investigated existence of global weak solutions for a system of chemotaxis type with nonlinear degenerate diffusion, arising in modelling Multiple Sclerosis disease. The model consists of three equations describing the evolution of macrophages (m), cytokine (c) and apoptotic oligodendrocytes (d). The main novelty in our work is the presence of a nonlinear diffusivity $D(m)$, which results to be more appropriate from the modelling point of view. We first show the existence of global bounded solutions for the model. We then investigate some properties on the stationary states and pattern formation.

Properties of given and detected unbounded solutions to a class of chemotaxis models

Schedule: December 19 16:45-17:15 Capital Suite 7

Silvia Frassu
University of Cagliari
Italy

Co-Author(s): Alessandro Columbu, Giuseppe Viglialoro

Abstract:
This talk deals with unbounded solutions to a class of chemotaxis systems. In particular, for a rather general attraction-repulsion model, with nonlinear productions, diffusion, sensitivities and logistic term, we detect Lebesgue spaces where given unbounded solutions blow-up also in the corresponding norms of those spaces; subsequently, estimates for the blow-up time are established. Finally, for a simplified version of the model, some blow-up criteria are proved.

Finite-time blow-up in fully parabolic quasilinear Keller--Segel systems with supercritical exponents

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Schedule: December 18 9:30-10:00 Capital Suite 7

Mario Fuest
Leibniz University Hannover
Germany

Co-Author(s): Xinru Cao

Abstract:
The fully parabolic quasilinear Keller--Segel system

$$\{ u_t = \nabla \cdot ((u+1)^{m-1} \nabla u - u(u+1)^{q-1} \nabla v),\ v_t = \Delta v - v + u,$$

which we consider in a ball $\Omega \subset \mathbb{R}^n$, $n \geq 2$, admits unbounded solutions whenever $m, q \in \mathbb{R}$ satisfy $m - q < \frac{n-2}{n}$. These are necessarily global in time if $q \leq 0$ and finite-time blow-up is known to be possible if $q > 0$ and $\max\{m, q\} \geq 1$. Utilizing certain pointwise upper estimates for u, we are able to give an affirmative answer to the (for nearly a decade formerly open) question whether solutions may blow up in finite time if $\max\{m, q\} < 1$. If $n = 2$, for instance, we construct solutions blowing up in finite time whenever ($m - q < 0$ and) $q < 2m$.

Analysis of a Navier-Stokes-Cahn-Hilliard system with unmatched densities and chemotaxis

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Schedule: December 19 9:00-9:30 Capital Suite 7

Andrea Giorgini
Politecnico di Milano
Italy

Abstract:
We consider the initial-boundary value problem for an incompressible Navier-Stokes-Cahn-Hilliard model with non-constant density and chemotaxis for soluble species proposed by Abels, Garcke and Gr\{u}n in 2012. In this talk I will present recent results concerning the global existence of weak solutions and propagation of regularity. A main feature of this contribution is the lack of the regularization effect given by the logistic source in the equation for the density of the soluble species. This is a joint work with Jingning He (The Hong Kong Polytechnic University) and Hao Wu (Fudan University).

Global boundedness and blow-up in a repulsive chemotaxis-consumption system

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Schedule: December 19 18:00-18:30 Capital Suite 7

Dongkwang Kim
Ulsan National Institute of Science and Technology, Department of Mathematical Sciences
Korea

Co-Author(s): Jaewook Ahn, Kyungkeun Kang

Abstract:
In this presentation, we explore the parabolic-elliptic chemotaxis-consumption system of repulsion type in higher dimensions under no-flux/Dirichlet boundary conditions. We discuss the criteria for solutions to remain bounded over time and the conditions under which blow-up occurs. Specifically, we show that the system admits globally bounded solutions when the diffusion of the organisms is enhanced, or when it is weakened but the boundary data for the signal substance is sufficiently small. Furthermore, we demonstrate that when the diffusion is further weakened and the boundary data for the signal is appropriately large, the system possesses blow-up solutions.

Global solvability and immediate regularization of measure-type population densities in a flux-limited Keller--Segel system

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Schedule: December 19 14:00-14:30 Capital Suite 7

Shohei Kohatsu
Tokyo University of Science
Japan

Abstract:
We consider a flux-limited Keller--Segel system in a bounded domain, for which global existence and boundedness of classical solutions with linear diffusion and regular initial data were considered by Winkler (Math.\ Nachr.; 2022; 295; 1840--1862). It is shown that under conditions on the strength of diffusion and flux limitation, for any Radon measure initial data the system admits a global solution which immediately becomes smooth and classical, and approaches the given initial data in an appropriate sense.

On a chemotaxis-May-Nowak Model for virus infection with superlinear dampening

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Schedule: December 19 13:30-14:00 Capital Suite 7

Yan Li
Nanjing University of Posts and Telecommunications
Peoples Rep of China

Abstract:
In this talk, we consider a three-component reaction-diffusion system, originating from the classical May-Nowak model for viral infections with superlinear dampening $-\mu u^{\alpha}$. Existence of classical solutions is verified and large time behavior of the solutions are investigated under the condition $\alpha > \frac{n+2}{2}$, while generalized solutions are constructed for arbitrary $\alpha > 1$. In addition, based on an analysis of a certain eventual Lyapunov-type functional, we prove that whenever $\alpha > \max\{1, \frac{n}{2}\}$, the corresponding generalized solution asymptotically enjoys relaxation by approaching the nontrivial homogeneous steady states.

Boundedness in a two-dimensional doubly degenerate nutrient taxis system

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Schedule: December 20 9:00-9:30 Capital Suite 7

Yuxiang Li
School of Mathematics, Southeast University
Peoples Rep of China

Co-Author(s): Zhiguang Zhang

Abstract:
In this talk, we study the doubly degenerate nutrient taxis system

$$\{ u_t = \nabla\cdot(uv\nabla u) - \chi\nabla\cdot\left(u^2 v\nabla v\right) + uv,\ v_t = \Delta v - uv \qquad (\star)$$

in a smooth bounded domain $\Omega \subset \mathbb{R}^2$, where $\chi > 0$. We prove that for all reasonably regular initial data, the corresponding homogeneous Neumann initial-boundary value problem for $(\star)$ possesses a global bounded weak solution which is continuous in its first and essentially smooth in its second component. There exists $u_\infty \in L^\infty(\Omega)$ such that this solution possesses the convergence property that

$$u(t) \overset{*}{\rightharpoonup} u_\infty \quad \text{and} \quad v(t) \to 0 \quad \text{in } L^\infty(\Omega) \quad \text{as } t \to \infty. \qquad (\star\star)$$

Furthermore, the limit u_∞ in $(\star\star)$ exhibits spatially heterogeneous under a criterion on the initial smallness of the second component.

Global bounded weak solutions to a 3D chemotaxis-Stokes system with slow p-Laplacian diffusion and rotation

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Schedule: December 20 15:00-15:30 Capital Suite 7

Zhongping Li
China West Normal University
Peoples Rep of China

Co-Author(s): Haolan He

Abstract:
In this talk, we are concerned with the following chemotaxis-Stokes system with p-Laplacian diffusion and rota
$\{ n_t + u\cdot\nabla n = \nabla\cdot(|\nabla n|^{p-2}\nabla n) - \nabla\cdot(nS(x,n,c)\nabla c), x \in \Omega, t > 0,\ c_t + u\cdot\nabla c = \Delta c - nc, x \in \Omega, t > 0,\ u_t + \nabla P =$
in a smooth bounded domain $\Omega \in \mathbb{R}^3$. We show the boundedness of the weak solutions to the 3D chemotaxis-S
under no-flux boundary conditions/Dirichlet signal boundary condition.

Schedule: December 19 18:30-19:00 Capital Suite 7

Monica Marras
University of Cagliari
Italy

Co-Author(s): F. Ragnedda S. Vernier-Piro, V. Vespri

Abstract:
We study qualitative properties as blow-up phenomena, decay in time, boundedness, global existence and H\older regularity for solutions of some classes of chemotaxis systems. In particular we consider a degenerate chemotaxis systems with porous media type diffusion and a source term satisfying the Hadamard growth condition. We prove the H\older regularity for bounded solutions to parabolic-parabolic as well as for parabolic-elliptic chemotaxis systems.

Properties of blow-up points in a parabolic-parabolic chemotaxis system with spatially heterogeneous logistic term

Schedule: December 19 17:30-18:00 Capital Suite 7

Masaaki Mizukami
Kyoto University of Education
Japan

Co-Author(s): Mario Fuest, Johannes Lankeit

Abstract:
This talk discusses possible points of blow-up in a chemotaxis system with spatially heterogeneous logistic term in two-dimensional smoothly bounded domains under the Neumann boundary conditions and initial conditions. About this problem, a property of possible blow-up points is recently studied; in the parabolic-elliptic setting, it was shown that finite-time blow-up of the classical solution can only occur in points where a coefficient is zero. In this talk we give a recent development of a result about a property of blow-up points in the system in the parabolic-parabolic setting. This is a joint work with Dr. Mario Fuest (Leibniz University Hannover) and Professor Johannes Lankeit (Leibniz University Hannover).

Global solvability of predator-prey model with prey-taxis or predator-taxis

Schedule: December 20 14:30-15:00 Capital Suite 7

Guoqiang Ren
Huazhong University of Science and Technology
Peoples Rep of China

Co-Author(s): Bin Liu and Jianshe Yu

Abstract:
In this paper, we study a two-species chemotaxis-Navier-Stokes system with Lotka-Volterra type competitive kinetics: $n_t + u \cdot \nabla n = \Delta n - \chi_1 \nabla \cdot (n \nabla w) + n(\lambda_1 - \mu_1 n^{\theta-1} - a_1 v)$; $v_t + u \cdot \nabla v = \Delta v - \chi_2 \nabla \cdot (v \nabla w) + v(\lambda_2 - \mu_2 v - a_2 n)$; $w_t + u \cdot \nabla w = \Delta w - w + n + v$; $u_t + \kappa(u \cdot \nabla)u = \Delta u + \nabla P + (n+v)\nabla\phi$; $\nabla \cdot u = 0, x \in \Omega, t > 0$ in a bounded and smooth domain $\Omega \subset \mathbb{R}^2$ with no-flux/Dirichlet boundary conditions, where χ_1, χ_2 are positive constants. We present the global existence of generalized solution to a two-species chemotaxis-Navier-Stokes system and the eventual smoothness already occurs in systems with much weaker degradation $(\theta > 1)$, again under a smallness condition on λ_1, λ_2.

Stabilization and pattern formation in a chemotaxis model with acceleration

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Schedule: December 20 14:00-14:30 Capital Suite 7

Weirun Tao
Southeast University
Peoples Rep of China

Co-Author(s): Chunlai Mu, Zhi-An Wang

Abstract:
In this talk, we consider a new type of chemotaxis model with acceleration, which assumes that species` advective acceleration instead of velocity in the classical chemotaxis model is proportional to the chemical signal concentration gradient. This new model has an additional equation governing the velocity field with more delicate boundary conditions. We shall introduce some results on global existence, stabilization, and pattern formation of the model with/without the logistic source term.

Well-posedness results on an oncolytic virotherapy model

Schedule: December 19 16:15-16:45 Capital Suite 7

Xueyan Tao
Ocean University of China
Peoples Rep of China

Co-Author(s): Shulin Zhou

Abstract:
One of the most promising strategies to treat cancer is attacking it with viruses. This talk begins with an introduction to a haptotactic cross-diffusion system modeling oncolytic virotherapy. After reviewing some existing results on this model, we shall report some recent results on global existence and asymptotic behavior of solutions to this system.

Existence and blow-up results to quasilinear chemotaxis-haptotaxis system

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Schedule: December 18 8:30-9:00 Capital Suite 7

Jagmohan Tyagi
Indian Institute of Technology Gandhinagar
India

Co-Author(s): Poonam Rani

Abstract:
We discuss the following quasilinear chemotaxis-haptotaxis system:
$u_t = \nabla \cdot (D(u)\nabla u) - \chi\nabla \cdot (S(u)\nabla v) - \xi\nabla \cdot (u\nabla w),\ x \in \Omega, t > 0,\ v_t \quad = \Delta v - v + u,\ x \in \Omega, t > 0,\ w_t = -vw,\ x \in$
under homogeneous Neumann boundary conditions in a smooth, bounded domain $\Omega \subset \mathbb{R}^n, n \geq 3$. We show th
$\frac{S(s)}{D(s)} \leq A(s+1)^\alpha$ for $\alpha < \frac{2}{n}$ and under suitable growth conditions on D, there exists a uniform-in-time bounded
solution to the above system. Also, we establish that for radial domains, when the opposite inequality is satisfi
corresponding solutions blow-up in finite or infinite-time.

Some discussions regarding the seminal Keller-Segel model with positive total flux

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Schedule: December 19 8:30-9:00 Capital Suite 7

Giuseppe Viglialoro
Universit \\` a degli Studi di Cagliari
Italy

Co-Author(s): Silvia Frassu, Yuya Tanaka

Abstract:
Since the advent of the seminal Keller-Segel models describing chemotaxis phenomena involving some cell and chemical distributions, the results obtained for related variants are innumerable. Nevertheless, the common denominator of such studies focuses on the assumption that the equation for the cells obeys a zero-flux boundary condition (impenetrable domains). The aim of this talk is to discuss preliminary results and share considerations on chemotaxis models where the total flux has a positive sign (penetrable domains). This is a joint project with Silvia Frassu and Yuya Tanaka.

Global existence and eventual smoothness of a Keller-Segel-consumption system involving local sensing and growth term

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Schedule: December 20 17:15-17:45 Capital Suite 7

Liangchen Wang
Chongqing University of Posts and Telecommunications
Peoples Rep of China

Abstract:
In this talk, we will consider a Keller-Segel-consumption system involving local sensing and growth term. For all suitably regular initial data, this system possesses global classical solutions in two-dimensional counterpart, whereas in the case of higher spatial dimensions ($n \geq 3$), globally-defined classical solutions were also constructed under some restriction conditions. In higher-dimensional settings, it is asserted that certain weak solutions exist globally, which become smooth after some waiting time.

The global solvability and asymptotic behavior for doubly degenerate nutrient model with large initial data

Schedule: December 20 8:30-9:00 Capital Suite 7

Duan Wu
Paderborn university
Peoples Rep of China

Abstract:
In this talk, we focus on the doubly degenerate nutrient model under no-flux boundary conditions in a two-dimensional smoothly bounded convex domain. In the previous related works, the results concerning the large time behavior were constrained to one dimension. In this work, we not only prove the global existence of solutions, but also show the asymptotic behavior.

On an inhomogeneous incompressible Navier-Stokes system with chemotaxis modeling vascular network

Schedule: December 20 15:30-16:00 Capital Suite 7

Zhaoyin Xiang
University of Electronic Science and Technology of China
Peoples Rep of China

Co-Author(s): Yazhi Xiao, Lu Yang

Abstract:
In this talk, we focus on an inhomogeneous incompressible Navier-Stokes system with chemotaxis modeling vascular network in a bounded domain. Precisely, the system consists of an inhomogeneous incompressible Navier-Stokes equations for the density of the endothelial cells and their velocity, coupled to a reaction-diffusion equation for the concentration of the chemoattractant, which triggers the migration of the endothelial cells and the blood vessel formation. The global solvability and vanishing viscosity limit of finite energy weak solutions will be investigated under suitable initial-boundary value conditions. The solutions also satisfy a relative energy inequality, which ensures the weak-strong uniqueness property. This is a joint work with Dr Yazhi Xiao and Dr Lu Yang.

Local existence and global boundedness for a chemotaxis system with gradient dependent flux limitation

Schedule: December 20 16:15-16:45 Capital Suite 7

Jianlu Yan
Nanjing University of Aeronautics and Astronautics
Peoples Rep of China

Co-Author(s): Yuxiang Li

Abstract:
In this talk, we investigate a Keller-Segel system with flux limitation under no-flux boundary conditions in a ball. It is proved that the problem possesses a unique classical solution that can be extended in time up to a maximal $T_{\max} \in (0, \infty]$. Moreover, we show that the above solution is global and bounded in certain subcritical cases. This is a joint work with Yuxiang Li (SEU).

Global existence and stabilization of weak solutions to a degenerate chemotaxis system arising from tumor invasion

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Schedule: December 19 13:00-13:30 Capital Suite 7

Tomomi Yokota
Tokyo University of Science
Japan

Co-Author(s): Sachiko Ishida

Abstract:
In this talk we consider a degenerate chemotaxis system arising from tumor invasion. We discuss global existence and stabilization of weak solutions to the system by a similar argument for the corresponding degenerate Keller-Segel system. This study is based on a joint paper with Professor Sachiko Ishida (J. Differential Equations, 371 (2023), 450-480).

Ratio-dependent motility in biological diffusion models

Schedule: December 18 8:00-8:30 Capital Suite 7

Changwook Yoon
Chungnam National University
Korea

Abstract:
In this study, we explore the application of ratio-dependent motility to biological diffusion models, providing a framework for understanding how organisms adjust their movement based on the ratio of available resources to population density. This approach reflects a more realistic perspective on biological systems, where resource competition, rather than absolute abundance, determines motility. We apply this motility concept in both chemotaxis and prey-predator models, demonstrating its potential to enhance global solvability and provide deeper insights into the dynamics of resource-limited environments.

On a Keller-Segel chemotaxis system with flux limitation and nonlinear signal production

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Schedule: December 19 15:45-16:15 Capital Suite 7

Wenji Zhang
Hunan University of Science and Technology
Peoples Rep of China

Abstract:
It is well known that critical exponents distinguishing between existence and blow-up have been established for the Keller-Segel chemotaxis system with flux limitation and with nonlinear signal production respectively. On this basis, we have obtained a critical parameter differentiating global existence from finite-time blow-up when this model combined with flux limitation and nonlinear signal production. This is an extension of previous results, and the monotonicity of the first solution component is the key gradient having this result.

Some results in Keller-Segel chemotaxis systems

Schedule: December 19 19:00-19:30 Capital Suite 7

Pan Zheng
Chongqing University of Posts and Telecommunications
Peoples Rep of China

Abstract:
It is well-known that chemotaxis is a common natural phenomenon describing a biochemical process through which the movement of an organism or entity is not only regulated by random diffusion, but also controlled by the concentration gradient of a chemical stimulus in the local environment. In this talk, I first mention some previous mathematical advances of chemotaxis systems. Then I introduce our recent results about Keller-Segel chemotaxis systems with indirect signal mechanisms.

Special Session 2 : Recent advances in nonlinear Schrodinger systems

Introduction: According to their important applications in mathematical physics and geometry, the nonlinear Schrodinger systems are the hot topics in the community of nonlinear analysis and nonlinear PDEs in the past twenty years or so. Even though various theorems, about the existence, multiplicity and qualitative properties of nontrivial solutions of the nonlinear Schrodinger systems, have been established in the literature under various assumptions by using variational methods, the Lyapunov-Schmidt reduction arguments or the bifurcation methods, there are still lots of unsettled problems in these topics which are very challenging. Thus, it is the time to organize the active researchers on these topics together to report their most recent works and discuss the potential directions in these topics.

Normalized solutions for a class of gradient-type Schrodinger systems under Neumman boundary condition

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Schedule: December 17 17:00-17:30 Capital Suite 10

Xiaojun Chang
Northeast Normal University
Peoples Rep of China

Abstract:
In this talk, we focus on the existence of normalized solutions for a class of gradient-type Schrodinger systems within bounded domains, subject to Neumann boundary conditions. By utilizing a parameterized minimax principle that incorporates Morse index information for constrained functionals, along with a novel blow-up analysis of the gradient-type Schrodinger system under these Neumann boundary conditions, we establish the existence of mountain pass-type normalized solutions.

Time periodic solutions of the wave equations in a ball

Schedule: December 17 18:00-18:30 Capital Suite 10

Jianyi Chen
Qingdao Agricultural University
Peoples Rep of China

Co-Author(s): Kui Li, Zhitao Zhang

Abstract:
We discuss several results on the existence of the time-periodic solutions for the Dirichlet problem of the nonlinear wave equation on the ball. Our method is based on critical point theory and the spectral properties of the radial wave operator. This is joint work with Kui Li and Zhitao Zhang.

Self-similar Blow-up Solutions of the Nonlinear Schrodinger Equation with Moving Mesh methods

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Schedule: December 17 13:30-14:00 Capital Suite 10

Shaohua Chen
Cape Breton University
Canada

Abstract:
This paper deals with the initial-value problem for the radially symmetric nonlinear Schrodinger equation with cubic non linearity in d = 2 and 3 space dimensions. A very simple, robust and efficient moving mesh method is proposed for numerically solving the radially symmetric nonlinear Schrodinger equation. It is employed in two schemes. The first numerical simulation aims to reproduce the stable self-similar blow-up solution for d=3. The computed data is used to compare it with the exact blow-up solution. The two solutions overlap when the amplitude of the solution is less than 10 to the 5th power. Next, a typical initial function is used to simulate the blow-up solution for d=3 and is compared with the corresponding exact blow-up solution. The graphs of the two solutions almost overlap when the amplitude of the solution reaches 10 to the 60th power and the adjacent mesh points near 0 are as small as 10 to the -61th power. The two solution curves and their derivatives are smooth in the whole domain and show slow oscillations in both r and t directions. However, when d = 2, the numerical solution becomes unstable due to high oscillations. A comparison with the corresponding asymptotic solution reveals that the amplitude of the two solutions almost overlap. Furthermore, both mass and energy are well conserved for d = 2 and 3.

Self-organizing pheonomena in Schrodinger type systems

Schedule: December 17 13:00-13:30 Capital Suite 10

Yeyao Hu
Central South University
Peoples Rep of China

Co-Author(s): Aleks Jevnikar and Weihong Xie

Abstract:
Self-organizing patterns are widely observed in various physical and biological systems. In Schrodinger-type reaction-diffusion systems, such as the Gierer-Meinhardt system, assemblies of interior and boundary spikes can be constructed. In contrast, the FitzHugh-Nagumo system reveals bubble-like assemblies. More recently, infinitely many solutions of Schrodinger-Newton systems have been constructed based on the ground state of the two-component systems. This talk will also cover new progress on cluster solutions and other related aspects.

New solutions for the Lane-Emden problem in planar domains

Schedule: December 17 14:45-15:15 Capital Suite 10

Isabella Ianni
Sapienza Universita di Roma
Italy

Abstract:
We consider the Lane-Emden problem $-\Delta u = |u|^{p-1}u \quad \text{in } \Omega, \quad u = 0 \quad \text{on } \partial\Omega,$ where $\Omega \subset \mathbb{R}^2$ is a smooth bounded domain. When the exponent p is large, the existence and multiplicity of solutions strongly depend on the geometric properties of the domain, which also deeply affect their qualitative behaviour. Remarkably, a wide variety of solutions, both positive and sign-changing, have been found when p is sufficiently large. In this talk, we focus on this topic and show the existence of new sign-changing solutions that exhibit an unexpected concentration phenomenon as $p \to +\infty$. These results are obtained in collaboration with L. Battaglia and A. Pistoia.

The existence of L^2-normalized solutions in the L^2-critical setting

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Schedule: December 17 16:15-16:45 Capital Suite 10

Norihisa Ikoma
Keio University
Japan

Co-Author(s): Silvia Cingolani, Marco Gallo, Kazunaga Tanaka

Abstract:
This talk is concerned with the existence of L^2-normalized solutions. In particular, we deal with the L^2-critical nonlinearity both at 0 and ∞. A model case is the power nonlinearity and this problem has a solution only for one mass. We consider a perturbation of this power nonlinearity and our problem is delicate since we could not expect the existence of solutions for general masses. This is joint work with Silvia Cingolani, Marco Gallo and Kazunaga Tanaka.

Bubbling solutions of slightly subcritical and critical Lane-Emden systems

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Schedule: December 17 15:45-16:15 Capital Suite 10

Seunghyeok Kim
Hanyang University
Korea

Abstract:
The Lane-Emden system is an extremal equation associated with a specific Sobolev embedding, and it is closely related to the Calderon-Zygmund estimates. This system is one of the simplest elliptic Hamiltonian systems, as the nonlinear Schroedinger system is that of elliptic gradient systems. In this talk, we examine recent developments in the theory of the Lane-Emden system. This includes discussions on slightly subcritical Lane-Emden systems on smooth bounded domains and the critical Lane-Emden system on the entire Euclidean space or smooth bounded domains with small spherical holes.

Multiple normalized solutions to a system of nonlinear Schroedinger equations

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Schedule: December 17 15:15-15:45 Capital Suite 10

Jaroslaw Mederski
Institute of Mathematics, Polish Academy of Sciences
Poland

Co-Author(s): Andrzej Szulkin

Abstract:
We present recent results concerning normalized solutions to a system of coupled nonlinear Schr\odinger equations. The problem appears in different areas of mathematical physics, e.g. in the analysis of Bose-Einstein condensation or in nonlinear optics. By means of spectral results, the Cwikel-Lieb-Rozenblum theorem, the Morse index and new Liouville-type results we show the existence of multiple normalized solutions for sufficiently large coupling. The talk is based on joint work with Andrzej Szulkin.

Quasilinear Schrodinger Equations Involving Stein-Weiss Convolution Type exponential Critical Nonlinearity

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Schedule: December 17 18:30-19:00 Capital Suite 10

Sarika Sarika
Netaji Subhas University of Technology Dwarka Delhi India
India

Co-Author(s): Dr. Reshmi Biswas and Prof. Konijeti Sreenadh

Abstract:
In this talk, we will discuss about the existence result of quasilinear Schrodinger equation involving critical Choquard type/Stein-Weiss convolution type exponential nonlinearity in bounded domain as well as in unbounded domain.

Normalized solutions of L^2-supercritical NLS equations on metric graphs

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Schedule: December 17 12:30-13:00 Capital Suite 10

Nicola Soave
Universit\`a degli Studi di Torino
Italy

Co-Author(s): Jack Borthwick, Xiaojun Chang, Louis Jeanjean

Abstract:
We present some results regarding existence of non-trivial bound states of prescribed mass for the L^2-supercritical nonlinear Schr\odinger equation on metric graphs. In recent years, the NLSE on graphs was studied by many authors in the L^2-subcritical or critical case. In parallel, the search for prescribed mass solutions to the L^2-supercritical NLSE in the Euclidean space attracted a lot of attention. However, the L^2-supercritical NLSE on graphs was essentially untouched. In such case, the mass constraint introduces severe complications in proving the existence of bounded Palais-Smale sequences. Several approaches have been developed to overcome these issues in the Euclidean case, but ultimately most of them seem to rely on the fact that critical points satisfy a natural constraint induced by a Pohozaev-type identity, on which the functional can be shown to be coercive. These methods allow to treat cases where the functional enjoys some nice scaling properties, but are not applicable if scaling is not allowed, such as on metric graphs. In this talk we present some existence results obtained by developing a new method based upon a variational principle which combines the monotonicity trick and a min-max theorem with second order information for constrained functionals, and upon the blow-up analysis of bound states with prescribed mass and bounded Morse index.

An Overview on Nonlinear Schrodinger systems

Schedule: December 17 14:00-14:30 Capital Suite 10

Giusi Vaira
University of Bari Aldo Moro
Italy

Abstract:
In this talk I will discuss about the existence of positive nonradial solutions for a system of Schrodinger equations in a fully attractive or repulsive regime in presence of an external trapping and radial potential. We also discuss the critical growth case and the case of logistic type interaction.

Extremal value of the L^2-Pohozaev manifold and its applications

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Schedule:

Yuanze Wu
China University of Mining and Technology
Peoples Rep of China

Co-Author(s): Taicheng Liu

Abstract:
We introduce the extremal value of the L2-Pohozaev manifold. As applications, we prove the existence and multiplicity of normalized solutions of Schrodinger equations under mild conditions.

Symmetric non-radial solutions for nonlinear Schr\odinger systems with mixed couplings

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Schedule: December 17 17:30-18:00 Capital Suite 10

Jiankang Xia
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Yohei Sato; Zhi-Qiang Wang

Abstract:
In this talk, I will present our recent results on bound state solutions for the coupled nonlinear elliptic system featuring both attractive and repulsive couplings. These solutions can be characterized as ground states within the subspace of even symmetric functions, whereas it is known that ground states do not exist in the full space of Sobolev functions. This scenario is referred to as the `repulsive-mixed case` according to the recent classification by Wei and Wu (J. Math. Pures Appl., 141:50-88, 2020), which established the non-existence of ground states for small attractive coupling. We extend this non-existence to all cases. This talk is based on the joint work with Professor Yohei Sato from Saitama University, Japan and Professor Zhi-Qiang Wang from Utah State University, USA.

Special Session 3 : Recent Mathematical Progress in Boundary Layer Problems

Introduction: This session provides a platform for mathematicians and researchers to present their latest theoretical contributions to the field of boundary layer problems. Boundary layers are a fundamental concept in fluid mechanics, heat transfer, and other areas, and understanding their mathematical underpinnings is of paramount importance. The session will encompass a range of topics related to mathematical theory in boundary layer problems and will provide an opportunity for participants to gain insights into the forefront of mathematical theory in boundary layer problems. It will promote the exchange of ideas, foster collaboration among mathematicians specializing in this field, and stimulate further research into the rigorous mathematical foundations of boundary layer phenomena.

Boundary Layer Analysis in Diffusive Limits of Radiative Heat Transfer System

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Schedule: December 19 16:45-17:15 Capital Suite 12 B

Mohamed Ghattassi
New York University Abu Dhabi
United Arab Emirates

Co-Author(s): Xiaokai Huo, Nader Masmoudi

Abstract:
This work investigates the diffusive limit of nonlinear radiative heat transfer systems, focusing on boundary layers under various conditions, including reflective radiative, Dirichlet, Robin, and curved boundaries. The global existence of weak solutions is demonstrated using the Galerkin method, and the convergence of these solutions to a nonlinear diffusion model in the diffusive limit is established through compactness techniques, Young measure theory, and the Banach fixed-point theorem. This work also addresses the nonlinear Milne problem, where the nonlinearity of the Stefan-Boltzmann law introduces additional mathematical challenges. Existence, exponential decay, and uniqueness of solutions are proven using uniform estimates, monotonicity properties, and spectral assumptions. Furthermore, the coupling between elliptic and kinetic transport equations is resolved via combined L^2-L^∞ estimates. The extension to curved boundary domains includes a novel geometric correction for boundary layers, ensuring stability and convergence of solutions. These results significantly extend the existing mathematical framework for radiative heat transfer systems, providing a rigorous analysis of diffusive limits in complex geometries.

Incompressible limit of compressible systems in $\R^3$

Schedule: December 19 16:15-16:45 Capital Suite 12 B

Xianpeng Hu
The Hong Kong Polytechnic University
Peoples Rep of China

Co-Author(s): Guochun Wu, Xin Zhong

Abstract:
We will discuss the incompressible limit of compressible Navier-Stokes equations. As the volume viscosity tends to infinity, the limit system of compressible Navier-Stokes equations with discontinuous initial data is the density-dependent incompressible Navier-Stokes equation. In this setting, the global convergence to the limit system around an equilibrium is justified.

On the hydrostatic approximation of Navier-Stokes-Maxwell system with Gevrey data

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Schedule: December 19 17:30-18:00 Capital Suite 12 B

Ning Liu
The Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Marius Paicu, Ping Zhang

Abstract:
In this talk, we establish the local well-posedness of a scaled anisotropic Navier-Stokes-Maxwell system in a 2-D striped domain with initial data around some nonzero background magnetic field in Gevrey-2 class. Then we rigorously justify the limit from the scaled anisotropic equations to the associated hydrostatic system and provide with the precise convergence rate. Finally, with small initial data in Gevrey-3/2 class, we also extend the lifespan of thus obtained solutions to a longer time interval.

On The Hydrostatic Approximation Of Navier-Stokes-Maxwell System With 2D Electronic Fields

Schedule: December 19 18:00-18:30 Capital Suite 12 B

Faiq Raees
New York University
United Arab Emirates

Co-Author(s): Weiren Zhao

Abstract:
In this talk, we establish the well-posedness of a scaled anisotropic Navier-Stokes-Maxwell system in a 2D striped domain with a transverse magnetic field around (0,0,1) in Gevrey-2 class. Then we justify the limit from the scaled anisotropic equations to the associated hydrostatic system and establish the precise convergence rate. Finally, we prove the global stability of the state (0,0,1) and show that small perturbations decay down exponentially. We will conclude the talk by giving some evidence that the Gevrey-2 class is optimal.

INTERACTIVE BOUNDARY LAYER THEORY

Schedule: December 19 15:15-15:45 Capital Suite 12 B

Marco Sammartino
University of Palermo
Italy

Co-Author(s): R.Caflisch, F.Gargano, V.Sciacca

Abstract:
The main aim of this talk is to give a mathematical justification for the interactive boundary layer theory. In the first part of the talk, we shall discuss the behavior of the Navier-Stokes solutions for a high Reynolds number flow interacting with a boundary. To describe these flows, one usually introduces the boundary layer and the Prandtl equations. A rigorous mathematical justification of this setting has been given in the analytic setting. However, the Euler--Prandtl matching does not allow the interaction between the Boundary Layer and the outer flow: this imposes severe limitations on the theory, ultimately leading to the lack of a sound description of the transition phenomena occurring close to the boundary. In the second part of the talk, we shall describe a different asymptotic approach that seems able to overcome the above-described difficulties. The well-posedness of the resulting equations in the analytic setting is the main result of the talk.

On the characterization, existence and uniqueness of steady solutions to the hydrostatic Euler equations in a nozzle

Schedule: December 19 15:45-16:15 Capital Suite 12 B

Tak Kwong Wong
The University of Hong Kong
Hong Kong

Co-Author(s): Wang Shing Leung and Chunjing Xie

Abstract:
As a variant of Prandtl boundary layer equations, the hydrostatic Euler equations describe the leading-order behavior of ideal flows passing through narrow domains. In this talk, we will discuss recent results about steady solutions to the hydrostatic Euler equations in nozzles. When expressed in terms of stream function formulation, the steady hydrostatic Euler equations become a degenerate elliptic equation, so the classical estimates for uniformly elliptic equations cannot directly apply. One of the key ingredients for the mathematical analysis is a new transformation that combines a change of variable and Euler-Lagrange transformation. With the aid of this new transformation, the solutions in the new coordinates enjoy explicit representations so that the regularity of steady solutions with respect to the horizontal variable can be gained in a clear way.

Mack modes in supersonic boundary layer

Schedule: December 19 18:30-19:00 Capital Suite 12 B

Di Wu
South China University of Technology
Peoples Rep of China

Co-Author(s): N. Masmoudi, Y. Wang, Z. Zhang

Abstract:
Understanding the transition mechanism of boundary layer flows is of great significance in physics and engineering, especially due to the current development of supersonic and hypersonic aircraft. In this talk, we construct multiple unstable acoustic modes so-called Mack modes, which play a crucial role during the early stage of transition in the supersonic boundary layer. To this end, we develop an inner-outer gluing iteration to solve a hyperbolic-elliptic mixed type and singular system.

Stability analysis of the subsonic boundary layers at the high Reynolds number

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Schedule: December 19 19:00-19:30 Capital Suite 12 B

ZHU ZHANG
The Hong Kong Polytechnic University
Hong Kong

Abstract:
In this talk, we will present a recent result on the stability of subsonic boundary layers for compressible Navier-Stokes equations at the high Reynolds numbers.

Special Session 4 : Delay and Functional Differential Equations and Applications

Introduction: Many real-life problems, which are traditionally formulated using ordinary differential equations (ODEs), can be more accurately and naturally modeled by delay differential equations (DDEs). Such DDEs are widely used in biological and physical systems, such as population dynamics, epidemiology, immunology, physiology, and neural networks. Most biological and engineering systems are characterized by time delays or lags. Thus, differential equations with memory, represented by time delays (time lags), are more advantageous than models without memory. Differential equations become more stable and dynamic when memory is added. The purpose of this special session is to explore new trends and analytical insights into delay differential equations in biological systems, including the existence and uniqueness of solutions, their boundedness and persistence, their oscillatory behavior, their stability and bifurcation analyses, their parameter estimation, their sensitivity analyses, and their numerical analyses.

Delay on time of Fractional Diabetes Model with Optimal Control, Numerical Treatments

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Schedule: December 17 9:30-10:00 Capital Suite 5

Muner Abou Hasan
emirates aviation university
United Arab Emirates

Co-Author(s): Muner M. Abou Hasan, Hannah Al Ali, Zindoga Mukandavire, Seham M. Al-Mekhlafi

Abstract:
In this paper, we presented the fractional optimal control of the diabetes disease mathematical model with time delay. The fractional order operator is defined in the Caputo sense. A control variable is considered to reduce the glucose in the blood by controlling insulin. The discretization of the nonstandard finite difference and Gr\{u}nwald−Letnikov is constructed to solve the obtained optimality system numerically. The stability analysis of the proposed method is studied. Numerical examples and comparative studies for testing the applicability of the utilized method and to show the simplicity of this approximation approach are presented.

Artificial Neural Networks for Stability Analysis and Simulation of Delayed Rabies Spread Models

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Schedule: December 17 8:30-9:00 Capital Suite 5

Ateq Alsaadi
Taif university
Saudi Arabia

Co-Author(s): Ramsha Shafqat

Abstract:
This article presents a delay differential equations model to track the spread of rabies among dog and human populations. It considers two delay effects on vaccination efficacy and incubation duration, and uses singular and non-singular kernels to evaluate other factors influencing rabies transmission. The model`s uniqueness is established using fixed point, piecewise derivative, and integral approaches. A piecewise numerical iteration scheme based on Newton interpolation polynomials is used to obtain an approximate solution. The study aims to improve our understanding of rabies spread dynamics using a novel piecewise derivative approach, clarifying the concept of piecewise derivatives and their significance in understanding crossover dynamics. The dataset is divided into training, testing, and validation sets using Artificial Neural Network (ANN) approaches.

Stochastic epidemic model based on Markovian switching with time delay

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Schedule: December 16 13:00-13:30 Capital Suite 5

Hebatallah Alsakaji
UAE University
United Arab Emirates

Co-Author(s): Fathalla Rihan

Abstract:
The dynamics of disease transmission are influenced by environmental changes. In this study, we incorporate unreported cases (U), environmental disturbances, and external events into the Susceptible; Exposed; Infectious; Unreported; Removed (SEIUR) epidemic model with time delays. We analyze the random transitions between different regimes. The criteria for ergodicity and stationary distribution are explored, and a Lyapunov function is employed to establish conditions under which the disease may be eradicated. Sudden external events, like hurricanes, can significantly impact disease spread during regime transitions. Numerical simulations are used to validate the model and the theoretical findings.

Delay equations in sequentially complete locally convex vector spaces

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Schedule: December 16 13:30-14:00 Capital Suite 5

Christian Budde
University of the Free State
So Africa

Co-Author(s): Christian Seifert

Abstract:
This work is initially motivated motivated by the work of B\`{a}tkai and Piazzera \cite{BP2005,BP2001}. They studied partial differential equations with finite delay using an operator theoretical approach by means of C_0-semigroups. The theory of strongly continuous one-parameter operator semigroups is well-developed. However, also this theory has its limitations as one deals with operators on a given Banach space. \medskip A possible generalization of the concept of C_0-semigroups on Banach spsaces are operator semigroups on locally convex spaces. There has been a lot of research regarding the formulation of operator semigroup theory on those spaces. The class of locally equicontinuous semigroups has been investigated for example by Dembard \cite{D1974}, Babalola \cite{Ba1974}, Ouchi \cite{O1973} and Komura \cite{Ko1968}. Here, one has to be a little bit more careful when it comes to resolvents as one only can work with so-called asymptotic resolvents as the Laplace transform does not need to converge. \medskip We show that one can combine equations with both finite and infinite delay in one theory. Evolution equations with infinite delay have been explored on their own by several authors not only on Banach spaces but also on Frechet spaces. However, it is worth mentioning, that Picard, Trostorff and Waurick showed \cite{PTW2014} that they do not need different treatment. \medskip This is joint work with C.~Seifert (Technical University Hamburg, Germany). \begin{thebibliography}{10} \bibitem{Ba1974} V.~A. Babalola. \newblock Semigroups of operators on locally convex spaces. \newblock {\em Trans. Am. Math. Soc.}, 199:163--179, 1974. \bibitem{BP2001} A.~B{\`a}tkai and S.~Piazzera. \newblock Semigroups and linear partial differential equations with delay. \newblock {\em J. Math. Anal. Appl.}, 264(1):1--20, 2001. \bibitem{BP2005} A.~B{\`a}tkai and S.~Piazzera. \newblock {\em Semigroups for delay equations}, volume~10 of {\em Res. Notes Math.} \newblock Wellesley, MA: A K Peters, 2005. \bibitem{D1974} B.~Dembart. \newblock On the theory of semigroups of operators on locally convex spaces. \newblock {\em J. Funct. Anal.}, 16:123--160, 1974. \bibitem{Ko1968} T.~Komura. \newblock Semigroups of operators in locally convex spaces. \newblock {\em J. Funct. Anal.}, 2:258--296, 1968. \bibitem{O1973} S.~Ouchi. \newblock Semi-groups of operators in locally convex spaces. \newblock {\em J. Math. Soc. Japan}, 25:265--276, 1973. \bibitem{PTW2014} R.~Picard, S.~Trostorff, and M.~Waurick. \newblock A functional analytic perspective to delay differential equations. \newblock {\em Oper. Matrices}, 8(1):217--236, 2014. \end{thebibliography}

Stability and Convergence in Asymptotic Systems of Neural Networks with Infinite Delays

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Schedule: December 16 14:00-14:30 Capital Suite 5

Ahmed Elmwafy
Universidade da Beira Interior
Portugal

Co-Author(s): A. Elmwafy, Jos\`{e} J. Oliveira, C\`esar M. Silva

Abstract:
We investigate both the global exponential stability and the existence of a periodic solution of a general differential equation with unbounded distributed delays. The main stability criterion depends on the dominance of the non-delay terms over the delay terms. The criterion for the existence of a periodic solution is obtained with the application of the coincidence degree theorem. We use the main results to get criteria for the existence and global exponential stability of periodic solutions of a generalized higher-order periodic Cohen-Grossberg neural network model with discrete-time varying delays and infinite distributed delays. Additionally, we provide a comparison with the results in the literature and a numerical simulation to illustrate the effectiveness of some of our results.

Refined Caputo Fractional Derivative for Non-Singular Nonlinear Systems with Delay: Its Application to Suppress the Aedes Aegypti Mosquitoes via Wolbachia

Schedule: December 16 15:45-16:15   Capital Suite 5

Soundararajan Ganesan
Nazarbayev University
Kazakhstan

Co-Author(s): Gopalakrishnan Karnan; Ardak Kashkynbayev; Minvydas Ragulskis; Chien-Chang Yen

Abstract:
This study refines the Caputo fractional derivative for non-singular nonlinear functions, unifying Riemann-Liouville and Caputo derivatives. We introduce an improved fractional derivative operator to establish stability outcomes for a model addressing cytoplasmic incompatibility in \textit{Aedes Aegypti} mosquitoes. This work builds on existing research where the Caputo-Fabrizio operator was used in logistic growth equations, confirming solution existence, uniqueness, and α-exponential stability. However, previous studies overlooked the non-singular aspects of nonlinear growth factors, which are crucial for our model. We extend existing results to a new fractional-order operator using singular and non-singular kernel functions and their well-posedness properties. Our mathematical model aims to increase cytoplasmic incompatibility in \textit{Aedes Aegypti} by releasing \textit{Wolbachia}-infected mosquitoes, reducing mosquito populations and the incidence of diseases like Dengue, Zika, Chikungunya, and Yellow Fever. We establish conditions for delay-dependent exponential stability using a Lyapunov-Kraskovskii functional and the linear matrix inequality framework. Finally, a numerical example with comparative analysis validates the theoretical outcomes of the improved fractional operator within the population model using real-world data.

On the qualitative behavior of a Hepatitis B epidemic model with a non-standard finite difference scheme

Schedule: December 16 18:30-19:00   Capital Suite 5

Mehmet Gumus
Zonguldak Bulent Ecevit University
Turkey

Co-Author(s): Kemal Turk

Abstract:
Hepatitis B is a significant global health issue with serious consequences like liver cancer, cirrhosis, and liver failure. The virus spreads through contact with infected blood, body fluids, or contaminated needles. With over 350 million chronic carriers and about 800,000 deaths annually, primarily from liver cancer and cirrhosis, it remains a major global threat. Despite advanced preventive treatments, including effective vaccination programs, the risk of chronic Hepatitis B virus infection persists. The dynamics of the spread of the Hepatitis B virus can be modeled mathematically. Epidemiological models are often formulated as systems of non-linear differential equations. These models can be discretized using methods like Euler and Runge-Kutta, but these can lead to undesirable behaviors such as incorrect equilibrium points or numerical instabilities. To address these issues, a non-standard finite difference scheme can be constructed. In this study, a Hepatitis B virus model will be discussed, and a non-standard finite difference scheme for this system will be established. It will be shown that the discrete system provides dynamically consistent results with the continuous model, regardless of the time step size h, regarding the positivity and boundedness of solutions, equilibrium points, basic reproduction number, and stability behavior. Numerical simulations will support theoretical results.

Non-Markovian models of collective motion

Schedule: December 17 9:00-9:30 Capital Suite 5

Jan Haskovec
King Abdullah University of Science and Technology
Saudi Arabia

Abstract:
I will give an overview of recent results for models of collective behavior governed by functional differential equations with non-Markovian structure. The talk will focus on models of interacting agents with applications in biology (flocking, swarming), social sciences (opinion formation) and engineering (swarm robotics), where latency (delay) plays a significant role. I will characterize two main sources of delay - inter-agent communications (transmission delay) and information processing (reaction delay) - and discuss their impacts on the group dynamics. I will give an ovierview of analytical methods for studying the asymptotic behavior of the models in question and their mean-field limits. In particular, I will show that the transmission vs. reaction delay leads to fundamentally different mathematical structures and requires appropriate choice of analytical tools. Finally, motivated by situations where finite speed of information propagation is significant, I will introduce an interesting class of problems where the delay depends nontrivially and nonlinearly on the state of the system, and discuss the available analytical results and open problems here.

Numerov Method for a Weakly Coupled System of Singularly Perturbed Delay Differential Equations

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Schedule: December 17 8:00-8:30 Capital Suite 5

Dany Joy
Vellore Institute of Technology, Vellore
India

Co-Author(s): Dinesh Kumar S and Fathalla A Rihan

Abstract:
This article presents an efficient numerical method for solving a weakly coupled system of singularly perturbed delay differential equations. The technique involves approximating the first-order derivative in the system using a Taylor series, followed by applying the Numerov method. A scheme incorporating a fitting factor is developed to solve the problem. To evaluate the method`s accuracy, error estimation is performed using the maximum principle, and theoretical justifications are provided through relevant numerical examples with varying perturbation parameters and mesh sizes. The numerical results are expressed in terms of maximum absolute errors and the rate of convergence. Our approach is shown to be uniformly convergent to the first order, as demonstrated by the tabulated values. Compared to previously published methodologies, this approach yields improved results and makes a valuable contribution to the existing literature.

Numerical approximation for singularly perturbed differential equations exhibiting significant positive shift arising in neuronal activity

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Schedule: December 16 18:00-18:30 Capital Suite 5

Akhila Mariya Regal
Vellore Institute of Technology, Vellore
India

Co-Author(s): Dinesh Kumar S

Abstract:
An approximation technique for singularly perturbed differential equations with a large positive shift parameter is presented in this article. The recommended numerical scheme is solved using the Gauss elimination method in MATLAB R2022a. The proposed scheme achieves a linear rate of convergence on a uniform grid. The convergence results, both theoretical and numerical, have been demonstrated and confirmed to be consistent with the proposed scheme. A few examples are provided in tables and charts to compute and demonstrate the theoretical analysis results. When compared to existing literature, our method produces better outcomes with lower error rates for the specified examples.

Finite-Time Synchronization of Complex-Valued Fractional Order Memristive Neural Networks with Time-Varying Delays

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Schedule: December 16 17:30-18:00 Capital Suite 5

Madina Otkel
Nazarbayev University
Kazakhstan

Co-Author(s): Ardak Kashkynbayev, Soundararajan Ganesan, Rakkiyappan Rajan

Abstract:
This paper investigates the problem of finite-time synchronization in complex-valued fractional-order memristive neural networks (CVMFONNs) with time-varying delays. The focus is on developing novel synchronization criteria and control strategies that ensure finite-time synchronization despite the inherent complexities introduced by fractional-order dynamics, memristive characteristics, and complex-valued states. By employing Lyapunov functional methods and fractional-order calculus, we derive sufficient conditions for finite-time synchronization, accounting for the influence of time-varying delays on system stability. The proposed control schemes are validated through rigorous theoretical analysis and numerical simulations, demonstrating their effectiveness and robustness. Our results contribute to the understanding and application of fractional-order neural networks in real-world scenarios where rapid synchronization is critical, offering potential insights for advancements in neuromorphic computing and complex system modeling.

DELAY DIFFERENTIAL EQUATIONS AND APPLICATIONS TO BIOLOGY

Schedule: December 16 12:30-13:00 Capital Suite 5

Fathalla Rihan
United Arab Emirates University
United Arab Emirates

Co-Author(s): Fathalla A. Rihan

Abstract:
Recently much attention has been given to mathematical modeling of real-life phenomena using differential equations with memory, such as delay differential equations (DDEs). This is because introducing memory terms in a differential model significantly increases the complexity of the model. Such a class of DDEs is widely used for analysis and predictions in various areas of life sciences and modern topics in population dynamics, computer science, epidemiology, immunology, physiology, and neural networks. In this talk, we provide a wide range of delay differential models with a richer mathematical framework (compared with ODEs) for analyzing biosystems. Qualitative and quantitative features of DDEs are discussed. Some numerical simulations are also provided to show the effectiveness of the theoretical results.

A fitted numerical technique using a cubic spline in compression for the singularly perturbed Fredholm integro differential equation

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Schedule: December 16 17:00-17:30 Capital Suite 5

RAJAGOPAL S
Research Scholar
India

Co-Author(s): Dinesh Kumar S

Abstract:
This paper deals with the second-order Fredholm integro differential equations perturbed singularly. Similar problems arise when modelling the spatiotemporal evolution of epidemics mathematically. An fitted difference scheme on a uniform mesh is accomplished by the method based on cubic spline in compression. An analysis is conducted on the scheme`s stability. The convergence of the proposed scheme is examined. The theory is supported numerically by the solutions to several example and are presented in the table.

Synchronization of Fuzzy Reaction-Diffusion Neural Networks via Semi-intermittent Hybrid control and its application to Medical Image Encryption

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Schedule: December 16 15:15-15:45 Capital Suite 5

Kathiresan Sivakumar
Nazarbayev University
Kazakhstan

Co-Author(s): Mohanrasu S S, Ardak Kashkynbayev, Rakkiyappan Rajan

Abstract:
This paper addresses the problem of synchronizing fuzzy reaction-diffusion neural networks (FRDNNs) with time-varying transmission delays using aperiodic semi-intermittent hybrid controls and its application in image encryption. The main challenge in analyzing the dynamics of FRDNNs included diffusion terms with uncertainty, and the inclusion of fuzzy logic operations further increases the system`s complexity. We propose a new concept called the average control width (ACW) for aperiodic semi-intermittent control (ASIC) systems; it is used in conjunction with the idea of average dwell time (ADT) for switched systems. A sufficient flexible condition for drive-response synchronization of neural networks using average-width semi-intermittent hybrid control assures ADT and ACW conditions. By utilizing these concepts, the proposed synchronization method can overcome the challenges posed by the diffusion terms and fuzzy logic operations in FRDNNs with time-varying transmission delays. Finally, the paper presents a theoretical framework for synchronizing FRDNNs with time-varying transmission delays using semi-intermittent hybrid control via LMI and suitable Lyapunov functional, validated through simulations. The proposed synchronization method is also applied to develop a novel chaos-based elliptic curve cryptography algorithm for medical image encryption.

Non polynomial spline approach on an adaptive mesh for a weakly coupled system of singularly perturbed delay differential equations of convection diffusion type with large delay

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Schedule: December 16 14:45-15:15 Capital Suite 5

Dinesh Kumar Subramani
Vellore Institute of Technology Vellore
India

Co-Author(s): Dany Joy

Abstract:
This paper presents a numerical scheme for solving a weakly coupled system of singularly perturbed delay differential equations of convection diffusion type with large delay. The difference scheme on adaptive mesh is accomplished by the method which is based on non polynomial spline approach. An analysis is conducted on the scheme`s stability. The convergence of the proposed scheme is examined. To illustrate the theoretical analysis, several examples are solved for different values of the perturbation parameter, with the computational results displayed in tables are more accurate than the previous results.

Special Session 5 : Recent developments in Partial Differential Equations from Physics

Introduction: The aim of this special session is to bring together experts in the area of partial differential equations from physics, such as Navier-Stokes equations and its variants from physics, to present their recent research results in theoretical analysis and applications in engineering. In this session, people are expected to exchange new ideas, to discuss challenging issues, to explore new directions and topics, and to foster new collaborations and connections.

The effective medium generated by a cluster of highly contrasting nanoparticles with periodic and nonperiodic distribution

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Schedule: December 19 18:30-19:00 Capital Suite 15

Xinlin Cao
The Hong Kong Polytechnic University
Peoples Rep of China

Co-Author(s): Ahcene Ghandriche and Mourad Sini

Abstract:
We derive the electromagnetic medium equivalent to a collection of all-dielectric nano-particles (enjoying high refractive indices) distributed periodically in a smooth domain. Then we extend and generalize the study to the medium with Van-Der-Waals Heterostructure possessing locally non-periodic distribution. For the periodic distribution case, we figure out that the effective medium is an alteration of the permeability that keeps the permittivity unchanged, which provides regimes under which the effective permeability can be positive or negative valued. For the heterostructure case, we build up a local distribution tensor, which models the local strong interaction of the nano-particles. To our best knowledge, such tensors are new in both the mathematical and engineering oriented literature.

Well-posedness for local and nonlocal quasilinear evolution equations in fluids and geometry

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Schedule: December 20 15:00-15:30 Capital Suite 15

Ke Chen
The Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Ruilin Hu, Quoc-Hung Nguyen

Abstract:
In this talk, I will present some recent results on local and global well-posedness results of some nonlocal and nonlinear evolution equations. These results are based on a Schauder type estimate for general nonlocal parabolic equations.

Incompressible limit of compressible viscoelastic system with vanishing shear viscosity

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Schedule: December 20 16:45-17:15 Capital Suite 15

Xiufang Cui
Lanzhou University
Peoples Rep of China

Abstract:
We study the vanishing shear viscosity limit and the incompressible limit of compressible viscoelastic system near the equilibrium. The large value of volume viscosity forces the limit system to be incompressible and the vanishing shear viscosity indicates that the limit system is inviscid. The generalized energy estimate and the ghost weight method are used to guarantee the global convergence from compressible viscoelastic system to the incompressible elastodynamics.

Steady compressible Navier-Stokes-Fourier system with slip boundary conditions arising from kinetic theory

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Schedule: December 19 19:00-19:30 Capital Suite 15

Renjun Duan
The Chinese University of Hong Kong
Hong Kong

Co-Author(s): Junhao Zhang

Abstract:
This talk concerns the boundary value problem on the steady compressible Navier-Stokes-Fourier system in a channel domain $(0,1)\times\mathbb{T}^2$ with a class of generalized slip boundary conditions that were systematically derived from the Boltzmann equation by Coron [JSP, 1989] and later by Aoki et al. [JSP, 2017]. We establish the existence and uniqueness of strong solutions in $(L^2_0\cap H^2(\Omega))\times V^3(\Omega)\times H^3(\Omega)$ provided that the wall temperature is near a positive constant. The proof relies on the construction of a new variational formulation for the corresponding linearized problem and employs a fixed point argument. The main difficulty arises from the interplay of velocity and temperature derivatives together with the effect of density dependence on the boundary.

Extrinsic Derivative Formula for Distribution Dependent SDEs

Schedule: December 19 18:00-18:30 Capital Suite 15

Panpan P Ren
City University of Hong Kong
Hong Kong

Abstract:
To characterize the regularity of nonlinear Fokker-Planck equations with respect to weighted variational distances, we establish for the first time a Bismut type formula for the extrinsic derivative of distribution dependent SDEs (DDSDEs). As an application, the Lipschitz continuity in the weighted variational distance is derived for the associated nonlinear Fokker-Planck equation, which can be regarded as the counterpart of the classical contraction property in the linear setting. The main results are illustrated by non-degenerate DDSDEs with space-time singular drift, as well as degenerate DDSDEs with weakly monotone coefficients.

Ill/well-posedness of non-diffusive active scalar equations with physical applications

Schedule: December 20 9:00-9:30 Capital Suite 15

Anthony Suen
The Education University of Hong Kong
Hong Kong

Co-Author(s): Susan Friedlander and Fei Wang

Abstract:
We consider a general class of non-diffusive active scalar equations with constitutive laws obtained via an operator $\mathcal{T}$ that is singular of order $r_0 \in [0, 2]$. We obtain ill/well-posedness results for various values for r_0. We then apply the results to several physical problems including the magnetogeostrophic equation, the incompressible porous media equation and the singular incompressible porous media equation. This is a joint work with Susan Friedlander and Fei Wang.

Regularity structure and asymptotic behavior of energy conservative solutions to the Hunter-Saxton equation

Schedule: December 20 8:30-9:00 Capital Suite 15

Tak Kwong Wong
The University of Hong Kong
Hong Kong

Co-Author(s): Yu Gao and Hao Liu

Abstract:
The Hunter-Saxton equation is an integrable equation, and can be used to study the nonlinear instability in the director field of a nematic liquid. In this talk, we will first introduce a new generalized framework for energy conservative solutions of the Hunter-Saxton equation, and then discuss how to apply this new framework to investigate the regularity structure and long-time behavior of these solutions. In particular, some new observations have been found and rigorously shown: (i) singularities for the energy measure may only appear at at most countably many times, and are completely determined by the absolutely continuous part of initial energy measure; (ii) the temporal and spatial locations of singularities are explicitly determined by the initial data; and (iii) the long-time behavior of energy conservative solution is given by a kink-wave that is determined by the total energy of the system only.

Long-time behavior to the 3D isentropic compressible Navier-Stokes equations

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Schedule: December 20 16:15-16:45 Capital Suite 15

Guochun Wu
Huaqiao University
Peoples Rep of China

Co-Author(s): Guochun Wu and Xin Zhong

Abstract:
We are concerned with the long-time behavior of classical solutions to the isentropic compressible Navier-Stokes equations in $\mathbb{R}^3$. Under the assumption that the density is uniformly bounded, we establish the global stability of classical solutions to the isentropic compressible Navier-Stokes equations. The main ingredient of the proof relies on the techniques involving blow-up criterion, a key time-independent positive upper and lower bounds of the density, and a regularity interpolation trick.

Transonic Shock with Large Swirl Velocity in a Finite Cylinder

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Schedule: December 20 14:00-14:30 Capital Suite 15

Wei XIANG
City University of Hong Kong
Hong Kong

Abstract:
In this talk, we introduce our recent work on the existence and unique location of the three-dimensional transonic shock with large swirl velocity for axisymmetric full Euler equations in a cylinder, with appropriate boundary conditions at the entrance of the nozzle and the receiver pressure at the exit of the nozzle. It is the first mathematical result on the three-dimensional transonic shock with large swirl velocity. We investigate the important role of the non-zero swirl in uniquely determining the shock location.

Long time instability of compressible planar Poiseuille flows

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Schedule: December 20 17:15-17:45 Capital Suite 15

Andrew Yang
City University of Hong Kong
Hong Kong

Co-Author(s): Zhu Zhang

Abstract:
It is well-known that at high Reynolds numbers, the linearized Navier-Stokes equations around the inviscid stable shear profile admit growing mode solutions due to the destabilizing effect of small viscosities. This phenomenon, which is related to Tollmien-Schlichting instability, has been rigoriously justified by Grenier-Guo-Nguyen [Adv. Math. 292 (2016); Duke J. Math. 165 (2016)] on incompressible Navier-Stokes equations. In this work, we aim to construct the Tollmien-Schlichting waves for the compressible Navier-Stokes equations over symmetric shear flows in a channel. We will also discuss the effect of temperature fields on the stability of these shear flows.

The 3D kinetic Couette flow via the Boltzmann equation in the diffusive limit

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Schedule: December 20 15:30-16:00 Capital Suite 15

Anita Yang
The Chinese University of Hong Kong
Hong Kong

Co-Author(s): Renjun Duan, Shuangqian Liu, Robert M. Strain

Abstract:
In this talk, we will study the Boltzmann equation in the diffusive limit in a channel domain $\backslash \mathrm{T}^2 \times (-1,1)$ for the 3D kinetic Couette flow. Our results demonstrate that the first-order approximation of the solutions is governed by the perturbed incompressible Navier-Stokes-Fourier system around the fluid Couette flow. Moreover, in the absence of external forces, the 3D kinetic Couette flow asymptotically converges over time to the 1D steady planar kinetic Couette flow. This is a joint work with Prof. Renjun Duan, Prof. Shuangqian Liu and Prof. Robert M. Strain.

Pattern formation in Landau-de Gennes theory

Schedule: December 20 8:00-8:30 Capital Suite 15

Yong Yu
The Chinese University of Hong Kong
Hong Kong

Co-Author(s): Ho Man Tai

Abstract:
In this talk, I will introduce the spherical droplet problem in the Landau-de Gennes theory. With a novel bifurcation diagram, we find solutions with ring and split-core disclinations, respectively. This work theoretically confirms the numerical results of Gartland and Mkaddem in 2000.

Some global existence and uniqueness of the strong solution for the multi-dimensional viscoelastic flows

Schedule: December 19 17:30-18:00 Capital Suite 15

Ting Zhang
Zhejiang University
Peoples Rep of China

Abstract:
In this talk, we mainly focus on the multi-dimensional viscoelastic flows of Oldroyd-B type. Considering a system of equations related to the compressible viscoelastic fluids of Oldroyd-B type with the general pressure law, $P'(\bar{\rho})+\alpha>0$, with $\alpha>0$ being the elasticity coefficient of the fluid, we prove the global existence and uniqueness of the strong solution in the critical Besov spaces when the initial data u_0 and the low frequency part of ρ_0, τ_0 are small enough compared to the viscosity coefficients. The proof we display here does not need any compatible conditions. In addition, we also obtain the optimal decay rates of the solution in the Besov spaces. At Last, considering the multi-dimensional compressible Oldroyd-B model, which is derived by Barrett, Lu, and Suli (Comm. Math. Sci. 2017) through the micro-macro analysis of the compressible Navier-Stokes-Fokker-Planck system in the case of Hookean bead-spring chains. We would provide a unified method to study the system with the background polymer number density $\eta_\infty \geq 0$, including the vanishing case and the nonvanishing case, and establish the global-in-time existence of the strong solution for the associated Cauchy problem when the initial data are small in the critical Besov spaces.

Nonlinear stability of entropy waves for the Euler equations

Schedule: December 20 14:30-15:00 Capital Suite 15

Wenbin Zhao
Renmin University of China
Peoples Rep of China

Abstract:
In this talk, we consider a special class of the contact discontinuity in the full compressible Euler equations, namely the entropy wave, where the velocity is continuous across the interface while the density and the entropy can have jumps. By deriving the evolution equation of the interface in the Eulerian coordinates, we relate the Taylor sign condition to the hyperbolicity of this evolution equation, which yields a stability condition for the entropy waves. With the optimal regularity estimates of the interface, we can derive the a priori estimates without loss of regularity.

Special Session 6 : Modeling and Data Analysis for Complex Systems and Dynamics

Introduction: Many dynamical systems, as examples from small scale neuronal systems and genomic systems in human, to large scale ecosystems of earth that impact climate change, are featured by nonlinear and complex patterns in spatial and temporal dimensions. These phenomena that are represented by massive amount of data, carry significant information and regulate downstream dynamics. Understanding the mechanisms underlying such events by quantitative modeling represents a mathematical challenge of current interest. Yet all these systems share the similar dynamical system issues in ordinary/partial different equation such as bifurcation, stability, oscillations, stochastic noise as well as issues in determining hidden model parameters from experimental data sets and computational errors of the models. This special session offers a forum to exchange the state of the art theoretical advances related to this promising area as well as computational tools. It will foster and encourage communication and interaction between researchers in these directions. The common themes include mathematical models and data analysis, theoretical analysis, computational and statistical methods of dynamical systems and differential equations for the bio-system focused models, as well as applications in brain research.

Global stability analysis of a novel epidemic model with separate compartments for symptomatic and asymptomatic cases

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Schedule: December 18 14:00-14:30 Capital Suite 14

Yerimbet Aitzhanov
SDU university
Kazakhstan

Co-Author(s): Shirali Kadyrov

Abstract:
This talk presents a novel epidemic model that incorporates both reported and unreported cases, distinguishing between symptomatic and asymptomatic individuals. The global stability of the model is demonstrated using a Lyapunov function, emphasizing the significant impact of asymptomatic cases on disease dynamics and control measures. The results of elasticity analysis also explores, revealing how this division influences the fundamental reproduction number. Additionally, sensitivity analysis is performed using Partial Rank Correlation Coefficient (PRCC) and Sobol indices to assess the influence of various parameters on the model`s compartments ($E, I_r, I_u, R$). The results reveal the critical roles of transmission rate ($\beta$), recovery rates ($\lambda_r, \lambda_u$), and immunity loss rate ($\alpha$) in shaping model dynamics. These findings provide insights into the primary drivers of the model`s behavior and underscore the importance of considering both symptomatic and asymptomatic cases in developing effective epidemic models and control strategies.

Dynamics of prey-predator network model with application to virus and immune response evolution

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Schedule: December 18 18:00-18:30 Capital Suite 14

Cameron Browne
University of Louisiana at Lafayette
USA

Abstract:
Recent work has sought to understand assembly and coexistence of interacting species in ecosystem models. However, the overwhelming number of species combinations and connecting the models to evolution have challenged researchers, especially in higher dimensional systems. Here, we aim to address this gap by looking through an evolutionary genetics lens in a prey-predator model of virus-immune dynamics, where viral variants can be represented by binary sequences which encode their resistance to immune responses. First, persistence and stability of equilibria are studied using Lyapunov functions and invasion analysis. Then, bifurcations between distinct ecological network structures are linked to epistasis (non-additivity) in the viral fitness landscape. Results are discussed in the context of HIV escape of host immune responses and, more generally, finding simplifying rules for prey-predator network evolution.

The seizure classification of focal epilepsy based on the network motif analysis

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Schedule: December 18 15:15-15:45 Capital Suite 14

Denggui Fan
University of Science and Technology Beijing
Peoples Rep of China

Abstract:
Due to the complexity of focal epilepsy and its risk for transiting to the generalized epilepsy, the development of reliable classification methods to accurately predict and classify focal and generalized seizures is critical for the clinical management of patients with epilepsy. In order to holistically understand the seizure propagation behavior of focal epilepsy, we propose a three-node motif reduced network by respectively simplifying the focal region, surrounding healthy region and their critical regions as the single node. Because three-node motif can richly characterize information evolutions, the motif analysis method could comprehensively investigate the seizure behavior of focal epilepsy. Firstly, we define a new seizure propagation marker value to capture the seizure onsets and intensity. Based on the three-node motif analysis, it is shown that the focal seizure and spreading can be categorized as inhibitory seizure, focal seizure, focal-critical seizure and generalized seizures, respectively. The four types of seizures correspond to specific modal types respectively, reflecting the strong correlation between seizure behavior and information flow evolution. In addition, it is found that the intensity difference of outflow and inflow information from the critical node (connection heterogeneity) and the excitability of the critical node significantly affected the distribution and transition of the four seizure types. In particular, the method of local linear stability analysis also verifies the effectiveness of four types of seizures classification. In sum, this paper computationally confirms the complex dynamic behavior of focal seizures, and the study of criticality is helpful to propose novel seizure control strategies.

Bistability in a Model of Hepatitis B Virus Dynamics

Schedule: December 18 17:30-18:00 Capital Suite 14

Hayriye Gulbudak
University of Louisiana at Lafayette
USA

Abstract:
Understanding the mechanisms responsible for different clinical outcomes following hepatitis B infection requires a systems investigation of dynamical interactions between the virus and the immune system. To help elucidate mechanisms of protection, we developed a deterministic mathematical model of hepatitis B infection that accounts for cytotoxic immune responses resulting in infected cell death, non- cytotoxic immune responses resulting in infected cell cure and protective immunity from reinfection, and cell proliferation. We analyzed the model and presented outcomes based on three important disease markers: the basic reproduction number R0, the infected cells death rate (describing the effect of cytotoxic immune responses), and the liver carrying capacity K (describing the liver susceptibility to infection). Using asymptotic and bifurcation analysis techniques, we determined regions where virus is cleared, virus persists, and where clearance-persistence is determined by the size of viral inoculum. These results can guide the development of personalized intervention.

Data Fitting in Fuzzy Epidemic Models Using Genetic Algorithms

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Schedule: December 18 13:00-13:30 Capital Suite 14

Shirali Kadyrov
New Uzbekistan University
Uzbekistan

Co-Author(s): Yerimbet Aitzhanov, Nurdaulet Shynarbek

Abstract:
The need for advanced modeling techniques in epidemiology has become increasingly evident. This presentation explores the integration of fuzzy set theory and genetic algorithms to enhance data fitting in fuzzy epidemic models. We focus on fuzzy epidemic models that accommodate uncertainties and population heterogeneity by treating epidemiological parameters as fuzzy variables. Our approach employs genetic algorithms for parameter estimation, enabling effective fitting of real-world epidemic data while addressing the complexities of disease transmission dynamics. The presentation highlights how genetic algorithms can refine model parameters and improve alignment between theoretical models and observed data.

Forecasting the Long-Term Trends of Tuberculosis Using the Time-series Analysis and Susceptible-Infectious-Recovered (SIR) Model

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Schedule: December 18 13:30-14:00 Capital Suite 14

Aigerim Kalizhanova
Nazarbayev University
Kazakhstan

Co-Author(s): Sauran Yerdessov, Yesbolat Sakko, Aigul Tursynbayeva, Shirali Kadyrov, Abduzhappar Gaipov, Ardak Kashkynbayev

Abstract:
Tuberculosis (TB) is a highly contagious disease that remains a global concern affecting numerous countries. Kazakhstan has been facing considerable challenges in TB control for decades. This talk explains TB dynamics by developing and comparing statistical and deterministic models: Seasonal Autoregressive Integrated Moving Average (SARIMA) and the basic Susceptible-Infected-Recovered (SIR). TB data from 2014 to 2019 were collected from the Unified National Electronic Health System (UNEHS) using retrospective quantitative analysis. SARIMA models were able to capture seasonal variations, with Model 2 exhibiting superior predictive accuracy. Both models showed declining TB incidence and revealed a notable predictive performance evaluated by statistical metrics. In addition, the SIR model calculated the basic reproduction number (R_0) below 1, indicating a receding epidemic. Models proved the capability of each to accurately capture trends (SARIMA) and provide mathematical insights (SIR) into TB dynamics. This talk contributes to the general knowledge of TB dynamics in Kazakhstan thus laying the foundation for more comprehensive studies on TB and control strategies.

Complex Systems on the Edge of Chaos: Temporal Precursors vs. Spatiotemporal Precursors

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Schedule: December 18 17:00-17:30 Capital Suite 14

Vasily Kornilov
Graduate School of Business, HSE University
Russia

Co-Author(s): Vasily Kornilov, Dmitry Mosharov, Andrey Dmitriev

Abstract:
Most complex systems, both natural and artificial, are capable of self-organization to the edge of a phase transition known as the edge of chaos. Examples of such systems include stock markets, online social networks, epidemic spread networks, and many others. The irreversible presence of a complex system on the edge of chaos is characterized by its avalanche-like behavior, which often leads to catastrophic consequences for the system. Therefore, early warning is very important for the system to approach the edge of chaos, which, with sufficient early warning time, will make it possible to take preventive measures to prevent the system from reaching the edge. Real-time early warning systems typically use temporal and/or spatiotemporal early warning measures of self-organization to the edge of chaos. Temporal measures are calculated in a sliding window of a time series corresponding to some dynamic variable, such as the number of reposts on an online social network. Such measures are computationally less complex and more accessible for calculations than spatiotemporal measures, the calculation of which requires information about the interactions between elements of the system in space and time. Recently, it has become increasingly common to hear the assertion that temporary measures are ineffective for the early warning. Moreover, some researchers claim that early warning using such measures is impossible. Therefore, we investigated the effectiveness of temporal and spatiotemporal measures associated with critical slowdown of a complex system as it approaches the edge of chaos. First, we introduce the concept of the effectiveness of an early warning measure in terms of the time of early warning and the number of false warning. Next, we calculate the spatiotemporal and corresponding temporal early warning measures associated with the critical slowdown of the sandpile cellular automaton as a system isomorphic to some real-world systems in the context of systems theory. Finally, we compare the effectiveness of the respective measures. We were able to establish that temporary measures are no less effective than the corresponding spatiotemporal measures.

Data-driven machine learning framework to predict dynamics of complex infectious disease models incorporating human behavior

Schedule: December 18 12:30-13:00 Capital Suite 14

PADMANABHAN SESHAIYER
George Mason University
USA

Abstract:
A complex system refers to a collection of interconnected elements or components that exhibit emergent behaviors and properties arising from their interactions. The COVID-19 pandemic, as an example of such a complex system, highlighted the significance of mathematical epidemiological modeling and data analysis in understanding disease dynamics. It also highlighted the importance of interdisciplinary collaborations integrating research on behavioral and/or social processes in mathematical epidemiological models with a goal to minimize unintended outcomes of public health interventions in response to pandemics. In this work we aim to enhance complex epidemiological models by integrating insights from social and behavioral sciences with data-driven predictive analytics. The proposed work will present a hybrid framework combining Agent-Based Modeling, Compartmental Models, and Physics-Informed Neural Networks applied to benchmark problems to efficiently conduct parameter estimation and data-driven decision-making.

Brain Complex Data Analytics To Identify Epileptic Activity Using EEG Source Localization Methods

Schedule: December 18 15:45-16:15 Capital Suite 14

Jianzhong Su
University of Texas at Arlington
USA

Co-Author(s): Julio Ensico-Elva, Talon Johnson

Abstract:
Data analytics plays an increasing role in brain research and medicine. The well-known Hodgkin-Huxley theory for neurons laid a foundation for computational neuroscience. However, understanding activities in the whole brain remains a focus of active research for this very complex system. Full brain Electroencephalography (EEG) and its source localization is a brain imaging modality based on multi-channel EEG signals. It measures the brain field potential fluctuations on the entire scalp for a period of time, and then we can compute the electric current density inside the brain by solving an inverse problem for an electric field equation on the 3-D brain finite element model. In this talk, we introduce computational methods for the EEG imaging problems, their validations through experimental data, and discuss its applications. One application is in identifying brain activity abnormalities and the sequence of excitation in brain anatomic areas during seizures of infant patients with Glucose Transporter Deficiency Syndrome. Our research shows the EEG data sets can be used to glean into the inner working of brain normal and pathological functions in specific brain areas using data analytic algorithms.

The Stability of Memory Storage in the Hippocampus

Schedule: December 18 14:45-15:15 Capital Suite 14

Honghui Zhang
Northwestern polytechnical university
Peoples Rep of China

Co-Author(s): Lei Yang, Zhongkui Sun

Abstract:
Based on the physiological mechanism underlying the hippocampus for memory storage, we have developed a CA3CA1 synaptic network memory model that elucidates the stored process of sensory information. Once information is stored in long-term memory, the model encodes it into trajectories within a stable heteroclinic network (SHN) in the phase space. Saddle points within the SHN represent the information blocks that information is divided into in the process of short-term memory. In this paper, memory strength and lifetime are introduced to measure the stability of memory storage in hippocampus. We track the storage process of initial memory, which is stored in distinct synaptic pattern, resulting in a durable memory engram. Subsequent memories are stored in either tracked or untracked synapses, which can cause decay and interference on the engram of the initial memory. We discussed the dynamics of AMPA receptors efficacy on tracked synapses based on the CA3CA1 synaptic network model. And estimated the decay effect of untracked synapses based on a synaptic plasticity discrete model. Numerical results indicate that the memory strength is dependent on the relative activation level of the PKA cascade within the postsynaptic neurons during encoding. This strength is further augmented during the consolidation process, which is induced by the decay effect. In the process of consolidation, the complexity of information and the number of synaptic inputs, as well as the excitatory-inhibitory balance, are important factors influencing the memory strength. The forgetting process for long-term memory is driven by the decay effect, and the memory information, efficiency, and various neurodegenerative diseases can alter the lifetime of initial memory by regulating the decay effect.

Dynamic analysis of beta oscillation in Parkinsonian neural networks with pedunculopntine nucleus under optogenetic control

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Schedule: December 18 16:15-16:45 Capital Suite 14

Yuzhi Zhao
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Yuzhi Zhao, Honghui Zhang, Ying Yu, Lin Du, Zichen Deng

Abstract:
Clinical experiments have proven that the pedunculopontine nucleus (PPN) plays a crucial role in the modulation of beta oscillations in Parkinson`s disease (PD). Here, we propose a new computational framework by introducing the PPN and related synaptic connections to the classic basal ganglia-thalamo-cortical (BGTC) model. Fascinatingly, the improved model can not only simulate the basic saturated and beta activities mentioned in previous studies but also produce the normal alpha rhythm that is much closer to physiological phenomena. Specifically, the results show that parkinsonian oscillation activities can be controlled and modulated by the connection strength between the PPN and the globus pallidus internal nucleus (GPi) and the subthalamic nucleus (STN), supporting the fact that PPN is overinhibited in PD. Meanwhile, the internal mechanism underlying these state transitions is further explained from the perspective of dynamics. Additionally, both deep brain stimulation (DBS) and optogenetic technology are considered effective in terms of abnormal oscillations. Especially when a low-frequency DBS is added to the PPN, beta oscillations can be suppressed, but it is excited again as the DBS`s frequency gradually increases to a larger value. These results coincide with the experimental results that low frequency stimulation of the PPN is effective, and verify the rationality of the model. Furthermore, we show that optogenetic stimulation of the globus pallidus external (GPe) expressing excitatory channelrhodopsin (ChR2) can effectively inhibit beta oscillations, whereas exciting the STN and PPN has a limited effect. These results are consistent with experimental reports suggesting that the symptoms of PD`s movement disorder can be alleviated under the GPe-ChR2, but not STN-ChR2, situation. Although the functional role of the PPN and the feasibility of optogenetic stimulation remain to be clinically explored, the results obtained help us understand the mechanisms of beta oscillations in PD.

Special Session 7 : Lie Symmetries, Conservation Laws, and Other Approaches in Solving Nonlinear Differential Equations

Introduction: This session is devoted to research areas that are related to nonlinear differential equations and their applications in science and engineering. The main focus of this special session is on the Lie symmetry analysis, conservation laws and their applications to ordinary and partial differential equations. Other approaches in finding exact solutions to nonlinear differential equations will also be discussed. This includes, but not limited to, asymptotic analysis methodologies, the simplest equation method, the multiple exp-function method, inverse scattering transform techniques, the upper-lower solutions method, the Hirota method, and others.

Distributed Position and Velocity Delay Effects in a Van der Pol System with Time-periodic Feedback

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Schedule: December 19 13:30-14:00 Conference Hall B (C)

Sudipto Roy Choudhury
University of Central Florida
USA

Co-Author(s): Ryan Roopnarain

Abstract:
The effects of a distributed delay on a parametrically forced Van der Pol limit cycle oscillator are considered. Delays modeling time lags due to a variety of factors in self-excited systems, have been considered earlier in the context of modification and control of limit cycle and quasiperiodic responses. Those studies are extended here to include the effects of periodically amplitude modulated {\it distributed} delays in both the position and velocity. A normal form or `slow flow` is employed to search for various bifurcations and transitions between regimes of different dynamics, including amplitude death and quasiperiodicity. The existence of quasiperiodic solutions then motivates the derivation of a second slow flow. A detailed comparison of the results and predictions from the second slow flow to numerical solutions is made. The second slow flow is also employed to approximate the amplitudes of the quasiperiodic solutions, yielding close agreement with the numerical results on the original system. Finally, the effect of varying the delay parameter is briefly considered, and the results and conclusions are summarized.

A study of a generalized nonlinear (3+1)-D breaking soliton equation

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Schedule: December 19 14:00-14:30 Conference Hall B (C)

Chaudry Masood Khalique
North-West University, Mafikeng Campus
So Africa

Abstract:
Higher-order nonlinear wave models have recently attracted significant interest from researchers due to their importance in mathematical physics, various nonlinear sciences, and engineering applications. In this talk, we present analytical studies focused on a generalized form of a nonlinear breaking soliton equation with higher-order nonlinearity, highlighting its relevance to both science and engineering. We employ Lie group theory and derive a Lie algebra associated with the equation. This approach also facilitates reductions of various subalgebras related to the model. Additionally, we use direct integration techniques to obtain an analytic solution. Furthermore, we apply the simplest equation technique to uncover additional general solutions. Finally, we compute the conserved quantities associated with the equation using the well-known Noether theorem.

Nonlocal integrability and solitons

Schedule: December 19 13:00-13:30 Conference Hall B (C)

Wen-Xiu Ma
University of South Florida
USA

Abstract:
We will explore integrable models involving involution points. Classical Lax pairs are employed to derive nonlocal integrable models and their associated Riemann-Hilbert problems. Soliton solutions are obtained through reflectionless Riemann-Hilbert problems. Novel solution phenomena will also be discussed within the nonlocal framework.

Capillary rise in partially saturated rigid porous media

Schedule:

Javed I Siddique
Penn State York
USA

Co-Author(s): Javed I Siddique and Daniel M. Anderson

Abstract:

\begin{abstract} We explore predictions of two models of one-dimensional capillary rise in rigid and partially saturated porous media. One is an existing one from the literature and the second is a free-boundary model based on Richards` equation with two moving boundaries of the evolving partially saturated region. Both models involve the specification of saturation-dependent functions for local capillary pressure and permeability and connect to classical models for saturated porous media. Existing capillary-rise experiments show two notable regimes: (1) an early time regime typically well-described by classical capillary-rise theory in a fully saturated porous media, and (2) a long-time regime that has anomalous dynamics in which the capillary-rise height may scale with a non-classical power law in time or have more complicated dynamics. We demonstrate that the predictions of both models compare well with experimental capillary-rise data over early- and long-time regimes gathered from three independent studies in the literature. The model predictions also shed light on recent scaling laws that relate the capillary pressure and permeability of the partially saturated media to the capillary-rise height. We use these models to probe computationally observed permeability relationships to capillary-rise height. We demonstrate that a recently proposed permeability scaling for the anomalous capillary-rise regime is indeed realized and is particularly apparent in the lower portion of the partially saturated media. For our free-boundary model we also compute capillary pressure measures and show that these reveal the linear relation between the capillary pressure and capillary rise height expected for a capillarity/gravity balance in the upper portion of the partially saturated porous media. \end{abstract}

Special Session 8 : Recent Progress on Mathematical Analysis of PDEs Arising in Fluid Dynamics

Introduction: This special session aims to bring together researchers to present their recent results in partial differential equations arising in fluid dynamics. In particular it focuses on existence and uniqueness, long-time behaviors, stability and instability, free boundary problems, etc for Navier-Stokes equations (single-phase flow), two-phase model and related physical models. Some challenging open problems in these interesting fields are expected to emphasize in this section.

Optimal decay rates of compressible Navier-Stokes equations and the related model

Schedule: December 17 17:00-17:30 Capital Suite 2

Guangyi HONG
South China University of Technology
Peoples Rep of China

Co-Author(s): Changjiang Zhu

Abstract:
In this talk, we will introduce our recent results on the large-time behaviors of solutions to the one-dimensional compressible Navier-Stokes equations and the related compressible two-phase model with free boundaries. Specifically, for both the case of constant viscosity and the case of degenerate viscosity, we prove the decay estimates for the solutions of the models in the vacuum free boundary setting. In particular, we derive the optimal pointwise decay estimates of the density function and the mass function for the compressible Navier-Stokes equations and the two-phase model, respectively. This talk is mainly based on some joint work with Prof. Changjiang Zhu.

Some recent progress on mathematical analysis of nematic liquid crystals

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Schedule: December 17 16:15-16:45 Capital Suite 2

Jinrui Huang
Wuyi University
Peoples Rep of China

Abstract:
In this talk, we will present some results on mathematical analysis of nematic liquid crystals in recent years, mainly about the unique continuation, orientability and singular limit for the Q-tensor system, and Freedericksz Transition for the Ericksen-Leslie system. This talk is based on the joint works with Shijin Ding and Junyu Lin.

Nonlinear stability of traveling waves to a parabolic-hyperbolic system modeling chemotaxis with periodic perturbations

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Schedule: December 17 14:45-15:15 Capital Suite 2

Haiyang Jin
South China University of Technology
Peoples Rep of China

Co-Author(s): Feifei Zou

Abstract:
We prove the nonlinear stability of large-amplitude traveling waves under space-periodic perturbations to a parabolic-hyperbolic system derived from a singular chemotaxis model describing the initiation of tumor angiogenesis. Compared with the previous results, we are able to prove the nonlinear stability of traveling waves even though the perturbation oscillates at the far fields.

Existence of solutions to Dirichlet boundary value problems of the relativistic Boltzmann equation

Schedule: December 17 13:00-13:30 Capital Suite 2

Li Li
Ningbo University
Peoples Rep of China

Co-Author(s): Yi Wang, Zaihong Jiang

Abstract:
We study the boundary value problem of the steady-state relativistic Boltzmann equation in the half-space, assigning the Dirichlet data for outgoing particles at the boundary and a Maxwellian at the far field, under the hard potential model. It is proved that the solvability condition varies with the Mach number of the problem.

Stability of hyperbolic wave for the viscous vasculogenesis model

Schedule: December 17 15:15-15:45 Capital Suite 2

Qingqing Liu
South China University of Technology
Peoples Rep of China

Co-Author(s): Xiaoli Wu, Qian Yan, Wenwen Fu

Abstract:
Experiments of in vitro vasculogenesis show that endothelial cells randomly distributed on the gel matrix will organize themselves into a connected capillary network. As a kind of taxis, this network aggregation phenomenon of endothelial cells can not be simulated by the classical Keller-Segel model. The viscous vasculogenesis model proposed by the biologist Gamba et al. can model the experimental phenomenon very well. This talk will present a series of studies on the existence and long-time behavior of the solution for viscous vasculogenesis model, including: the stability of rarefaction wave for the Cauchy problem of the one-dimensional viscous vasculogenesis model, the stability of rarefaction wave and the boundary layer for the initial boundary value problem of the one-dimensional viscous vasculogenesis model over $\mathbb{R}^1_+$, and the stability of planar staionary solution for the initial boundary value problem of the three-dimensional viscous vasculogenesis model over $\mathbb{R}^3_+$.

Recent progress on the 3D kinetic shear flow via the Boltzmann equation in the diffusive limit

Schedule: December 17 12:30-13:00 Capital Suite 2

Shuangqian Liu
Central China Normal University
Peoples Rep of China

Abstract:
In this talk, I will present our recent study on the Boltzmann equation in the diffusive limit for 3D kinetic shear flow. Our results show that the first-order approximation of the solutions is governed by the perturbed incompressible Navier-Stokes-Fourier system around the fluid shear flow. The proof is based on: (i) applying the Fourier transform on $\T^2$ to effectively reduce the 3D problem to a one-dimensional one; (ii) using anisotropic Chemin-Lerner type function spaces, incorporating the Wiener algebra, to control nonlinear terms and address the singularities arising from the small Knudsen number in the diffusive limit; and (iii) employing Caflisch`s decomposition, together with the $L^2 \cap L^\infty$ interplay technique, to manage the growth of large velocities.

The Cauchy problem for an inviscid Oldroyd-B model in three dimensions: global well posedness and optimal decay rates

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Schedule: December 17 18:30-19:00 Capital Suite 2

Sili Liu
Changsha University of Science and Technology
Peoples Rep of China

Co-Author(s): Wenjun Wang; Huanyao Wen.

Abstract:
In this talk I will introduce our recent work on the Cauchy problem for an inviscid compressible Oldroyd-B model in three dimensions. The global well posedness of strong solutions and the associated time-decay estimates in Sobolev spaces are established near an equilibrium state. The vanishing of viscosity is the main challenge compared with [Wang-Wen, Sci.China Math., 2021] where the viscosity coefficients are included and the decay rates for the highest-order derivatives of the solutions seem not optimal. One of the main objectives of this paper is to develop some new dissipative estimates such that the smallness of the initial data and decay rates are independent of the viscosity. Moreover, we prove that the decay rates for the highest-order derivatives of the solutions are optimal, which is of independent interest. Our proof relies on Fourier theory and delicate energy method. This talk is based on joint works with Prof. Wenjun Wang and Prof. Huanyao Wen.

On a hyperbolic-parabolic chemotaxis system

Schedule: December 17 15:45-16:15 Capital Suite 2

Hongyun Peng
Guangdong University of Technology
Peoples Rep of China

Co-Author(s): Kun Zhao

Abstract:
Stability of steady state solutions associated with initial and boundary value problems of a coupled fluid-reaction-diffusion system in one space dimension is analyzed. It is shown that under Dirichlet-Dirichlet type boundary conditions, non-trivial steady state solutions exist and are locally stable when the system parameters satisfy certain constraints.

Some recent progress on blowup criteria for compressible Navier-Stokes equations

Schedule: December 17 19:00-19:30 Capital Suite 2

Huanyao Wen
South China University of Technology
Peoples Rep of China

Co-Author(s): Eduard Feireisl and Changjiang Zhu

Abstract:
In this talk, we will introduce some recent progress on blowup criteria in terms of concentration of density and absolute temperature for viscous, compressible, and heat-conducting flow with vaccum.

Nonlinear stability of viscous contact wave for the isentropic MHD equations with free boundary

Schedule: December 17 17:30-18:00 Capital Suite 2

Huancheng Yao
South China Agricultural University
Peoples Rep of China

Co-Author(s): Changjiang Zhu

Abstract:
In this talk, we will introduce our recent results on the nonlinear stability of viscous contact wave for the isentropic compressible magnetohydrodynamics (MHD) equations with a free boundary. It is shown that when time tends to infinity, the fluid part of solutions will asymptotically converge to the viscous contact waves, and more importantly, the magnetic field will converge to a nontrivial wave pattern. This wave phenomenon is different from those of isentropic compressible Navier-Stokes equations, which means the magnetic field truly makes an essential effect on the fluid behavior. The main result is proved by using elaborate wave pattern analysis and elementary energy methods, provided the initial perturbations and wave strength are suitably small.

Initial boundary value problem for 3D non--conservative compressible two--fluid model

Schedule: December 17 13:30-14:00 Capital Suite 2

Lei Yao
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Guochun Wu; Lei Yao; Yinghui Zhang;

Abstract:
We study the initial boundary value problem of the 3D non--conservative compressible two--fluid model with common pressure (P^+=P^-) in a bounded domain with no--slip boundary conditions. The global existence and uniqueness of classical solution are established when the initial data is near its equilibrium in H^4(\Omega) by delicate energy methods. By a product, the exponential convergence rates of the pressure and velocities in H^3(\Omega) are obtained. To overcome the difficulties arising from boundary effects, on the one hand, we separate the energy estimates for the spatial derivatives into that over the region away from the boundary and near the boundary by using cutoff functions and localizations of \Omega. On the other hand, by exploiting the dissipation structure of the system, we employ regularity theory of the stationary Stokes equations and elliptic equations to get higher--order spatial derivatives of pressure and velocities, which is very different from the Cauchy problem in [Wu--Yao--Zhang, Math. Ann., 2024] where the effective viscous flux played an important role in their analysis.

Vanishing shear viscosity limit for the compressible planar MHD system with boundary layer

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Schedule: December 17 18:00-18:30 Capital Suite 2

Xinhua Zhao
Guangdong Polytechnic Normal University
Peoples Rep of China

Co-Author(s): Huanyao Wen

Abstract:
This paper is devoted to the study of the vanishing shear viscosity limit and strong boundary layer problem for the compressible, viscous, and heat-conducting planar MHD equations. The main aim is to obtain a sharp convergence rate which is usually connected to the boundary layer thickness. However, The convergence rate would be possibly slowed down due to the presence of the strong boundary layer effect and the interactions among the magnetic field, temperature, and fluids through not only the velocity equations but also the strongly nonlinear terms in the temperature equation. Our main strategy is to construct some new functions via asymptotic matching method which can cancel some quantities decaying in a lower speed. It leads to a sharp L^∞ convergence rate as the shear viscosity vanishes for global-in-time solution with arbitrarily large initial data.

Stability threshold of Couette flow for the 3D MHD equations

Schedule: December 17 14:00-14:30 Capital Suite 2

Ruizhao Zi
Central China Normal University
Peoples Rep of China

Abstract:
In this talk, we consider the stability of 3D Couette flow $(y,0,0)^\top$ in a uniform background magnetic field $\al(\sig,0,1)^\top$. It is shown that if the background magnetic field $\al(\sig,0,1)^\top$ with $\sig\in\mathbb{R}\backslash\mathbb{Q}$ satisfying a generic Diophantine condition is so strong that $|\al|\gg\fr{\nu+\mu}{\sqrt{\nu\mu}}$, and the initial perturbations $u_{\rm in}$ and $b_{\rm in}$ satisfy $\|(u_{\rm in},b_{\rm in})\|_{H^{N+2}}\ll\min\{\nu,\mu\}$ for sufficiently large N, then the resulting solution remains close to the steady state in L^2 at the same order for all time. Compared with the result of Liss [Comm. Math. Phys., 377(2020), 859--908], we use a more general energy method to address the physically relevant case $\nu\neq\mu$ based on some new observations. This is based on a joint work with Yulin Rao and Zhifei Zhang.

Special Session 9 : Recent Progress in Mathematical Theory of Stability and Instability in Fluid Dynamics

Introduction: Fluid dynamics stability and instability remain at the forefront of mathematical exploration. This session is dedicated to unveiling the latest mathematical advancements that underpin our understanding of fluid flow stability. The session will feature presentations that delve deep into mathematical techniques, models, and methodologies relevant to understanding fluid flow stability. Topics covered will include the (in)stability problems in fluid equations such as the stability of shear flows and point vortex. We want to bring together well-known experts and young researchers to present new developments in partial differential equations (PDEs) related to the stability of fluids.

The long way of a viscous vortex dipole

Schedule: December 16 15:45-16:15 Capital Suite 21 A

Michele Dolce
EPFL
Switzerland

Co-Author(s): Thierry Gallay

Abstract:
The Helmholtz Kirchhoff system governs the evolution of two counter rotating point vortices in a 2D inviscid fluid, resulting in constant translation at a constant speed. However, at large but finite Reynolds numbers, the size of the vortex cores grows because of diffusion. This means that the point vortex approximation is not valid over long times for the resulting viscous dipole. This talk aims to systematically define an asymptotic expansion accounting for streamlines deformation from vortex interactions and to understand the finite size effects on the dipole`s translation speed. We then prove that the exact solution remains close to our approximation over a very long time interval, extending unboundedly as the Reynolds number approaches infinity. The proof relies on energy estimates inspired by Arnold`s variational characterization of the steady states of the 2D Euler equation, as recently revised by Gallay and Sverak for viscous fluids. This work is a collaboration with T. Gallay.

Traveling waves near shear flows for 2D Euler

Schedule: December 16 17:00-17:30 Capital Suite 21 A

Daniel Lear
Universidad de Cantabria
Spain

Co-Author(s): Angel Castro

Abstract:
In this talk we will consider the existence of traveling waves arbitrarily close to shear flows for the 2D incompressible Euler equations. In particular we shall present some results concerning the existence of such solutions near the Couete, Taylor-Couete and the Poiseuille flows. In the first part of the talk we will introduce the problem and review some well known results on this topic. In the second one some of the ideas behind the construction of our traveling waves will be sketched.

Viscosity driven instability of shear flows without boundaries

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Schedule: December 16 18:00-18:30 Capital Suite 21 A

Hui Li
New York University Abu Dhabi
United Arab Emirates

Co-Author(s): Hui Li and Weiren Zhao

Abstract:
In this talk, we discuss the instability caused by viscous dissipation in a domain without boundaries. We construct a shear flow that is initially spectrally stable but evolves into a spectrally unstable state due to the influence of viscous dissipation.

Nonlinear Inviscid damping for 2-D inhomogeneous incompressible Euler equations

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Schedule: December 16 14:45-15:15 Capital Suite 21 A

Chen Qi
Zhejiang University School of mathematical sciences
Peoples Rep of China

Co-Author(s): Dongyi Wei, Ping Zhang, Zhifei Zhang

Abstract:
We prove the asymptotic stability of shear flows close to the Couette flow for the 2-D inhomogeneous incompressible Euler equations on TxR. More precisely, if the initial velocity is close to the Couette flow and the initial density is close to a positive constant in the Gevrey class 2, then 2-D inhomogeneous incompressible Euler equations are globally well-posed and the velocity converges strongly to a shear flow close to the Couette flow, and the vorticity will be driven to small scales by a linear evolution and weakly converges as t tends to infinity.

THE TRANSITION TO INSTABILITY FOR STABLE SHEAR FLOWS IN INVISCID FLUIDS

Schedule: December 16 17:30-18:00 Capital Suite 21 A

Daniel Sinambela
NYUAD
United Arab Emirates

Co-Author(s): Weiren Zhao

Abstract:
This talk focuses on the generation of eigenvalues of a stable monotonic shear flow under perturbations in C^s with $s

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Small-amplitude finite-depth Stokes waves are transversally unstable

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Schedule: December 16 19:00-19:30 Capital Suite 21 A

Zhao Yang
Academy of Mathematics and Systems Science
Peoples Rep of China

Co-Author(s): Ziang Jiao, L. Miguel Rodrigues, Changzhen Sun, Zhao Yang

Abstract:
We prove that all irrotational planar periodic traveling waves of sufficiently small-amplitude are spectrally unstable as solutions to three-dimensional inviscid finite-depth gravity water-waves equations.

Asymptotic stability of Couette flow for the Stokes-transport equations

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Schedule: December 16 18:30-19:00 Capital Suite 21 A

Ruizhao Zi
Central China Normal University
Peoples Rep of China

Abstract:
In this talk, we investigate the asymptotic stability of the three-dimensional Couette flow in a stratified fluid governed by the Stokes-transport equation. We observe that a similar lift-up effect to the three-dimensional Navier-Stokes equation near Couette flow destabilizes the system, while the inviscid damping type decay due to the Couette flow (Y,0,0) together with the damping structure caused by the decreasing background density $\varrho_{\rm S}(Y)$ stabilizes the system. This is based on a joint work with Weiren Zhao and Daniel Sinambela.

On Resonances in Dissipative Magnetohydrodynamics

Schedule: December 16 15:15-15:45 Capital Suite 21 A

Christian Zillinger
Karlsruhe Institute of Technology
Germany

Co-Author(s): Niklas Knobel

Abstract:
We consider the stability and long time behavior of the inviscid magnetohydrodynamics equations with magnetic dissipation near a combination of a shear flow and a constant magnetic field. While the linearized equations around this stationary solution are stable in Sobolev regularity, we show that in any small analytic neighborhood there exist non-trivial low frequency solutions of the nonlinear problem, which are unstable. More precisely, we show that the critical regularity of the corresponding linearized problem is given by a Gevrey class. This talk is based on joint work with Niklas Knobel.

Special Session 10 : Analysis of diffuse and sharp interface models

Introduction: Numerous significant real-world phenomena are characterized by the evolution of interfaces separating distinct chemical species, such as the behavior of multi-phase fluids, intracellular phase separation, tumor growth dynamics, image reconstruction (inpainting), and self-assembly processes in diblock copolymers. The classical description of moving interfaces is called Sharp Interface (SI) theory. The interface separating the phase boundary is assumed to be an evolving in time surface with zero thickness. This formulation leads to free-boundary problems. A more recent approach instead treats the interface as a narrow region with finite thickness. This is the so-called Diffuse Interface (DI) theory. In the latter case, the evolution of the interface is described as the level set of the fluid concentration (called phase-field), which is uniform in bulk phases and varies steeply but continuously across the interface. Over the past few decades, there has been remarkable activity in both the theoretical analysis and numerical simulations of SI and DI models. This session aims to spotlight recent advancements in these fields and possibly related free boundary problems, providing a platform for experts in the field and emerging researchers to share their cutting-edge techniques, innovative perspectives, and future goals.

Phase-Field Approaches for Shape Reconstruction in Elastic Inverse Problems

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Schedule: December 18 18:00-18:30 Conference Hall B (A)

Andrea Aspri
University of Milan
Italy

Co-Author(s): Elena Beretta, Cecilia Cavaterra, Elisabetta Rocca, Marco Verani

Abstract:
In this talk, I will discuss recent advances in solving elastic inverse problems, specifically focusing on the shape reconstruction of cavities and inclusions in a bounded linear isotropic medium using boundary measurements. Our approach leverages optimal control theory, reformulating the inverse problem as a minimization process. The objective is to minimize a misfit boundary functional or an energy-type functional, within the class of Lipschitz domains. To enhance the accuracy of the reconstruction, we introduce a regularization term that penalizes the perimeter of the cavity or inclusion being reconstructed. The optimization problem is tackled using a phase-field method, where the perimeter functional is approximated via the Modica-Mortola relaxation.

Existence and continuity of inertial manifolds for singularly perturbed conserved phase-field systems

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Schedule: December 18 15:45-16:15 Conference Hall B (A)

Ahmed Bonfoh
KFUPM
Saudi Arabia

Abstract:
We will prove that the solution semigroup generated by the singularly perturbed conserved phase-field system admits an inertial manifold of dimension independent of the perturbation parameter (the heat capacity). Moreover, we will show the convergence of the intersection of the inertial manifold with an absorbing set as the heat capacity tends to zero. This work was recently proven by the speaker in [Evol. Equ. and Control Theory, 11 no.4 (2022),1399-1454].

An optimal distributed control problem for a Cahn-Hilliard-Darcy system

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Schedule: December 18 8:00-8:30 Conference Hall B (A)

Cecilia Cavaterra
University of Milan
Italy

Co-Author(s): M. Abatangelo, M. Grasselli, H. Wu

Abstract:
We consider a Cahn-Hilliard-Darcy system with mass sources, equipped with an impermeability condition for the (volume) averaged velocity as well as homogeneous Neumann boundary conditions for the phase field and the chemical potential. The source term in the convective Cahn-Hilliard equation contains a control R that can be thought, for instance, as a drug or a nutrient in applications to solid tumor growth evolution. We present some recent results obtained in collaboration with M. Abatangelo, M. Grasselli, and H. Wu on a distributed optimal control problem in the two dimensional setting with a cost functional of tracking-type. These results have been achieved In the physically relevant case, that is, assuming unmatched viscosities for the binary fluid mixtures and considering a Flory-Huggins type potential. In particular, we show that a second-order sufficient condition for the strict local optimality can also be proven.

A Cahn-Hilliard-Navier-Stokes model for tumor growth

Schedule: December 18 17:30-18:00 Conference Hall B (A)

Charles Elbar
Sorbonne Universite
France

Co-Author(s): Alexandre Poulain

Abstract:
I will discuss a compressible Navier-Stokes Cahn-Hilliard model. The model, intended to describe tumor growth takes into possible non-matching densities and contrasts in mechanical properties (viscosity, friction) between the two phases of the fluid. It also comprises a term to account for possible exchange of mass between the two phases. I will give an idea of the scheme to prove the existence of weak solutions. Also, I will show a structure preserving numerical scheme and present some numerical simulations validating the properties of the numerical scheme and the behavior of the model.

Droplet models with singular potentials: equilibria and travelling waves

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Schedule: December 18 14:45-15:15 Conference Hall B (A)

Lorenzo Giacomelli
Sapienza University of Rome
Italy

Abstract:
We look at spreading phenomena under the action of singular potentials modeling repulsion between the liquid/gas interface and the substrate. First we briefly review the statics: depending on the form of the potential, the macroscopic profile of minimizers (when they exist) can be either droplet-like or pancake-like, with a transition profile between the two at zero spreading coefficient. Then we focus on the dynamics, assuming null slippage at the contact line. Based on formal arguments and numerical evidences, we report that travelling-wave solutions generically exist and have finite rate of bulk dissipation, indicating that singular potentials stand as an alternative solution to the contact-line paradox. In agreement with steady states, travelling-wave solutions have finite energy for mild singularities. Time permitting, we also discuss a selection criterion for travelling waves, based on thermodynamically consistent contact-line conditions modeling friction at the contact line. Based on joint works with Riccardo Durastanti (Universiy of Naples Federico II).

On a Navier-Stokes-Cahn-Hilliard system with chemotaxis, active transport and reaction

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Schedule: December 18 9:00-9:30 Conference Hall B (A)

Jingning He
Hangzhou Normal University
Peoples Rep of China

Co-Author(s): Hao Wu

Abstract:
In this talk, we discuss a Navier--Stokes--Cahn--Hilliard model for viscous incompressible two-phase flows where the mechanisms of chemotaxis, active transport and reaction are taken into account. The evolution system couples the Navier--Stokes equations for the volume-averaged fluid velocity, a convective Cahn--Hilliard equation for the phase-field variable, and an advection-diffusion equation for the density of certain chemical substance. This system is thermodynamically consistent and generalizes the well-known ``Model H`` for viscous incompressible binary fluids. For the initial-boundary value problem with a physically relevant singular potential in a three dimensional bounded smooth domain, we first prove the existence and uniqueness of a local strong solution. When the initial velocity is small and the initial phase-field function as well as the initial chemical density are small perturbations of a local minimizer of the free energy, we establish the existence of a unique global strong solution. Afterwards, we show the uniqueness of asymptotic limit for any global strong solution as time goes to infinity and provide an estimate on the convergence rate.

Two-phase flows through porous media: A Cahn-Hilliard-Brinkman model with dynamic boundary conditions

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Schedule: December 18 13:30-14:00 Conference Hall B (A)

Patrik Knopf
University of Regensburg
Germany

Co-Author(s): Pierluigi Colli, Andrea Signori, Giulio Schimperna

Abstract:
We consider a new diffuse-interface model that describes creeping two-phase flows (i.e., flows exhibiting a low Reynolds number), especially flows that permeate a porous medium. The system of equations consists of a Brinkman equation for the volume averaged velocity field as well as a convective Cahn-Hilliard equation with dynamic boundary conditions for the phase-field, which describes the location of the two fluids within the domain. The dynamic boundary conditions are incorporated to model the interaction of the fluids with the wall of the container more precisely. In particular, they allow for a dynamic evolution of the contact angle between the interface separating the fluids and the boundary, and also for a convection-induced motion of the corresponding contact line. In this talk, modeling aspects as well as analytical results will be discussed.

Navier-Stokes equations with dynamic boundary conditions and related problems

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Schedule: December 18 13:00-13:30 Conference Hall B (A)

Dalibor Prazak
Charles University, Prague
Czech Rep

Co-Author(s): B. Priyasad, M. Zelina

Abstract:
We consider the evolutionary Stokes system subject to the so-called dynamic boundary condition

$$\beta\partial_t u + \alpha u + \nu[(Du)n]_\tau = h \qquad \text{on } \partial\Omega$$

where Du is the symmetric velocity gradient, n is outer normal, and subscript τ denotes the tangential projection relative to $\partial\Omega$. \par Our first aim is to establish the basic L^p theory, including the existence of an analytic semigroup and optimal $W^{k,p}$ estimates for $k = 1$ and 2. \par These results are then applied to related nonlinear systems: Navier-Stokes and Cahn-Hilliard Navier-Stokes equations.

The random separation property for stochastic phase-field models

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Schedule: December 18 8:30-9:00 Conference Hall B (A)

Luca Scarpa
Politecnico di Milano
Italy

Co-Author(s): Federico Bertacco, Carlo Orrieri

Abstract:
We introduce the concept of random separation property for stochastic phase-field models with singular potential. This consists in showing that almost every trajectory of the stochastic flow, with probability one, is detached from the potential barriers: the separation threshold depends on the trajectory itself and identifies thus a random variable. We illustrate the idea of the proof in the case of the stochastic Allen-Cahn equation, as well as qualitative properties of the random separation layer. Eventually, possible developments on the stochastic Cahn-Hilliard equation are also discussed. The works presented in the talk are based on joint collaborations with Federico Bertacco (Imperial College London) and Carlo Orrieri (University of Pavia).

On a Cahn-Hilliard-Brinkman-chemotaxis model with nonlinear sensitivity

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Schedule: December 18 17:00-17:30 Conference Hall B (A)

Giulio Schimperna
University of Pavia
Italy

Abstract:
We will present some mathematical results for a new model coupling the Cahn-Hilllard-Brinkman system with an evolutionary equation describing the active (chemotactic) transport of a chemical species influencing the phase separation process. Specifically, the model may arise in connection with tumor growth processes; mathematically speaking, it may be interesting in itself as it provides a new coupling between a Keller-Segel-like relation (the equation describing the evolution of the concentration of the chemical substance) and a fourth order (rather than a second order as in most models for chemotaxis) evolutionary system. Our main result will be devoted to proving existence of weak solution in the case when the chemotaxis sensitivity function has a controlled growth at infinity; a particular emphasis will be given to discussing the occurrence of critical exponents and to presenting a regularization scheme compatible with the a-priori estimates.

Active droplet formation in Cahn-Hilliard models with chemical reactions

Schedule: December 18 9:30-10:00 Conference Hall B (A)

Andrea Signori
Politecnico di Milano
Italy

Abstract:
This presentation examines a Cahn-Hilliard model incorporating chemical reactions that facilitate active droplet formation while suppressing Ostwald ripening. We establish the model`s well-posedness and connect the diffuse interface model to a sharp interface model of Mullins-Sekerka type using matched asymptotic expansions. Our stability analysis demonstrates the coexistence of stable and unstable stationary solutions under specific conditions. Additionally, we utilize finite element computations to validate our results and illustrate various splitting scenarios.

The convergence of a nonlocal to a local anisotropic Cahn-Hilliard equation

Schedule: December 18 15:15-15:45 Conference Hall B (A)

Yutaka Terasawa
Nagoya University
Japan

Co-Author(s): Helmut Abels

Abstract:
We consider a nonlocal Cahn-Hilliard equation with singular or regular kernel, where the kernel is symmetric and non-radial. We get the existence of a weak solution of the equation using the Moreau regularization of the potential and an implicit time discretization. We then prove convergence of suitable sequence of weak solutions of the equation to weak solutions of a local anisotropic Cahn-Hilliard equation. This talk is based on a joint work with Professor Helmut Abels (Regensburg Univ.).

Variational approach to pure traction and Signorini problem between linear and finite elasticity

Schedule: December 18 12:30-13:00 Conference Hall B (A)

Franco TOMARELLI
Politecnico di Milano
Italy

Co-Author(s): Francesco Maddalena (Politecnico di Bari) and Danilo Percivale (Universita` degli Studi di Genova)

Abstract:
An energy functional for the obstacle problem in linear elasticity is obtained as a variational limit of nonlinear elastic energy functionals describing a material body subject to pure traction load under a unilateral constraint representing the rigid obstacle. There exist loads pushing the body against the obstacle, but unfit for the geometry of the whole system body-obstacle, so that the corresponding variational limit turns out to be different from the classical Signorini problem in linear elasticity. However, if the force field acting on the body fulfills an appropriate geometric admissibility condition, we can show coincidence of minima. The analysis developed here provides a rigorous variational justification of the Signorini problem in linear elasticity, together with an accurate analysis of the unilateral constraint.

Special Session 11 : Eigenvalue problems in reaction-diffusion equations and applications

Introduction: This session is concerned with the theory and applications of eigenvalue problems arising from studies of reaction-diffusion equations. The specific topics include theoretical analysis of the principal eigenvalues and its applications in ecology, epidemiology, evolution and related fields. The aim of the session is to disseminate new research results, exchange ideas, and find interesting open problems.

Asymptotic behavior of the principal eigenvalue for cooperative periodic-parabolic systems and applications

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Schedule: December 17 13:30-14:00 Capital Suite 21 A

Xueli Bai
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Xiaoqing He

Abstract:
The effects of spatial heterogeneity on population dynamics have been studied extensively. However, the effects of temporal periodicity on the dynamics of general periodic-parabolic reaction-diffusion systems remain largely unexplored. As a first attempt to understand such effects, we analyze the asymptotic behavior of the principal eigenvalue for linear cooperative periodic-parabolic systems with small diffusion rates. As an application, we show that if a cooperative system of periodic ordinary differential equations has a unique positive periodic solution which is globally asymptotically stable, then the corresponding reaction⊠diffusion system with either the Neumann or regular oblique derivative boundary condition also has a unique positive periodic solution which is globally asymptotically stable, provided that the diffusion coefficients are sufficiently small. The role of temporal periodicity, spatial heterogeneity and their combined effects with diffusion will be studied in subsequent papers for further understanding and illustration.

A scattering theory on hyperbolic spaces

Schedule: December 17 15:15-15:45 Capital Suite 21 A

Lu Chen
Beijing Institute of Technology
Peoples Rep of China

Abstract:
In this talk, we introduce a theoretical framework for scattering theory on hyperbolic spaces. We give the accurate characterization of the asymptotic behavior of the Green functions and use them to establish the ingoing and outgoing radiation conditions. Finally, we also discuss a hyperbolic Rellich lemma.

Investigating receptor-based models with hysteresis

Schedule: December 17 16:15-16:45 Capital Suite 21 A

Lingling Hou
College of Mathematics and System Science Xinjiang University
Peoples Rep of China

Co-Author(s): Izumi Takagi

Abstract:
In this presentation, we delve into the existence of traveling wave solutions within a coupled system comprising a reaction-diffusion ordinary differential equation and a trio of additional ordinary differential equations. We apply geometric singular perturbation theory to establish the presence of these traveling wave solutions. Following this, we employ the contraction mapping principle to affirm the uniqueness of the wave speed. To substantiate our theoretical findings, we conclude with numerical simulations for a particular model that aligns with our theoretical assumptions, thereby validating our results.

The global dynamics of an age-structured model with spatial structure

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Schedule: December 17 18:00-18:30 Capital Suite 21 A

Hao Kang
Tianjin University
Peoples Rep of China

Co-Author(s): Hao Kang, Rui Peng and Maolin Zhou

Abstract:
In this paper we investigate the global dynamics of an age-structured model with spatial structure including random diffusion and advection, and with a monotone nonlinearity in the birth rate. The existence, uniqueness and global stability of a positive equilibrium are given briefly via the theory of monotone dynamical systems. More interesting, we obtain the asymptotic behavior of principal eigenvalue and asymptotic profiles of the equilibrium under the large advection, small diffusion and large diffusion, respectively, which are new compared with the previous work on the diffusive age-structured models. Our tool is the principal spectral theory of linear age-structured operators with diffusion and advection. The proofs are based on the construction of new super-/sub-solutions to solve the issue of the nonlocal birth term which is specific in age-structured models.

Systems of parabolic equations with delays: Continuous dependence on parameters

Schedule: December 17 12:30-13:00 Capital Suite 21 A

Marek Kryspin
Wroclaw University of Science and Technology
Poland

Co-Author(s): Janusz Mierczy\`{n}ski

Abstract:
The presentation will cover results concerning linear non-autonomous systems of parabolic partial differential equations with delay. More specifically, I will present theorems regarding the existence and uniqueness of such initial-boundary value problems. Additionally, I will discuss theorems on the regularization of solutions over time and the continuous dependence of solutions on parameters (not just the initial condition) among other functional coefficients of the equation. These types of equations are important for many reasons; however, it should be noted that they generate dynamical systems, and their random versions generate measurable skew-product semi-flows for which the theory of Lyapunov exponents, exponential separation, and Oseledets decomposition is still being developed. Moreover, models based on this type of differential equations are important in mathematical ecology, particularly when modeling interactions between species. The presentation will be based on joint work with Janusz Mierczy\`{n}ski.

On principal eigenvalue for time-periodic parabolic operators

Schedule: December 17 18:30-19:00 Capital Suite 21 A

Shuang Liu
Beijing Institute of Technology
Peoples Rep of China

Co-Author(s): Yuan Lou

Abstract:
In this talk, we shall discuss some qualitative properties of the principal eigenvalue for a linear time-periodic parabolic operator under zero Neumann boundary conditions. Various asymptotic behaviors of the principal eigenvalue and its monotonocity, as a function of the diffusion rate and frequency, will be discussed. This analysis will lead to the classification of the topological structures of the level sets for the principal eigenvalue, in the plane of frequency and diffusion rate. This will help us better understand the joint effects of various parameters on the principal eigenvalue.

VANISHING PROPERTY OF PRINCIPAL EIGENFUNCTION FOR COOPERATIVE ELLIPTIC SYSTEMS

Schedule:

Suying Liu
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Xueli Bai, Ziyang Chen, Yumeng Yin

Abstract:
It is well-known that the normalized principal eigenfunction of single elliptic eigenvalue problem with Neumann boundary condition converges to 0 as d goes to 0 for those points satisfies $c(x)

Principal eigenvalues for elliptic operators with large drift

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Schedule: December 17 14:45-15:15 Capital Suite 21 A

Yuan Lou
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Shuang Liu

Abstract:
The study on the qualitative properties of principal eigenvalues for second order elliptic operators with drift has a long history. In recent years there are some growing interest in investigating the asymptotic behaviors of such principal eigenvalues with large drift rates. In this talk we will give a brief review and discuss some recent works. This talk is mainly based on joint work with Shuang Liu (Beijing Institute of Technology) .

Nonradial boundary spiky steady states of chemotaxis systems in a symmetric convex planar domain.

Schedule: December 17 14:00-14:30 Capital Suite 21 A

Hongze Wang
Chinese university of Hong Kong (Shenzhen)
Peoples Rep of China

Co-Author(s): Hongze Wang, Xuefeng Wang

Abstract:
We investigate the existence of the non-radial steady states of the Keller-Segel model in a bounded convex planar domain that is symmetric with respect to two orthogonal directions via global bifurcation. It is shown that non-radial steady states exist if the chemotactic coefficient exceeds a critical threshold. To model the cell aggregation, one of the most important phenomena in chemotaxis, we also show that boundary spiky solutions exist if the chemotactic coefficient tends to infinity. Our results provide a new insight on the mechanism of the pattern formation and cell aggregation in a bounded convex planar domain with two orthogonal directions.

Linear viscous instability of boundary layer flow

Schedule: December 17 17:00-17:30 Capital Suite 21 A

Di Wu
South China University of Technology
Peoples Rep of China

Co-Author(s): Q, Chen, N. Masmoudi, Y. Wang, Z. Zhang

Abstract:
The Tollmien-Schlichting (T-S) waves play a key role during the early stage of the boundary layer transition. In a breakthrough work (Duke Math Jour, 165(2016)), Grenier, Guo and Nguyen gave a first rigorous construction of the T-S waves of temporal mode for the incompressible fluid. In this talk, we show two results about the Tollmien-Schlichting waves: 1. For the incompressible case, we confirm the existence of neutral curve by constructing stable and neutral stable Tollmien-Schlichting waves. 2. We construct the unstable Tollmien-Schlichting waves of both temporal and spatial mode to the linearized compressible Navier-Stokes system around the boundary layer flow in the whole subsonic regime.

Basic reproduction ratios for time-periodic homogeneous evolution systems

Schedule: December 17 15:45-16:15 Capital Suite 21 A

Lei Zhang
Shaanxi Normal University
Peoples Rep of China

Co-Author(s): Fengbin Wang, Xiaoqiang Zhao

Abstract:
This report will focus on the basic reproduction ratio in homogeneous evolutionary systems, particularly investigating the equivalence between the basic reproduction ratio and the stability of the corresponding homogeneous system, as well as methods for numerically computing this ratio. The main difficulties will be addressed in the following two aspects: the invariance of homogeneous mappings does not guarantee order-preserving; the cone spectral radius of a compact, positively order-preserving homogeneous mapping may not be continuous.

The nonexistence on the limit of elliptic operators with large drift

Schedule: December 17 13:00-13:30 Capital Suite 21 A

Maolin Zhou
Nankai University
Peoples Rep of China

Abstract:
The asymptotic behavior of the principal eigenvalue of elliptic operators has been widely investigated for last decades. All previous studies are focusing on how to give an better estimate on the limit for different kinds of operators. In this talk, we will show the first counterexample such that the limit does not exist for some operators with degeneracy.

Linear stability/instability and nonlinear dynamics of the 3-jet zonal flow

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Schedule: December 17 17:30-18:00 Capital Suite 21 A

Hao Zhu
Nanjing University/University of Vienna
Peoples Rep of China

Abstract:
The classical Rayleigh`s criterion gives a necessary condition for the linear instability of a zonal flow on a sphere. In this talk, we will see that it is far from sufficient for the 3-jet flow, and will give the sharp criteria. Mechanisms that induce unstable eigenvalues are provided. Furthermore, we will discuss nonlinear dynamics near the 3-jet flow, as well as near some general steady flows.

Special Session 12 : Hyperbolic Partial Differential Equations and Applications

Introduction: The aim of this special session is to bring together experts in the area of partial differential equations to present their recent research results in theoretical analysis of hyperbolic PDEs and applications in some related fields like fluid dynamics. In this session, people are expected to exchange new ideas, to discuss challenging issues, to explore new directions and topics, and to foster new collaborations and connections.

Unconditional flocking for weak solutions to self-organized systems of Euler-type

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Schedule: December 17 15:15-15:45 Conference Hall B (D)

Debora Amadori
University of L`Aquila
Italy

Co-Author(s): Cleopatra Christoforou (University of Cyprus)

Abstract:
In this talk, we present some results on the time-asymptotic flocking of weak solutions to a hydrodynamic model of flocking-type with all-to-all interaction kernel, in one-space dimension. An appropriate notion of entropy weak solutions with bounded support is given to capture the behavior of solutions to the Cauchy problem with any BV initial data that has finite total mass confined in a bounded interval and initial density uniformly positive therein. We will discuss the long time behavior of these solutions, which are shown to experience flocking for large time: their support is uniformly bounded in time, and the velocity converges to the mean value. The rate of convergence is exponential. The proof is based on the decay of positive waves and on cancellation properties between positive and negative waves.

Sharp lifespan estimate for the compressible Euler system with critical time-dependent damping in \R^2

Schedule: December 17 16:15-16:45 Conference Hall B (D)

Lv Cai
Shanghai University
Peoples Rep of China

Co-Author(s): Ning-An Lai, Wen-Ze Su

Abstract:
In this talk, I will report some results on the long time existence to the smooth solutions of the compressible Euler system with critical time dependent damping in \R^2. We establish the sharp lifespan estimate from below, with respect to the small parameter of the initial perturbation. New vector fields are introduced and better decays for the linear error terms are obtained. This talk is based on a recent joint work with Ning-An Lai and Wen-Ze Su.

Local existence and uniqueness of the strong solution to the heat and moisture transport system in fibrous porous media

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Schedule: December 17 9:30-10:00 Conference Hall B (D)

Runmei Du
Changchun University of Technology
Peoples Rep of China

Co-Author(s): Ronghua Pan

Abstract:
In this paper, we consider a model coming from textile industries, which can be used to describe the heat and moisture transfer processes in a clothing assembly. The model is a system consisting of two strongly coupled nonlinear parabolic equations in three dimensions, with Robin type boundary conditions. We establish the local existence and uniqueness of the strong solution to the model.

Spectral stability of weak dispersive shocks in quantum hydrodynamics with nonlinear viscosity

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Schedule: December 17 13:00-13:30 Conference Hall B (D)

Raffaele Folino
Universidad Nacional Autonoma de Mexico
Mexico

Abstract:
In this talk, I consider a compressible viscous-dispersive Euler system in one space dimension in the context of quantum hydrodynamics. In particular, the dispersive term is due to quantum effects described through the Bohm potential, while the viscosity term is nonlinear. The main goal is to prove that small-amplitude viscous-dispersive shock profiles for the system under consideration are spectrally stable. The proof is based on spectral energy estimates, for which the monotonicity of the profiles in the small-amplitude regime plays a crucial role. This is a joint work with Ramon Plaza (UNAM) and Delyan Zhelyazov (University of Surrey).

Large Time Behaviors of Solutions to the Euler / Euler-Poisson Equations with Time-dependent Damping

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Schedule: December 17 15:45-16:15 Conference Hall B (D)

Haitong Li
Changchun University of Technology
Peoples Rep of China

Co-Author(s): Shaohua Chen, Jingyu Li, Ming Mei and Kaijun Zhang

Abstract:
In this talk, we consider the Cauchy problem for the 1D Euler / Euler-Poisson equations with time-dependent damping whose coefficient is $-\frac{\mu}{(1+t)^\lambda}$. Firstly, we consider the large time behaviors of solutions to the Euler / Euler-Poisson equations for $\mu = 1, -11$ and $\mu > 0$, or $\lambda = 1$ but $0

Non-uniqueness in law of Leray solutions to 3D forced stochastic Navier-Stokes equations

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Schedule: December 17 12:30-13:00 Conference Hall B (D)

Yachun Li
Shanghai Jiao Tong University
Peoples Rep of China

Abstract:
This talk concerns the 3D forced stochastic Navier-Stokes equation driven by additive noise. By constructing an appropriate forcing term, we prove that there exist distinct Leray solutions in the probabilistically weak sense. In particular, the joint uniqueness in law fails in the Leray class. The non-uniqueness also displays in the probabilistically strong sense in the local time regime, up to stopping times. Furthermore, we discuss the optimality from two different perspectives: sharpness of the hyper-viscous exponent and size of the external force. This is a joint work with Elia Bru\`e, Rui Jin, and Deng Zhang.

Rayleigh-Taylor instability and beyond

Schedule: December 17 8:30-9:00 Conference Hall B (D)

Ronghua Pan
Georgia Institute of Technology
USA

Abstract:
It is known in physics that steady state of fluids under the influence of uniform gravity is stable if and only if the convection is absent. In the context of incompressible fluids, convection happens when heavier fluids is on top of lighter fluids, known as Rayleigh-Taylor instability. However, in real world, heat transfer plays an important role in convection of fluids, such as the weather changes, and or cooking a meal. In this context, the compressibility of the fluids becomes important. Indeed, using the more realistic model of compressible flow with heat transfer, the behavior of solutions is much closer to the real world and more complicated. We will discuss these topics in this lecture, including some on-going research projects.

Global large smooth solutions and relaxation limit of isothermal Euler equations

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Schedule: December 17 14:45-15:15 Conference Hall B (D)

Richard Yue-Jun RYJ Peng
University of Clermont Auvergne
France

Abstract:
In this talk, I show that the Cauchy problem for isothermal Euler equations with relaxation admits a unique global smooth solution when either the relaxation time or the initial datum is sufficiently small. The large smooth solution is then obtained when the relaxation time is sufficiently small. Moreover, I establish error estimates for the convergence of the large density of the Euler equations toward the solution of the heat equation as the relaxation time tends to zero. Besides classical energy estimates, a uniform estimate for a quantity related to Darcy` s law is important in the proof of the above results.

Vanishing Shear Viscosity and Boundary Layer for the Navier-Stokes Equations with Cylindrical Symmetry and Planar MHD system

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Schedule: December 17 13:30-14:00 Conference Hall B (D)

Xulong Qin
Sun Yat-sen University
Peoples Rep of China

Abstract:
We consider an initial boundary problem for the Navier-Stokes Equations with Cylindrical Symmetry and the planar MHD system . The limit of the vanishing shear viscosity is justified. In addition, the L^2 convergence rate is obtained together with the estimation on the thickness of the boundary layer.

Global Existence and Convergence of Large Strong Solutions to the 3D Full Compressible Navier Stokes Equations

Schedule: December 17 14:00-14:30 Conference Hall B (D)

Zhaoyang Shang
Shanghai Lixin University of Accounting and Finance
Peoples Rep of China

Co-Author(s): Co-author: Yachun Li, Peng Lu, Shaojun Yu

Abstract:
In this talk we consider the Cauchy problem of global in time existence of large strong solutions to the Navier Stokes equations for compressible viscous and heat conducting fluids. A class of density dependent viscosity is considered. By introducing the modified effective viscous flux and using the bootstrap argument, we establish the global existence of large strong solutions when the initial density is linearly equivalent to a large constant state. It should be mentioned that this result is obtained without any restrictions on the size of initial velocity and initial temperature. In addition, we establish the convergence of the solutions to its associated equilibrium with an explicit decay rate.

Stability of stationary solutions for viscoelastic fluids in half-space

Schedule: December 17 9:00-9:30 Conference Hall B (D)

Yoshihiro Ueda
Kobe University
Japan

Co-Author(s): Yusuke Ishigaki

Abstract:
In this talk, we discuss the stability of the compressible fluid with viscoelasticity. We consider the outflow problem in a one-dimensional half-space and show the existence of a stationary solution and its stability. There exists a lot of known results for compressible fluids. In particular, the existence and stability of stationary solutions to the outflow problem were discussed in Nakamura-Nishibata-Yuge (2007) and Nakamura-Ueda-Kawashima (2010), where the Mach number was used as a criterion. Similar results are obtained for viscoelastic fluids, however, the main feature is that the criterion is constructed by the modified Mach number, which takes into account the effect of viscoelasticity. This result is based on joint research with Yusuke Ishigaki of Osaka University.

Special Session 13 : Propagation Phenomena in Reaction-Diffusion Systems

Introduction: This special session is concerned with mathematical analysis on propagation phenomena or pattern formation appearing in reaction-diffusion systems. Related topics are traveling waves, entire solutions and asymptotic behaviors of solutions in reaction-diffusion systems.

Transition layer structures in reaction-diffusion models with Perona-Malik diffusion

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Schedule: December 18 14:45-15:15 Capital Suite 13

Raffaele Folino
Universidad Nacional Autonoma de Mexico
Mexico

Abstract:
In this talk, I consider a reaction-diffusion equation in a bounded interval of the real line with no-flux boundary conditions. In particular, the linear diffusion (typical of the classical reaction-diffusion models) is replaced by the (nonlinear) Perona-Malik diffusion and the reaction term is the derivative of a double well potential with wells of equal depth. After investigating the associated stationary problem and highlighting the differences with the standard results (linear diffusion), we focus the attention on the long time dynamics of solutions, proving either exponentially or algebraic slow motion of profiles with a transition layer structure. This is a joint work with Alessandra De Luca (University of Turin) and Marta Strani (University of Venice).

Traveling Wave Analysis in Receptor-Mediated Models Incorporating Hysteresis Effects

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Schedule: December 18 8:30-9:00 Capital Suite 13

Lingling Hou
College of Mathematics and System Science Xinjiang University
Peoples Rep of China

Co-Author(s): Izumi Takagi

Abstract:
In this talk, we investigate the existence of traveling wave solutions in a reaction-diffusion ordinary differential system, which is coupled by a set of three ordinary differential equations and a reaction-diffusion equation. We employ the geometric singular perturbation theory to demonstrate the existence of the traveling wave solutions. Subsequently, we utilize the contraction mapping principle to prove the uniqueness of the wave speed. At the end of the paper, we conduct numerical simulations for a specific model that meets the hypothetical conditions, validating the obtained results.

Surface curvature drives propagation and chaos of Turing pattern

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Schedule: December 18 17:30-18:00 Capital Suite 13

Shuji Ishihara
The University of Tokyo
Japan

Co-Author(s): Ryosuke Nishide

Abstract:
We study the Turing pattern on curved surfaces. Since the seminal work by A. Turing many researchers have investigated the pattern formation on curved surfaces such as spheres and tori, in which it has been presumed that the Turing pattern is static on curved surfaces, as it is on a flat plane. We show that the Turing pattern on curved surfaces actually moves on curved surfaces. We mainly study reaction-diffusion systems on an axisymmetric surface with periodic boundary conditions, with parameters showing Turing pattern on a flat plane. Our numerical and theoretical analyses reveal that there exist propagation solutions along the azimuth direction, and the symmetries of the surface as well as pattern are involved for the initiation of the pattern propagation. By applying weakly non-linear analysis, we derive the amplitude equations and show that the intricate interactions between modes rise on curved surface and results in the initiation of pattern propagation and even more complex behaviors such as oscillation and chaos. This study provides a novel and generic mechanism of pattern propagation that is caused by surface curvature (which is not possible in 1D systems), as well as new insights into the potential role of surface geometry in pattern dynamics.

Propagating front solutions to Fisher-KPP equation with time-fractional derivative

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Schedule: December 18 13:30-14:00 Capital Suite 13

Hiroshi Ishii
Hokkaido University
Japan

Abstract:
In this talk, we address the Fisher-KPP equation with a Caputo derivative as the time derivative and discuss the long-time behavior of the front solution. After briefly explaining the background of the model, we will introduce numerical results and discuss the expected properties of the solution. Additionally, to characterize the long-time behavior of the solution, we assume that the solution asymptotically behaves like a traveling wave solution and present the results of our analysis of potential traveling wave solutions to which the solution may converge. We will also explain the usefulness of these results.

Unbounded traveling wave solutions for reaction-diffusion equations

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Schedule: December 18 9:00-9:30 Capital Suite 13

Ryo Ito
Kanagawa University
Japan

Co-Author(s): Hirokazu Ninomiya

Abstract:
We consider unbounded traveling wave solutions for one dimensional reaction-diffusion equations. Main interest of this talk is existence of unbounded traveling wave solutions and the relation between unbounded and bounded traveling wave solutions. We prove that there exists a threshold speed, called the minimal speed, that separates the existence and non-existence of unbounded wave solutions under few technical assumptions for nonlinearity, especially it includes bistable type nonlinearity, and we reconsider min-max type characterization of the threshold speeds.

Large time behavior of solutions of a cooperative system with population flux by attractive transition

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Schedule: December 18 16:15-16:45 Capital Suite 13

Kousuke Kuto
Waseda University
Japan

Co-Author(s): Ryuichi Kato

Abstract:
In this talk, we consider a cooperative model with cross-diffusion terms of attractive transition type. In the weak cooperative 3D case, the time global well-posedness of classical non-stationary solutions is shown. Especially in the case of large random diffusion coefficients, we show that any nonstationary positive solution asymptotically approaches the coexistence constant steady state at time infinity by constructing a Lyapunov function. We also discuss the relationship between the bifurcation diagram of the steady states obtained by Adachi-Kuto (2024) and the long-time behavior of the non-stationary solutions.

Asymptotic behavior of spreading fronts in an anisotropic multi-stable equation on $\mathbb{R}^N$

Schedule: December 18 15:15-15:45 Capital Suite 13

Hiroshi Matsuzawa
Kanagawa University
Japan

Co-Author(s): Mitsunori Nara

Abstract:
In this talk, we consider the Cauchy problem for an anisotropic reaction-diffusion equation with a multi-stable nonlinearity on $\mathbb{R}^N$ and study the asymptotic behavior of its solutions. Matano, Mori, and Nara (2019) previously investigated this problem with a bistable nonlinearity, demonstrating that, under suitable conditions on the initial function, the solution develops a spreading front closely approximated by the expanding Wulff shape for sufficiently large times. In this talk, we extend their results to cases involving multi-stable nonlinearities, where the nonlinearity can be decomposed into multiple bistable components.

Compact traveling wave solutions to a mean-curvature flow with driving force

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Schedule: December 18 9:30-10:00 Capital Suite 13

Harunori Monobe
Osaka Metropolitan University
Japan

Abstract:
Mean-curvature flow with a driving force appears in various mathematical problems such as motion of soap films, grain boundaries and singular limit problems of various reaction diffusion systems, e.g., Allen-Cahn-Nagumo equation. In this talk, we show the existence and uniqueness of traveling waves, composed of a Jordan curve (or closed surface), for an anisotropic curvature flow with a driving force. We call such a solution ``compact traveling wave in this talk. Our aim is to investigate the condition of external driving force when the curvature flow has traveling waves. This is a joint work with H. Ninomiya.

Blocking and propagation in two-dimensional undulating cylinders with spatial periodicity

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Schedule: December 18 15:45-16:15 Capital Suite 13

Ryunosuke Mori
Meiji University
Japan

Co-Author(s): Hiroshi Matano

Abstract:
We consider blocking and propagation phenomena of mean curvature flow with a driving force in two-dimensional undulating cylinders with spatial periodicity. In this problem, Matano, Nakamura and Lou in 2006 prove the tmie global existence of the classical solutions under some boundary-slope condition that means the bumps of the boundary is not steep. Moreover they characterize the effect of the shape of the boundary to blocking and propagation by introducing a notion called maximal opening angle. However if we do not assume the boundary-slope condition, then the classical solutions do not always exist in time globally and their characterization by the maximal opening angle is not always applicable. In this talk, we consider the effect of the shape of the boundary to blocking and propagation of this problem under more general situation that the solutions may develop singularities near the boundary.

Front propagation for the bistable reaction-diffusion equation on unbounded metric graphs

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Schedule: December 18 12:30-13:00 Capital Suite 13

Yoshihisa Morita
Ryukoku Joint Research Center Sci & Tech
Japan

Abstract:
We are concerned with the front propagation for the reaction-diffusion equation with bistable nonlinearity on metric graphs composed of half-lines and branching points. We demonstrate the asymptotic behavior of front-like entire solutions that either propagate beyond the branching points or are blocked by them on certain specific metric graphs. This talk is based on the works Jimbo-M (2019, 2021, 2024), Iwasaki-Jimbo-M (2022), and M (2023).

Reaction-diffusion systems of topological signals coupled by the Dirac operator: a new framework for the emergence of stationary and dynamical Turing patterns.

Schedule: December 18 17:00-17:30 Capital Suite 13

Riccardo Muolo
Tokyo Institute of Technology
Japan

Co-Author(s): Ginestra Bianconi (Queen Mary U London and The Alan Turing Institute, UK) & Timoteo Carletti (U Namur and naXys, Belgium)

Abstract:
Pattern formation is a key feature of many natural and engineered systems, ranging from ecosystems to neural dynamics. Turing instability provides one of the most famous theories for pattern formation in a continuous domain, which was later extended to networked systems, where the dynamical variables interact in the nodes and flow among nodes by using network links. However, in a number of real systems, including the brain and the climate, dynamical variables are not only defined on nodes but also on links, triangles and higher-dimensional simplexes, leading to topological signals. The discrete topological Dirac operator is emerging as the key operator that allows cross-talk between signals defined on simplexes of different dimensions, for instance among nodes and links signals of a network. Here, we propose a mathematical framework able to generate stationary and dynamical Turing patterns of topological signals defined on nodes and links of networks. This framework accounts for a rich dynamical behavior even without the (Hodge-Laplacian) diffusion term, i.e., occurring solely due to the Dirac operator. This work opens a new framework displaying a rich interplay between topology and dynamics with possible applications to brain and climate networks.

Propagation and Blocking of Bistable Waves by Variable Diffusion

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Schedule: December 18 18:00-18:30 Capital Suite 13

Hirokazu Ninomiya
Meiji University
Japan

Co-Author(s): Keita Nakajima

Abstract:
Biological diffusion processes are often influenced by environmental factors. In this talk, we investigate the effects of variable diffusion, which depends on a point between the departure and arrival points, on the propagation of bistable waves. This process includes neutral, repulsive, and attractive transitions. By using singular limit analysis, we derive the equation for the interface between two stable states and examine the relationship between wave propagation and variable diffusion. More precisely, when the transition probability depends on the environment at the dividing point between the departure and arrival points, we derived an expression for the wave propagation speed that includes this dividing point ratio. This shows that, asymptotically, the boundary between wave propagation and blocking in a one-dimensional space corresponds to the case where the transition probability is determined by a dividing point ratio of 3:1 between the departure and arrival points. Furthermore, as an application of this concept, we consider the Aliev-Panfilov model to explore the mechanism for generating target patterns.

Long time dynamics of a reaction-diffusion model of obesity-induced Alzheimers disease and its control strategies

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Schedule: December 18 13:00-13:30 Capital Suite 13

Rana parshad
iowa state university
USA

Co-Author(s): Ranjit Upadhyay, Debashish Pradhan, Parimita Roy

Abstract:
Evidence suggests that obesity, diabetes, and aging notably increase susceptibility to dementia related conditions such as Alzheimers disease. This work explores the correlations between obesity, diabetes, and this disease. It introduces a reaction diffusion model encompassing variables like glucose dynamics, insulin levels, microglia, cytokines, plaques, neurofibrillary tangles, and cognitive decline. The system proposed is an example of a partly dissipative system, as there is a lack of smoothing in several of the state equations. Despite this challenge, we explore the long time behavior of this system, via showing the existence of a global attractor. Several control strategies for the disease are also proposed.

Convergence to forced waves of the Fisher-KPP equation in a shifting environment by utilizing a relative entropy

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Schedule: December 18 14:00-14:30 Capital Suite 13

Masahiko Shimojo
Tokyo Metropolitan University
Japan

Co-Author(s): Jong-Shenq Guo, Karen Guo

Abstract:
This talk aims to investigate the stability of forced waves for the Fisher-KPP equation in a shifting environment, without imposing the monotonicity condition on the shifting intrinsic growth term. A new method is introduced to derive the stability of forced waves under certain perturbation of a class of initial data.

Entire solutions with and without radial symmetry in balanced bistable reaction-diffusion equations

Schedule: December 18 8:00-8:30 Capital Suite 13

Masaharu Taniguchi
Research Institute for Interdisciplinary Science, Okayama University
Japan

Abstract:
Let $n \geq 2$ be a given integer. In this paper, we assert that an n-dimensional traveling front converges to an $(n-1)$-dimensional entire solution as the speed goes to infinity in a balanced bistable reaction-diffusion equation. As the speed of an n-dimensional axially symmetric or asymmetric traveling front goes to infinity, it converges to an $(n-1)$-dimensional radially symmetric or asymm\ etric entire solution in a balanced bistable reaction-diffusion equation, respectively. We conjecture that the radially asymmetric entire solutions obtained in this paper are associated with the ancient solutions called the Angenent ovals in the mean curvature flows.

Special Session 14 : The recent progress on Allen-Cahn equation, Liouville equation and critical exponent equation

Introduction: The Allen-Cahn equation, Liouville equation and the critical exponent equation are of paramount significance in the fields of differential geometry and mathematical physics, boasting strong connections to various other mathematical branches. This session primarily focuses on the recent progress on these equations. These advancements encompass aspects like investigating the existence, symmetry, and monotonic behavior of solutions, classifying the finite Morse index solutions, and exploring the blow-up phenomena in both elliptic and parabolic problems.

The optimal stability of geometric inequality with the dimension-dependent or order-dependent constants.

Schedule: December 16 16:15-16:45 Capital Suite 6

Lu Chen
Beijing Institute of Technology
Peoples Rep of China

Abstract:
In this talk, we will first introuduce the sharp geometric inequality and their stability. Then we present recent progress on the optimal stability for Hardy-Littlewood-Sobolev (HLS) inequality, fractional Sobolev inequality, Log-Sobolev inequality and trace Sobolev inequality. Some interesting open problems will be also discussed.

The limiting case of the fractional Caffarelli-Kohn-Nirenberg inequality

Schedule: December 16 15:45-16:15 Capital Suite 6

Ali Hyder
TIFR-CAM Bangalore
India

Co-Author(s): M. d. M. Gonzalez and M. Saez

Abstract:
It is known that there exist radially symmetric monotone decreasing optimizers for the fractional Caffarelli-Kohn-Nirenberg inequality in some suitable range of parameters. In this talk we will focus on the behavior of these optimizers in dimension one. We will show that after a suitable normalization they converge to a solution of the Liouville equation in R. As a byproduct we obtain a generalized Onofri`s inequality in dimension one.

On the bifurcation diagram for free boundary problems arising in plasma physics

Schedule: December 16 15:15-15:45 Capital Suite 6

Aleks Jevnikar
University of Udine
Italy

Co-Author(s): Daniele Bartolucci, Ruijun Wu

Abstract:
We are concerned with qualitative properties of the bifurcation diagram of a free boundary problem arising in plasma physics, showing in particular uniqueness and monotonicity of its solutions. We then discuss sharp positivity thresholds and spike condensation phenomenon.

The Sphere Covering Inequality and Applications

Schedule: December 17 9:30-10:00 Capital Suite 6

Amir Moradifam
University of California at Riverside
USA

Co-Author(s): Changfeng Gui

Abstract:
We demonstrate that the total area of two distinct surfaces with Gaussian curvature 1, which share the same conformal factor on the boundary and are conformal to the Euclidean unit disk, must be at least 4π . In other words, the areas of these surfaces must cover the entire unit sphere after an appropriate rearrangement. We refer to this minimum total area as the Sphere Covering Inequality. This inequality and its generalizations are applied to several open problems related to Moser-Trudinger type inequalities, mean field equations, and Onsager vortices, among others, yielding optimal results. In particular, we confirm the best constant of a Moser-Trudinger type inequality that was conjectured by A. Chang and P. Yang in 1987. This work is a collaboration with Changfeng Gui.

Regularity and Liouville property for stable solutions to semilinear elliptic equations

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Schedule: December 16 13:00-13:30 Capital Suite 6

Fa Peng
Beihang University
Peoples Rep of China

Co-Author(s): Yi Ru-Ya Zhang, Yuan Zhou

Abstract:
The aim of this talk is twofold. First, when dimension $n \leq 9$ and the nonlinearities f changes sign, we will study the boundness of stable solutions to semilinear elliptic equations $-\Delta u = f(u)$. When dimension $n \geq 10$ and $f \geq 0$, we shall prove the sharp BMO and Morrey regularity for stable solutions. Second, as an application, we show a sharp Liouville property for stable solutions when dimension $n \geq 10$. This work is a collaboration with Prof. Yi Ru-Ya Zhang and Yuan Zhou.

Singularly perturbed elliptic systems modeling partial separation and their free boundaries

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Schedule: December 16 14:45-15:15 Capital Suite 6

Susanna Terracini
University of Turin
Italy

Co-Author(s): Nicola Soave

Abstract:
We investigate the asymptotic behavior, as $\beta \to +\infty$, of solutions to competition-diffusion system of type

$$\left\{ \Delta u_{i,\beta} = \beta u_{i,\beta} \prod_{j\neq i} u_{j,\beta}^2 \quad \text{in } \Omega, \; u_{i,\beta} = \varphi_i \geq 0 \quad \text{on } \partial\Omega, \qquad i = 1, 2, 3, \right.$$

where $\varphi_i \in W^{1,\infty}(\Omega)$ satisfy the \emph{partial segregation condition}

$$\varphi 1 \, \varphi 2 \, \varphi 3 \equiv 0 \quad \text{in } \overline{\Omega} \, .$$

For $\beta > 1$ fixed, a solutions can be obtained as a minimizer of the functional

$$J\beta(\mathbf{u}, \Omega) := \int_\Omega \big(\sum_{i=1}^{3} |\nabla u_i|^2 + \beta \prod_{j=1}^{3} u_j^2 \big) \, dx$$

on the set of functions in $H^1(\Omega, \backslash \mathrm{R}^3)$ with fixed traces on $\partial\Omega$. We prove \emph{a priori} and \emph{uniform in β} H\older bounds. In the limit, we are lead to minimize the energy

$$J\mathbf{u}, \Omega) := \int_\Omega \sum_{i=1}^{3} |\nabla u_i|^2 \, dx$$

over all partially segregated states:

$$u1 \, u2 \, u3 \equiv 0 \quad \text{in } \overline{\Omega}$$

satisfying the given, partially segregated, boundary conditions above. We prove regularity of the free boundary up to a low-dimensional singular set.

Mean field type equations and the applications in Aubin-Onofri type inequalities

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Schedule: December 16 14:00-14:30 Capital Suite 6

Xie Weihong
Central South University
Peoples Rep of China

Co-Author(s): Changfeng Gui and Yeyao Hu

Abstract:
In this talk, we will first review Aubin-Onofri type inequality on the sphere. Then higher dimensional analogues will be presented and some very recent progress will be introduced. The talk is based on collaborations with Changfeng Gui and Yeyao Hu.

Uniqueness of blowup solutions and non-degeneracy for singular Liouville equations.

Schedule: December 17 9:00-9:30 Capital Suite 6

Lei Zhang
University of Florida
USA

Co-Author(s): Daniele Bartolucci, Wen Yang, Lei Zhang

Abstract:
For singular mean field equations defined on a compact Riemann surface, we prove the uniqueness of bubbling solutions when blowup points are either regular points or non-quantized singular sources. In particular the uniqueness result covers the most general case extending or improving all previous works. For example, unlike previous results, we drop the assumption of singular sources being critical points of a suitably defined Kirchoff-Routh type functional. Our argument is based on refined estimates, robust and flexible enough to be applied to a wide range of problems requiring a delicate blowup analysis. In particular we come up with a major simplification of previous uniqueness proofs. Besides the uniqueness of blowup solutions, we also established the non-degeneracy of the linearized equations. This is a joint work with Daniele Bartolucci and Wen Yang.

Special Session 15 : On the dynamics of hyperbolic partial differential equations: theory and applications

Introduction: The objective of this special session is to bring together experts in the area of hyperbolic partial differential equations to present their recent research results. Hyperbolic systems play important roles in multiple domains of applied sciences, ranging from high-speed flows in fluids, to astrophysics and to plasma physics. It is a field where the interplay between theory and applications has been advantageous to both sides. The field has seen important recent advances in the study of blow up phenomena and the structure of weak solutions for hyperbolic problems. The goal of the session is to gather a number of participants working on different aspects of the field of hyperbolic equations to exchange new ideas in both theory and applications, discuss challenges, explore new directions and topics, and encourage and foster new collaborations and connections. There will be an effort to combine participation from researchers from the Gulf area with overseas experts.

Bernstein`s Problem and Positivity Preserving Exponential Integrators for Evolution Equations

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Schedule: December 20 15:30-16:00 Capital Suite 21 A

Rachid Ait Haddou
King Fahd University of Petroleum and Minerals
Saudi Arabia

Co-Author(s): Huda Altamimi

Abstract:
Bernstein`s problem asks for the maximum positive real number R for which an absolutely monotonic function, with a specified number of derivatives at the origin, exists on the interval $(-R, 0)$. Optimal threshold factors govern the maximum allowable step-size for positivity preserving integration methods of initial-value problems. This talk establishes a link between Bernstein`s problem and optimal threshold factors and presents algorithms for computing the latter. Derivation of optimal exponential integrators of specified accuracy for evolution equations is discussed.

Asymptotic Limits for Strain-Gradient Viscoelasticity with Nonconvex Energy

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Schedule: December 18 9:00-9:30 Capital Suite 21 A

Aseel AlNajjar
King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): Stefano Spirito and Athanasios E. Tzavaras

Abstract:
We consider the system of viscoelasticity with higher-order gradients and nonconvex energy in several space dimensions. After deriving the compactness estimates for the system, we first establish global existence of weak solutions. We then study the asymptotic limits as the viscosity tends to zero or as the coefficient of the higher-order gradient vanishes. In the latter problem and for the two-dimensional case, we also prove a stability result for the solutions in the regularity class and establish a rate of convergence.

Euler-Riesz systems: Compensated Integrability and connections to Harmonic Analysis

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Schedule: December 20 15:00-15:30 Capital Suite 21 A

Nuno J Alves
University of Vienna
Austria

Co-Author(s): Loukas Grafakos and Athanasios E. Tzavaras

Abstract:
In this talk, we consider a Euler-Riesz system and establish a higher integrability estimate for the density. This is achieved through a reformulation of the system and compensated integrability. We will also discuss connections to harmonic analysis, particularly the introduction of a bilinear fractional integral operator, whose uniform estimates are derived via restricted weak-type endpoint bounds and Marcinkiewicz interpolation.

A phase separation model for binary fluids with hereditary viscosity

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Schedule: December 19 8:00-8:30 Capital Suite 21 A

Maurizio Grasselli
Politecnico di Milano
Italy

Co-Author(s): Andrea Poiatti

Abstract:
We consider a diffuse interface model for an incompressible binary viscoelastic fluid flow. The model consists of the Navier-Stokes-Voigt equations where the instantaneous kinematic viscosity has been replaced by a memory term incorporating hereditary effects. These equations are coupled with the Cahn-Hilliard equation with Flory-Huggins type potential. The resulting system is subject to no-slip condition for the (volume averaged) fluid velocity and no-flux boundary conditions for the order parameter as well as for the chemical potential. The presence of a memory term entails hyperbolic features (i.e. the fluid velocity does not regularize in finite time). The corresponding initial and boundary value problem is well posed. Moreover, by adding an Eckman-type damping, we show that it defines a dissipative dynamical system in a suitable phase space, i.e., there is a bounded absorbing set. Then, we discuss the existence of global and exponential attractors.

On the well-posedness and stability for carbon nanotubes as coupled two Timoshenko beams with frictional dampings

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Schedule: December 19 8:30-9:00 Capital Suite 21 A

Aissa Guesmia
Lorraine University
France

Abstract:
The objective of this work is to study the well-posedness and stability questions for double wall carbon nanotubes modeled as linear one-dimensional coupled two Timoshenko beams in a bounded domain under frictional dampings. First, we prove the well-posedness of our system by applying the semigroups theory of linear operators. Second, we show several strong, non-exponential, exponential, polynomial and non-polynomial stability results depending on the number of frictional dampings, their position and some connections between the coefficients. In some cases, the optimality of the polynomial decay rate is also proved. The proofs of these stability results are based on a combination of the energy method and the frequency domain approach. For the details, see the following paper: A. Guesmia, On the well-posedness and stability for carbon nanotubes as coupled two Timoshenko beams with frictional dampings, J. Appl. Anal. Comp., 14 (2024), 1-50.

On the Cauchy problem of the MGT-Viscoelastic plate with heat conduction of Fourier law

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Schedule: December 20 8:00-8:30 Capital Suite 21 A

Bounadja Hizia
University of Sciences and Technology Houari Boumediene
Algeria

Co-Author(s): Mounir Afilal & Abdelaziz Soufyane

Abstract:
In this paper, we consider the MGT viscoelastic plate model in $\mathbb{R}^N$ with heat conduction of Fourier law. First, we give the appropriate functional setting needed for the well-posedness. Second, using the energy method in the Fourier space, we obtain the decay rate of a norm related to the solutions in both cases sub-critical and critical cases. In particular, we prove that the decay rate does not exhibit the well-known regularity loss phenomenon present in some models existing in the literature.

A new duality method for mean-field limits with singular interactions

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Schedule: December 20 Capital Suite 21 A

Pierre-Emmanuel Jabin
Pennsylvania State University
USA

Co-Author(s): D. Bresch, M. Duerinckx

Abstract:
We introduce a new approach to justify mean-field limits for first- and second-order particle systems with singular interactions. It is based on a duality approach combined with the analysis of linearized dual correlations, and it allows to cover for the first time arbitrary square-integrable interaction forces with a possibly vanishing temperature parameter.

On a truncated thermoelastic Timoshenko System with a dual-phase-lag model

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Schedule: December 20 9:00-9:30 Capital Suite 21 A

Salim Messaoudi
University of Sharjah
United Arab Emirates

Co-Author(s): Ahmed keddi and Mohamed Alahyane

Abstract:
In this work, we consider a one-dimensional truncated Timoshenko system coupled with a heat equation, where the heat flux is given by the generalized dual-phase lag model. By using the semigroup theory and some non classical diferential operators, we establish the well-posedness of the problem. Then, we use the multiplier method to show that the only one heat control is enough to stabilize the whole system exponentially without imposing the usual equal-speed assumption or any other stability number. Moreover, to illustrate our theoretical results, we give some numerical tests. Our result seems to be the first of this type.

The Westervelt-Pennes model of nonlinear thermo-acoustics: local well-posedness and singular limit for vanishing relaxation time

Schedule: December 20 8:30-9:00   Capital Suite 21 A

Belkacem Said-Houari
University of Sharjah
United Arab Emirates

Abstract:
In this work, we investigate a mathematical model of nonlinear ultrasonic heating based on a coupled system of the Westervelt equation and the hyperbolic Pennes bioheat equation (Westervelt-Pennes-Cattaneo model). Using the energy method together with a fixed point argument, we prove that our model is locally well-posed and does not degenerate under a smallness assumption on the pressure data in the Westervelt equation. In addition, we perform a singular limit analysis and show that the Westervelt-Pennes-Fourier model can be seen as an approximation of the Westervelt-Pennes-Cattaneo model as the relaxation parameter tends to zero. This is done by deriving uniform bounds of the solution with respect to the relaxation parameter.

STATIONARY SHEAR FLOW OF NEMATIC LIQUID CRYSTALS: MULTIPLICITY, STABILITY, AND BIFURCATION

Schedule: December 18 8:30-9:00   Capital Suite 21 A

Majed Sofiani
King Abdullah University of Science and Technology (KAUST)
Saudi Arabia

Co-Author(s): Weishi Liu

Abstract:
Liquid crystal is a state of matter that has crystal properties and can flow like a liquid. These two characteristics interact with each other so that any distortion of the crystal structure affects the flow, and vice versa. In this talk, I will present recent results on the boundary value problem for the shear flow of nematic liquid crystals via the parabolic Ericksen-Leslie model. In particular, I will discuss the existence of multiple stationary solutions, bifurcation phenomenon, and stability/instability of bifurcating solutions.

Cahn-Hillard and Keller-Segel systems as high-friction limits of gas dynamics

Schedule: December 18 9:30-10:00   Capital Suite 21 A

Agnieszka Swierczewska-Gwiazda
University of Warsaw
Poland

Abstract:
Several recent studies considered the high-friction limit for systems arising in fluid mechanics. Following this approach, we rigorously derive the nonlocal Cahn-Hilliard equation as a limit of the nonlocal Euler-Korteweg equation using the relative entropy method. Applying the recent result about relations between non-local and local Cahn-Hilliard, we also derive rigorously the large-friction nonlocal- to-local limit. The result is formulated for dissipative measure-valued solutions of the nonlocal Euler-Korteweg equation which are known to exist on arbitrary intervals of time. This approach provides a new method to derive equations not enjoying classical solutions via relative entropy method by introducing the nonlocal effect in the fluid equation. During the talk I will also discuss the high-friction limit of the Euler-Poisson system.

Evolution problems with non-small amplitudes

Schedule: December 20 14:00-14:30 Capital Suite 21 A

NAASER-EDDINE TATAR
KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
Saudi Arabia

Co-Author(s): Mohamed Kafini

Abstract:
In most of the existing works on partial differential equations of hyperbolic type, vibrations or oscillations are assumed to be small in a certain sense. Whilst this is acceptable in many situations, it may be considered as a severe simplification in other situations. Indeed, the obtained simpified models are much simpler but may be far away from the reality in case of large amplitudes. In this presentation, we will briefly discuss some evolution problems with large amplitudes. The main difficulties will be highlighted and some new elements will be put forward.

Sustained Oscillations in Hyperbolic-Parabolic Systems

Schedule: December 18 8:00-8:30 Capital Suite 21 A

Athanasios Tzavaras
King Abdullah University of Science and Technology
Saudi Arabia

Abstract:
We provide examples of sustained oscillations for hyperbolic-parabolic systems. The existence of sustained oscillations in hyperbolic-parabolic system is studied systematically via examples, for paradigm systems from viscoelasticity and for the compressible Navier-Stokes system with non-monotone pressures. In several space dimensions oscillatory examples are associated with lack of rank-one convexity of the stored energy. The subject naturally leads to the problem of deriving effective equations for the associated homogenization problems. We address that in a context of a simple one-dimensional model be addressed by employing ideas from the kinetic formulation for conservation laws.

The wave equation with acoustic boundary conditions on non-locally reacting surfaces

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Schedule: December 19 9:00-9:30 Capital Suite 21 A

Enzo Vitillaro
Universit\\`a degli Studi di Perugia
Italy

Co-Author(s): Delio Mugnolo

Abstract:
We deal with the wave equation in a suitably regular open domain of the Euclidean space, supplied with an acoustic boundary condition on a part of the boundary and a homogeneous Neumann boundary condition on the (possibly empty) remaining part of it. This problem has been proposed a long time ago by Beale and Rosencrans, to model acoustic wave propagation with locally reacting boundary, and it has been the object of a wide literature. The case of non--locally reacting boundaries, when the homogeneous Neumann boundary condition is replaced by the mathematically more attracting homogeneous Dirichlet boundary condition, has been studied as well. The physical derivation of the problem is treated in the talk by the author in SS96. In this talk, we focus on non-locally reacting boundaries without any Dirichlet boundary condition. We first give well-posedness results in the natural energy space and regularity results. Hence, we shall give precise qualitative results for solutions when the domain is bounded and sufficiently regular. The results presented will appear in the Memoirs of the American Mathematical Society and are available at the address https://doi.org/10.48550/arXiv.2105.09219.

Energy methods for an improved blow-up bound for a superconformal wave equation

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Schedule: December 20 14:30-15:00 Capital Suite 21 A

Hatem Zaag
CNRS and Universite Sorbonne Paris Nord
France

Co-Author(s): M.A. Hamza

Abstract:
We address the blow-up rate issue for the Nonlinear Wave Equation (NLW) with superlinear power nonlinearity. For subconformal and conformal power, the blow-up rate is given by the solution of the associated ODE, as this was shown by Merle and Zaag in 2003 and 2005. In the superconformal case below the Sobolev exponent, various bounds are known, from the work of Killip, Stovall and Visan in 2014, and also in our earlier paper in 2013. The aim of this talk is to give a better bound. Our method relies on some energy estimates in similarity variables, where we consider the superconformal case as a (large) perturbation of the conformal case. This leads to some exponential bound on the self-similar version, directly related to the size of the large perturbation.

Special Session 16 : Recent Development of Stochastic Optimal Control and Differential Games

Introduction: As two important directions in the area of stochastic optimization, stochastic optimal control theory and stochastic differential games have been developing very fast in the recent years. They have been widely applied to solving many optimization problems raised in engineering, economy, biology, especially the recent very popular areas such as automotive driving, reinforcement (machine/deep) learning, AI technology, and so on. The purposes of this special session are to present the recent developments and to discuss the future directions in stochastic optimal control and differential games. The main topics are focused on, but are not limited to, (1) linear-quadratic optimal control and differential game theory, (2) mean-field control and game theory, (3) stochastic optimization with partial information and filtering, (4) optimal control of hybrid problems, (5) relevant numerical methods, and (6) other topics for stochastic systems such as stability and so on.

Optimal investment and consumption under forward performance criteria with relative concerns

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Schedule: December 17 18:00-18:30 Capital Suite 15

Matoussi Anis
Risk and Insurance Institute, Le Mans University
France

Abstract:
My talk will focus on the presentation of some theoretical and numerical tools for adaptive decision-making in uncertain environments, within the scope of forward utilities. We investigate an investment-consumption optimization problem in both the many player and mean-field settings, under the framework of forward utilities with relative performance concerns and non-zero volatility. We will also provide numerical examples. If time permits, I will also present a numerical methods for forward utilities in a stochastic factor model (for both standard and regime-switching models), using their representation with ergodic backward stochastic differential equations (eBSDEs).

Deep learning methods to solve some of stochastic optimal control problems

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Schedule: December 18 9:30-10:00 Capital Suite 15

Omar Kebiri
BTU Cottbus-Senftenberg
Germany

Abstract:
In this talk, I will presents deep learning methods to solve some stochastic optimal control (SOC in short) problems. The first SOC is an application for solving initial path optimization of mean-field systems with memory where we consider the problem of finding the optimal initial investment strategy for a system modeled by a linear McKean-Vlasov (mean-field) stochastic differential equation with positive delay, driven by a Brownian motion and a pure jump Poisson random measure. The problem is to find the optimal initial values for the system in this period, before the system starts at t equal zero. Because of the delay in the dynamics, the system will after startup be influenced by these initial investment values. It is known that linear stochastic delay differential equations are equivalent to stochastic Volterra integral equations. By using this equivalence, we can find implicit expression for the optimal investment. We deep machine learning algorithms to solve explicitly some examples The second type of dynamic is a second BSDE that represent a fully nonlinear second order PDE. As an application here, we study alpha-hypergeometric model with uncertain volatility (UV) where we derive a worst-case scenario for option pricing. The approach is based on the connection between a certain class of nonlinear partial differential equations of HJB-type (G-HJB equations), that govern the nonlinear expectation of the UV model and that provide an alternative to the difficult model calibration problem of UV models, and second-order backward stochastic differential equations (2BSDEs). Using a deep learning based approximation of the underlying 2BSDE we can find the solution of our problem.

Discrete-Time Mean-Variance Strategy Based on Reinforcement Learning

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Schedule: December 17 15:45-16:15 Capital Suite 15

Xun Li
HK PolyU
Hong Kong

Co-Author(s): Xiangyu Cui, Yun Shi, Si Zhao

Abstract:
This talk studies a discrete-time mean-variance model based on reinforcement learning. Compared with its continuous-time counterpart in Wang and Zhou (2020), the discrete-time model makes more general assumptions about the asset`s return distribution. Using entropy to measure the cost of exploration, we derive the optimal investment strategy, whose density function is also Gaussian type. Additionally, we design the corresponding reinforcement learning algorithm. Both simulation experiments and empirical analysis indicate that our discrete-time model exhibits better applicability when analyzing real-world data than the continuous-time model.

Advances in Linear-Quadratic Stochastic Differential Games

Schedule: December 17 17:30-18:00 Capital Suite 15

Jun Moon
Hanyang University
Korea

Co-Author(s): Jun Moon

Abstract:
Since the seminal paper of Fleming and Souganidis, stochastic differential games have been playing a central role in mathematical control theory, as they can be applied to model the general decision-making process between interacting players under stochastic uncertainties. Two different types of stochastic differential games can be formulated depending on the role of the interacting players. Specifically, when the interaction of the players can be described in a symmetric way, it is called the Nash differential game. On the other hand, the Stackelberg differential game can be used to formulate the nonsymmetric leader-follower hierarchical decision-making process between the players. This talk consists of two parts, studying various recent results on LQ stochastic Nash and Stackelberg differential games. In the first part, the rigorous mathematical formulation on LQ stochastic Nash and Stackelberg differential games will be covered within various different frameworks, including systems with random-coefficients, games of mean-field type, Markov-jump systems, and systems with delay, where we will also provide several different notions of Nash and Stackelberg equilibria depending on the underlying information structures. In the second part, we will address the detailed mathematical approaches to and analyses of the LQ stochastic differential games formulated in the first part, and present their explicit Nash/Stackelberg equilibrium solutions expressed by Riccati differential equations. Some examples including numerical solvability of the corresponding Riccati differential equations will also be discussed to illustrate the theoretical results of this talk.

Strict Dissipativity in Stochastic Optimal and Predictive Control

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Schedule: December 17 16:15-16:45 Capital Suite 15

Jonas Schiessl
University of Bayreuth
Germany

Co-Author(s): Ruchuan Ou, Michael H. Baumann, Timm Faulwasser, Lars Gruene

Abstract:
Since its introduction by Jan C. Willems, the concept of dissipativity has become a valuable tool for analyzing optimal and model predictive control problems. While dissipativity and its relationship to the so-called turnpike property are well-established for deterministic problems, further theoretical development is required to extend these notions to stochastic settings. In this talk, we introduce different forms of dissipativity based on stationarity concepts in distribution and random variables. We show that these notions are suitable for analyzing the distributional and pathwise behavior of stochastic problems and highlight their connection to different stochastic turnpike properties. Furthermore, we demonstrate how the proposed dissipativity and turnpike concepts can be utilized to analyze the performance of stochastic economic model predictive control schemes.

Mean field LQG games and teams

Schedule: December 18 9:00-9:30 Capital Suite 15

Bingchang Wang
Shandong University
Peoples Rep of China

Co-Author(s): Huanshui Zhang and Ji-Feng Zhang

Abstract:
This work studies linear-quadratic-Gaussian (LQG) mean field games and teams, where agents are coupled via dynamics and individual costs. We propose an approach of decoupling mean field FBSDEs (forward- backward stochastic differential equations), and obtained the necessary and sufficient conditions for uniform stabilization of mean field control systems. In this work, a new approach is developed for mean field games and control, and the essential difference and connection is also revealed between the direct method and the fixed point method. We further apply the approach to investiage feedback solutions to mean field LQG Stackelberg games.

Stochastic maximum principle for weighted mean-field system with application to ambiguity filtering

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Schedule: December 18 8:30-9:00   Capital Suite 15

Jie Xiong
Southern University of Science and Technology
Peoples Rep of China

Co-Author(s): YanyanTang and Jiaqi Zhang

Abstract:
We study the optimal control problem for a weighted mean-field system. A new feature of the control problem is that the coefficients depend on the state process as well as its weighted measure and the control variable. By applying variational technique, we establish a stochastic maximum principle. Also, we establish a sufficient condition of optimality. As an application, we investigate the optimal ambiguity filtering problem.

Computational Nonlinear Filtering Using A Deep Learning Approach

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Schedule: December 18 8:00-8:30   Capital Suite 15

George Yin
University of Connecticut
USA

Co-Author(s): Hongjian Qian, George Yin, Qing Zhang

Abstract:
Nonlinear filtering is a fundamental problem in signal processing, information theory, communication, control and optimization, and systems theory. In the 1960s, celebrated results on nonlinear filtering were obtained. Nevertheless, the computational issues for nonlinear filtering remained to be a long-standing (60-year-old) and challenging problem. In this talk, in lieu of treating the stochastic partial differential equations for obtaining the conditional distribution or conditional measure, we construct finite-dimensional approximations using deep neural networks for the optimal weights. Two recursions are used in the algorithm. One of them is the approximation of the optimal weight and the other is for approximating the optimal learning rate. If time permits, we will also discuss our recent work on system identification.

Linear-Quadratic Optimal Control Problem for Mean-Field SDEs With Certain Random Coefficients

Schedule: December 17 17:00-17:30   Capital Suite 15

Jiongmin Yong
University of Central Florida
USA

Co-Author(s): Jiongmin Yong

Abstract:
Motivated by linear-quadratic optimal control problems for mean-field SDEs with regime switching, we formulate an LQ problem governed by a standard Brownian motion, with the coefficients of the state equation and the weighting matrices/vectors being adapted to the filtration generated by the Markov chain independent of the Brownian motion governing the state equation. Through such a problem, we are going to approach our LQ problem in the following aspects: (1) Classical completing the squares gives a sufficient condition for the open-loop solvability of the LQ problem. However, this method is relevant to the optimality system, and therefore the optimal control could be anticipating which is not practical feasible. This leads to the following question: (2) Does the optimal control admit a non-anticipating representation? Under certain conditions, we found a closed-loop representation of open-loop optimal control, which is non-anticipating. Then it is natural to ask whether such a representation is itself optimal within the class of closed-loop controls. This leads to the problem (3) the closed-loop solvability of our LQ problem, a characterization is given. Finally, both open-loop and closed-loop solvability will be implied by the unform convexity of the cost functional in the control.

Optimization Methods Based on Optimal Control

Schedule: December 17 15:15-15:45   Capital Suite 15

Huanshui Zhang
Shandong University of Science and Technology
Peoples Rep of China

Co-Author(s): Hongxia Wang, Yeming Xu, Ziyuan Guo

Abstract:
Optimization is critical in Applied Mathematics. It is also a scientific basis for engineering and information fields. The development of optimization theory spans hundreds of years, featuring classic algorithms such as gradient descent, improved gradient descent, Newton`s iteration, and enhanced quasi-Newton methods. While these algorithms have acknowledged strengths, they also have limitations: gradient descent is stable but typically suffers from slow convergence, whereas Newton`s iteration converges quickly but can easily diverge, with similar issues also present in their improved versions. This report introduces a novel optimization algorithm that is both fast-converging and stable, with its core idea rooted in optimal control theory. The update size of the iterative algorithm is treated as a control input, designed to minimize the sum of the optimized function and the control energy at future moments. Minimizing the optimized function ensures the fastest convergence while minimizing the control energy guarantees the algorithm`s stability. By applying Taylor expansion for linearization, the algorithm is further refined into an iterative form, thus avoiding the complexities of solving nonlinear forward-backward difference equations. The new algorithm is rigorously shown to achieve super-linear convergence similar to Newton`s iteration, along with the stability characteristic of gradient descent. Moreover, this algorithm can recover gradient descent, Newton`s iteration, as well as improved accelerated gradient descent and regularized Newton methods, providing the first theoretical foundation for the scientific validity of both gradient descent and Newton`s iteration.

Pairs Trading: An Optimal Selling Rule with Constraints

Schedule: December 17 14:45-15:15 Capital Suite 15

Qing Zhang
University of Georgia
USA

Co-Author(s): Ruyi Liu, Jingzhi Tie, Zhen Wu, Qing Zhang

Abstract:
The talk is to focus on pairs trading selling rules. In pairs trading, a long position is held in one stock and a short position is held in another. The goal is to determine the optimal time to sell the long position and repurchase the short position in order to close the pair position. This talk presents an optimal pairs-trading selling rule with trading constraints. In particular, the underlying stock prices evolve according to a two-dimensional geometric Brownian motion, and the trading permission process is given in terms of a two-state {trading allowed, trading not allowed} Markov chain. It is shown that the optimal policy can be determined by a threshold curve which is obtained by solving the associated Hamilton- Jacobi-Bellman (HJB) equations (quasi-variational inequalities). A closed-form solution is obtained. A verification theorem is provided. Numerical experiments are also reported to demonstrate the optimal policies and value functions.

Special Session 17 : New developments on nonlinear expectations

Introduction: Motivated by uncertainty problems, risk measures and the super-hedging in finance, Shige Peng introduced a fully nonlinear expectation, called G-expectation, which effectively characterize the Knightian uncertainty of data. Under the G-expectation framework a new type of Brownian motion, the so-called G-Brownian motion, has been introduced and the stochastic calculus with respect to the G-Brownian motion has been developed. The G-expectation theory has been widely used to evaluate random outcomes with model ambiguity, not using a single probability measure, but using the supremum over a family of possibly mutually singular probability measures. The theory of nonlinear expectations has been developing very dynamically thanks to its many typical applications, so in economics, finance, information and computation science and many other domains. In our symposium we will study some new developments on nonlinear expectations.

Sequential propagation of chaos: theory and algorithms

Schedule: December 19 13:00-13:30 Capital Suite 14

Kai Du
Fudan University
Peoples Rep of China

Abstract:
A new class of particle systems with sequential interaction is proposed to approximate the McKean-Vlasov process that originally arises as the limit of the mean-field interacting particle system. The weighted empirical measure of this particle system is proved to converge to the law of the McKean-Vlasov process as the system grows. Numerical experiments are implemented to demonstrate the theoretical results.

Upper and lower covariance under sublinear expectation

Schedule: December 19 14:30-15:00 Capital Suite 14

Xinpeng Li
Shandong University
Peoples Rep of China

Abstract:
In this talk, we define the upper (resp. lower) covariance under sublinear expectation via a corresponding max-min-max (resp. min-max-min) problem and the related properties of covariances are obtained. In particular, we propose a fast algorithm of calculation for upper and lower covariances under a finite number of probabilities. As an application, our algorithm can be used to solve a class of quadratic programming problems which is an NP-hard problem in some cases, and we obtain a probabilistic representation of such quadratic programming problem.

Maximum principle for recursive optimal control problem of stochastic delayed evolution equations

Schedule: December 19 14:00-14:30 Capital Suite 14

Guomin Liu
Nankai University
Peoples Rep of China

Co-Author(s): Jian Song, Meng Wang

Abstract:
For a class of stochastic delay evolution equations driven by cylindrical Q-Wiener process, we study the Pontryagin`s maximum principle for the stochastic recursive optimal control problem. The delays are given as moving averages with respect to general finite measures and appear in all the coefficients of the control system. In particular, the final cost can contain the state delay. To derive the maximum principle, we introduce a new form of anticipated backward stochastic evolution equations with a terminal acting on an interval as adjoint equations of delay state equations, and deploy a proper dual analysis between them. Under certain convex assumptions, we also show the sufficiency of the maximum principle.

Nonlinear expectation algorithm in machine learning

Schedule: December 19 8:00-8:30 Capital Suite 14

Shige Peng
Shandong University
Peoples Rep of China

Abstract:
Most of machine learning algorithms are directly related to the concept of expectations. In particular, the analysis and calculation of the expected value of the loss functions or utility functions directly and deeply involve the optimization problem. But in most cases, people often make a very heavy assumption about the data samples, that is, the samples are required to be i.i.d., but it is well-known that the real world`s situation is often far from these conditions. In fact, this problem has become a well-known open and major issue in the field of machine learning. In this talk, we give more realistic assumptions: we only need to assume that the data sample is ``nonlinear iid``, e.g., iid under nonlinear expectations. Based on this more relaxed condition we obtain a very robust algorithm. The theoretical foundation is the law of large numbers and central limit theorem in the framework of sublinear expectations.

Quadratic Mean-Field Reflected BSDEs

Schedule: December 19 13:30-14:00 Capital Suite 14

Falei Wang
Shandong University
Peoples Rep of China

Abstract:
In this paper, we analyze mean-field reflected backward stochastic differential equations when the driver has quadratic growth in the second unknown z. Using a linearization technique and the BMO martingale theory, we first apply a fixed-point argument to establish the uniqueness and existence result for the case with bounded terminal condition and obstacle. Then, we develop a successive approximation procedure to remove the boundedness condition on the terminal condition and obstacle when the generator is concave (or convex) with respect to the second unknown. In a similar way, we also considermean reflected backward stochastic differential equations.Based on a joint work with Y. Hu and R. Moreau.

Value at risk model under sublinear expectation

Schedule: December 19 8:30-9:00 Capital Suite 14

Shuzhen Yang
Shandong University
Peoples Rep of China

Co-Author(s): Shige Peng

Abstract:
In this paper, we review the value at risk (VaR) model under sublinear expectation. We first consider the classical VaR model, and then introduce the basic concepts under sublinear expectation. Based on sublinear expectation, we show the definition of the VaR under model uncertainty, which is called G-VaR. Furthermore, we present three methods for estimating the parameters of the G-VaR model. Those are the long-time average method, the first-order autoregressive method, and the adapted learning method. In the end, we use S&P500 index to verify the performance of G-VaR model.

A rough path approach to robust filtering

Schedule: December 19 9:00-9:30 Capital Suite 14

Huilin Zhang
Shandong University
Peoples Rep of China

Co-Author(s): Peter K. Friz, Khoa Le

Abstract:
In 1978, J. M. C. Clark introduced the idea that the solution of the stochastic filtering problem should be naturally continuous in the observed signal. Such related theory is known as the robust filtering. In this talk, I would like to show the robust filtering by the rough path theory to the generality of related and non-Markovian case. Moreover, we show that the optional filter can be approximated by a discrete rough Euler scheme, and the optional convergence rate is obtained. This talk is based on an ongoing work with Peter K. Friz and Khoa Le.

Special Session 19 : New trends in inverse problems for partial differential equations

Introduction: Inverse problems for partial differential equations arise in many fields like medical imaging, nondestructive testing of materials, seismology, astronomy, and signal processing to mention but a few. These are problems where the cause for an observed or desired effect is to be determined. In many situations, the mathematical modeling of inverse problems is based on linear and nonlinear PDEs and reduces to determine unknown parameters or sources from indirect measurements. A characteristic property of these problems is that they are ill-posed. Therefore, the study of these problems is challenging and it involves techniques from many areas of mathematics and computing such as the analysis of PDEs, micro-local analysis, spectral theory, harmonic analysis, numerical analysis, probability, and machine learning. The field of inverse problems is experiencing tremendous growth leading to many interesting open problems that depend on novel approaches from areas within the discipline of mathematics as well as across different disciplines. In this mini-symposium, we plan to bring together experts working at the forefront of research in inverse problems for PDEs and to focus mainly on inverse problems for nonlinear partial differential equations addressing crucial aspects like uniqueness, stability, and reconstruction.

Localization of Point Scatterers via Sparse Optimization on Measures

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Schedule: December 18 14:45-15:15 Capital Suite 4

Giovanni S. Alberti
University of Genoa
Italy

Co-Author(s): Romain Petit, Matteo Santacesaria

Abstract:
We consider the inverse scattering problem for time-harmonic acoustic waves in a medium with pointwise inhomogeneities. In the Foldy--Lax model, the estimation of the scatterers` locations and intensities from far field measurements can be recast as the recovery of a discrete measure from nonlinear observations. We propose a ``linearize and locally optimize`` approach to perform this reconstruction. We first solve a convex program in the space of measures (known as the Beurling LASSO), which involves a linearization of the forward operator (the far field pattern in the Born approximation). Then, we locally minimize a second functional involving the nonlinear forward map, using the output of the first step as initialization. We provide guarantees that the output of the first step is close to the sought-after measure when the scatterers have small intensities and are sufficiently separated. We also provide numerical evidence that the second step still allows for accurate recovery in settings that are more involved.

Lipschitz-Stable Identification of Polyhedral Inclusions via Local Boundary Measurements

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Schedule: December 18 8:30-9:00 Capital Suite 4

Andrea Aspri
University of Milan
Italy

Co-Author(s): Elena Beretta, Elisa Francini, Sergio Vessella

Abstract:
In this talk, we address the nonlinear inverse problem of identifying polyhedral inclusions within a three-dimensional homogeneous isotropic conducting body using boundary measurements. Our focus is on the conductivity equation, where we derive a Lipschitz stability estimate for the Hausdorff distance between polyhedral inclusions, based on the local Dirichlet-to-Neumann (DtN) map. Additionally, we present a new uniqueness result in this general framework. This work is the result of a collaboration with Elena Beretta (NYU Abu Dhabi), Elisa Francini, and Sergio Vessella (University of Florence).

A Duality Between Scattering Poles and Interior Eigenvalues in Scattering Theory

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Schedule: December 18 13:30-14:00 Capital Suite 4

Fioralba Cakoni
Rutgers, The State University of New Jersey
USA

Co-Author(s): Fioralba Cakoni and Dana Ziberberg

Abstract:
The spectral properties of operators associated with scattering phenomena carry critical information about the scattering media. The theory of scattering resonances is a rich and elegant area of scattering theory. Although resonances are inherently dynamic in nature, they can be mathematically formulated as the poles of the meromorphic extension of the scattering operator. Scattering poles, which are complex with a negative imaginary part, encapsulate physical information: the real part of a pole corresponds to the rate of oscillation, while the imaginary part reflects the rate of decay. At a scattering pole, a non-zero scattered field exists even in the absence of an incident field. On the other side of this characterization, one could ask if there are frequencies for which an incident field does not scatter from the scattering object. For inhomogeneous media, this question leads to the concept of transmission eigenvalues, or interior eigenvalues in the case of obstacles. In this talk, we present a conceptually unified approach for characterizing and determining scattering poles and transmission eigenvalues for the scattering problem for inhomogeneous media. Our approach explores a duality that arises by interchanging the roles of incident and scattered fields. Both sets -the scattering poles and transmission eigenvalues- are connected to the kernel of the relative scattering operator, which maps incident fields to scattered fields. This operator corresponds to the exterior scattering problem for transmission eigenvalues and the interior scattering problem for scattering poles. We will conclude with numerical examples for the scattering by an obstacle as a proof of concept.

Uniqueness in the inverse boundary value problem for the weighted p-Laplacian in the plane

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Schedule: December 18 9:30-10:00 Capital Suite 4

Catalin I Carstea
National Yang Ming Chiao Tung University
Taiwan

Co-Author(s): Ali Feizmohammadi

Abstract:
In this talk I will show a proof of uniqueness in the inverse boundary value problem for the coefficient of the equation, in dimension 2. The approach involves the higher linearization procedure but, unlike the usual case, the linearization is done at a non-trivial solution. The question then reduces to an anisotropic Calderon problem.

Compressed sensing for photoacoustic tomography on the sphere

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Schedule: December 18 16:15-16:45 Capital Suite 4

Alessandro Felisi
University of Genoa
Italy

Abstract:
Photoacoustic Tomography (PAT) is an emerging medical imaging technology, distinguished as one of the most sophisticated hybrid modalities. Its primary aim is to map the high-contrast optical properties of biological tissues by leveraging high-resolution ultrasound measurements. Mathematically, this can be framed as an inverse source problem for the wave equation over a specific domain. In this talk, I will show how, by assuming signal sparsity, it is possible to establish stable recovery guarantees when the domain is spherical and the data collection is restricted to a limited portion of the boundary. The result is a consequence of a general compressed sensing framework for inverse problems developed with co-authors and stability estimates tailored to this specific problem.

Reconstructing early stages of prostate cancer growth

Schedule: December 18 14:00-14:30 Capital Suite 4

Matteo Fornoni
University of Pavia
Italy

Co-Author(s): Elena Beretta, Cecilia Cavaterra, Guillermo Lorenzo, Elisabetta Rocca

Abstract:
To facilitate the estimation of disease dynamics and better guide ensuing clinical decisions, we investigate an inverse problem enabling the reconstruction of earlier tumour stages by using a single diagnostic MRI scan. We describe tumour dynamics with an Allen--Cahn phase-field model driven by a generic nutrient that follows reaction-diffusion dynamics. The model is completed with another reaction-diffusion equation for the local production of prostate-specific antigen, a key prostate cancer biomarker. We first improve previous well-posedness results by showing that the solution operator is continuously Fr\`{e}chet differentiable. We then analyse the backward inverse problem concerning the reconstruction of earlier tumour stages starting from measurements of the model variables at the final time. Since this problem is severely ill-posed, only very weak conditional stability of logarithmic type can be recovered from the terminal data. Nevertheless, by restricting the unknowns to a compact subset of a finite-dimensional subspace, we can derive an optimal Lipschitz stability estimate. Such results then lead to the development of a locally convergent iterative reconstruction algorithm based on the Landweber scheme. We finally show some numerical experiments validating the obtained theoretical results.

Uniqueness and stability in anisotropic inverse problems.

Schedule: December 18 9:00-9:30 Capital Suite 4

Romina Gaburro
University of Limerick
Ireland

Abstract:
In this talk we discuss the issues of uniqueness and stability in anisotropic inverse problems. As is well known, these are typically ill-posed and nonlinear problems. In the presence of anisotropy, there is a well-known fundamental obstruction to uniqueness due to Tartar: any diffeomorphism of the domain under investigation, which keeps the boundary fixed, modifies the physical properties under investigation (e.g. the conductivity of the medium in the celebrated Calder\`on`s inverse conductivity problem) but such change is not visible in the measurements of the inverse problem (e.g. in the Dirichlet-to-Neumann map in Calder\`on`s problem). In this talk we discuss recent advancements in anisotropic inverse problems, in particular regarding the issues of uniqueness and stability.

Direct sampling methods for elliptic inverse problems

Schedule: December 18 15:15-15:45 Capital Suite 4

Bangti Jin
The Chinese University of Hong Kong
Hong Kong

Abstract:
Elliptic inverse problems represent a very broad range of applied problems. Traditionally these problems are solved using regularized least-squares methods, which however are computationally expensive. In this talk, we describe a novel direct sampling method for solving several model elliptic inverse problems, and present numerical experiments to illustrate the performance.

Calderon problem for fractional Schrodinger operators on closed Riemannian manifolds

Schedule: December 18 17:00-17:30 Capital Suite 4

Katya Krupchyk
University of California, Irvine
USA

Abstract:
In this talk, we will discuss an analog of the anisotropic Calderon problem for fractional Schrodinger operators on closed Riemannian manifolds of dimension two and higher. We will demonstrate that the knowledge of a Cauchy data set of solutions to the fractional Schrodinger equation, given on an open nonempty subset of the manifold, determines both the Riemannian manifold up to an isometry and the potential up to the corresponding gauge transformation, under certain geometric assumptions on the manifold as well as the observation set. This is joint work with Ali Feizmohammadi and Gunther Uhlmann.

Construction of weakly neutral Inclusions via imperfect interfaces

Schedule: December 18 15:45-16:15 Capital Suite 4

Mikyoung Lim
Korea Advanced Institute of Science and Technology
Korea

Co-Author(s): Mikyoung Lim

Abstract:
We consider the problem of planar conductivity inclusion with the imperfect interface condition, characterized by an interface parameter defined as a function on the inclusion boundary. When embedded in a medium with different conductivity, the inclusion causes the perturbation in the incident background field. Using the multipole expansion of this perturbation, we determine the interface parameter for a given inclusion of arbitrary shape that results in negligible perturbations under all uniform incident fields.

Direct and inverse problems for viscoelastic models of dislocations

Schedule: December 18 18:00-18:30 Capital Suite 4

Anna L Mazzucato
Penn State University
USA

Co-Author(s): Arum Lee

Abstract:
We discuss both the forward as well as an inverse problem for viscoelastic models of dislocations that represent aseismic, creeping faults. We study a nonlocal linear slip rate-traction model and a nonlinear local slip rate-slip friction model. The inverse problem consists in determining the geometry of the dislocation surface as well as the slip vector from surface displacement measurements. This is joint work with PhD student Arum Lee, and extends prior results, joint work with Andrea Aspri, Elena Beretta, and Maarten de Hoop.

Nonlinearity helps convergence of the inverse Born series

Schedule: December 18 13:00-13:30 Capital Suite 4

Shari Moskow
Drexel University
USA

Co-Author(s): Nicholas Difilippis, John Schotland

Abstract:
In previous work of the authors, we investigated the Born and inverse Born series for a scalar wave equation with linear and nonlinear terms, the nonlinearity being cubic of Kerr type. We reported conditions which guarantee convergence of the inverse Born series, enabling recovery of the coefficients of the linear and nonlinear terms. In this work, we show that if the coefficient of the linear term is known, an arbitrarily strong Kerr nonlinearity can be reconstructed, for sufficiently small data. Additionally, we show that similar convergence results hold for general polynomial nonlinearities. Our results are illustrated with numerical examples.

Optimality of stabilized finite element methods for elliptic unique continuation

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Schedule: December 18 17:30-18:00 Capital Suite 4

Lauri Oksanen
University of Helsinki
Finland

Co-Author(s): Erik Burman, Mihai Nechita

Abstract:
We consider finite element approximation in the context of the ill-posed elliptic unique continuation problem, and introduce a notion of optimal error estimates that includes convergence with respect to a mesh parameter and perturbations in data. The rate of convergence is determined by the conditional stability of the underlying continuous problem and the polynomial order of the finite element approximation space. We present a stabilized finite element method satisfying the optimal estimate, and discuss a proof showing that no finite element approximation can converge at a better rate.

Stable determination of the Winkler subgrade coefficient in a nanoplate

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Schedule: December 18 8:00-8:30 Capital Suite 4

Eva Sincich
University of Trieste
Italy

Co-Author(s): G. Alessandrini, A. Morassi, E. Rosset, S. Vessella

Abstract:
We study the inverse problem of determining the Winkler coefficient in a nanoplate resting on an elastic foundation and clamped at the boundary. The nanoplate is described within a simplified strain gradient elasticity theory for isotropic materials, under the Kirchhoff-Love kinematic assumptions in infinitesimal deformation. We prove a global H\{o}lder stability estimate of the subgrade coefficient by performing a single interior measurement of the transverse deflection of the nanoplate induced by a load concentrated at one point.

Passive manipulation of electromagnetic fields

Schedule: December 18 12:30-13:00 Capital Suite 4

Michael Vogelius
Rutgers University
USA

Abstract:
In this talk I shall discuss some theoretical results concerning invisibility, non-scattering, and second harmonic generation. The results are in frequency domain and are formulated in the context of the Helmholtz equation.

Special Session 20 : Stochastic analysis, inverse problems and related topics

Introduction: The session aims to bring together researchers on stochastic analysis, inverse problems and related fields to discuss recent advances as well as to foster collaborations. Topics include but not limited to analysis and computation of stochastic differential equations, inverse problems for PDEs, uncertainty quantification, mean fields games, and stochastic control and optimization.

Solving the phaseless inverse source problem of the biharmonic equation

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Schedule: December 17 17:30-18:00 Capital Suite 4

Yukun Guo
Harbin Institute of Technology
Peoples Rep of China

Co-Author(s): Yan Chang, Yue Zhao

Abstract:
This talk concerns an inverse source problem for the biharmonic wave equation. A two-stage numerical method is proposed to identify the unknown source from the multifrequency phaseless data. In the first stage, we introduce some artificial auxiliary point sources to the inverse source system and establish a phase retrieval formula. Theoretically, we point out that the phase can be uniquely determined and estimate the stability of this phase retrieval approach. Once the phase information is retrieved, the Fourier method is adopted to reconstruct the source function from the phased multifrequency data. Numerical examples will be presented to verify the performance of the proposed method.

Aspects of the ill-posed inverse problem of deautoconvolution

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Schedule: December 17 17:00-17:30 Capital Suite 4

Bernd Hofmann
TU Chemnitz
Germany

Co-Author(s): Yu Deng and Frank Werner

Abstract:
There is extensive mathematical and physical literature on the ill-posed inverse problem of deautoconvolution for the reconstruction of real-valued as well as complex-valued functions x with support on the unit interval $[0,1] \subset \mathbb{R}$ from its autoconvolution $y = x * x$, and we mention some application in laser optics. However, little is known about the reconstruction of functions with support on the d-dimensional unit cube $[0,1]^d \subset \mathbb{R}^d$ from autoconvolution data. This talk presents recent analytical and numerical results for deautoconvolution in two and more dimensions with different types of data. In particular, there are new assertions on uniqueness or twofoldness of solutions to the deautoconvolution problem in the multidimensional case, which are based on extensions of the Titchmarsh convolution theorem published by Lions and Mikusi\`{n}ski.

Inverse problems in population models

Schedule: December 18 9:30-10:00 Capital Suite 4

Catharine WK Lo
City University of Hong Kong
Hong Kong

Co-Author(s): Yuhan Li, Hongyu Liu

Abstract:
I will discuss several recent works focusing on inverse problems in population ecological models, such as Lotka-Volterra models, chemotaxis models, and aggregation models. These works delve into the unique identifiability of multiple parameters in these models, including interaction terms, compression, prey attack, crowding, carrying capacity, diffusion coefficients, environmental factors such as gravitational potential and the oxygen carrying-capacity. These studies contribute unique insights and novel methodologies to advance the understanding of inverse problems for complex systems across diverse scientific disciplines.

Time Behavior of Acoustic Resonators and Applications to Inverse Problems

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Schedule: December 18 8:30-9:00 Capital Suite 4

Mourad Sini
Austrian Academy of Sciences
Austria

Co-Author(s): Long Li and Soumen Senapati

Abstract:
We deal with the time-domain acoustic wave propagation in the presence of subwavelength resonators given by small scaled bubbles enjoying high contrasting mass density and bulk modulus. It is well known that such bubbles generate a single subwavelength resonance called Minnaert resonance. We derive the point-approximation expansion of the wave field in terms of the contrasting scales. The dominant part is a sum of two terms. The first one, i.e. the primary wave, is the one generated in the absence of the bubble. The second one, i.e. the resonant wave, is generated by the interaction between the bubble and the background. 1. We estimate the birth-time of the resonant wave. This is nothing but the travel time needed by any wave to reach the location of the bubble. 2. We show that the life-time of the resonant wave is inversely proportional to the imaginary part of the resonance. 3. In addition, the period of the resonant wave is characterized by the real part of this resonance. The birth time, life-time and period have signatures of the background where the bubble is located. They have important applications in inverse problems for imaging modalities using contrast agents.

Generating customized field concentration via surface transmission resonance

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Schedule: December 17 18:00-18:30 Capital Suite 4

HU YUEGUANG
City University of HONG KONG
Hong Kong

Co-Author(s): YUEGUANG HU, HONGYU LIU, XIANCHAO WANG, AND DEYUE ZHANG

Abstract:
In this paper, we develop a mathematical framework for generating strong customized field concentration locally around the inhomogeneous medium inclusion via surface transmission resonance. The purpose of this paper is twofold. Firstly, we show that for a given inclusion embedded in an otherwise uniformly homogeneous background space, we can design an incident field to generate strong localized field concentration at any specified places around the inclusion. The aforementioned customized field concentration is crucially reliant on the peculiar spectral and geometric patterns of certain transmission eigenfunctions. Secondly, we prove the existence of a sequence of transmission eigenfunctions for a specific wavenumber and they exhibit distinct surface resonant behaviors, accompanying strong surface-localization and surface-oscillation properties. These eigenfunctions as the surface transmission resonant modes fulfill the requirement for generating the field concentration.

Propagation of chaos rate across dimensions and the L^p convergence rate of the numerical approximation for super-linear MV-SDEs

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Schedule: December 18 9:00-9:30 Capital Suite 4

Yuhang Zhang
Harbin Institute of Technology Zhengzhou Research Institute
Peoples Rep of China

Co-Author(s): Minghui Song

Abstract:
In this paper, we study the $\mathcal{L}^p$ convergence rate of the numerical approximation to the solution of the McKean-Vlasov stochastic differential equations (MV-SDEs) with super-linear growth in the spatial component in the drift. In contrast to standard SDEs, MV-SDEs require an approximation of the distribution law, and here we adopt the stochastic particle method to approximate the true measure using the empirical measure, the time-stepping scheme adopted here is the tamed Euler method. First, we show the strong convergence rate of the propagation of chaos (PoC) is of order $O(N^{-1/2})$ under the $\mathcal{L}^p$-norm for any $p \geq 2$, where N is the number of weakly interacting particles. This order is not only better than the existing results, but it is also across dimensions. In the second part we prove that the tamed Euler method is strongly convergent with the order of $O(\Delta^{1/2})$, which is consistent with the classical results. Finally, we present numerical experiments which confirm our theoretical estimates.

Special Session 21 : Fluid dynamics and PDE

Introduction:

Emergence of peaked singularities in the Euler-Poisson system

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Schedule: December 20 8:30-9:00 Conference Hall B (D)

Junsik Bae
Korea Advanced Institute of Science and Technology
Korea

Abstract:
We consider the one-dimensional Euler-Poisson system equipped with the Boltzmann relation and provide the exact asymptotic behavior of the peaked solitary wave solutions near the peak. This enables us to study the cold ion limit of the peaked solitary waves with the sharp range of Holder exponents. Furthermore, we provide numerical evidence for C^1 blow-up solutions to the pressureless Euler-Poisson system, whose blow-up profiles are asymptotically similar to its peaked solitary waves and exhibit a different form of blow-up compared to the Burgers-type (shock-like) blow-up. This is a joint work with Sang-Hyuck Moon(UNIST) and Kwan Woo(SNU).

The linear BBM-equation on the quarter-plane, revisited: A rigorous novel approach and unexpected phenomena

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Schedule: December 20 8:00-8:30 Conference Hall B (D)

Andreas Chatziafratis
University of California at Santa Cruz
USA

Co-Author(s): Jerry L. Bona, Hongqiu Chen, Spyridon Kamvissis

Abstract:
We shall discuss some of our recent findings concerning the rigorous solution and analysis of fully non-homogeneous initial-boundary-value problems for the linearized Benjamin-Bona-Mahony equation on the spatiotemporal quarter-plane. The approach is based on complex-analytic tools and a rigorous implementation of the Fokas unified transform method. Explicit solution formulae for the forced linear problem are thus derived in terms of contour integrals and analyzed for quite general initial values and boundary conditions in classical function spaces. The a posteriori pointwise verification of the closed-form representations brings to the fore a single compatibility condition that must be obeyed by smooth data for a well-defined global solution, thereby indicating a type of boundary-smoothing effect. Subsequent boundary-behaviour analysis allows for a uniqueness theorem to be established, relying also on an energy-type argument. Additional surprising observations (e.g., asymptotic instabilities) will be highlighted. For instance, both for Dirichlet and for Neumann boundary conditions, asymptotic periodicity holds. However, for Robin boundary conditions, we find not only that solutions lack the asymptotic periodicity property, but they in fact display instability, growing in amplitude exponentially in time. This is joint work with J.L. Bona, H. Chen and S. Kamvissis.

Water Wave Models: Bore Propagations

Schedule: December 20 15:30-16:00 Conference Hall B (D)

Hongqiu Chen
University of Memphis
USA

Abstract:

Considered here are two unidirectional water wave models for small amplitude long waves on the surface of ai ideal fluid $\eta t + \eta x + \frac{3}{4}\alpha(\eta^2)_x - \frac{1}{6}\beta\eta_{xxt} = 0$, and the higher-order model equation

$$\eta t + \eta x - \gamma 1\beta\eta_{xxt} + \gamma 2\beta\eta xxx + \delta 1\beta^2\eta_{xxxxt} + \delta 2\beta^2\eta xxxxx + \frac{3}{4}\alpha(\eta^2)x + \alpha\beta\Big(\gamma(\eta^2)xx - \frac{7}{48}\eta_x^2\Big)_x - \frac{1}{8}\alpha^2(\eta^3)_x =$$

where $\eta = \eta(x,t)$, $x \in \mathbb{R}$ and $t \geq 0$, is the deviation of the free surface from its rest position at the point corresponding to x at time t. $\alpha, \beta\, \gamma 1, \gamma 2, \delta 1, \delta 2, \gamma$ are physical parameters. In this talk, we discuss well-posednes issues when the initial dada is non-localized.

Stability and instability problems of MHD

Schedule: December 20 15:00-15:30 Conference Hall B (D)

Mimi Dai
University of Illinois at Chicago
USA

Abstract:

The stability and instability problems for magnetohydrodynamics (MHD) are challenging due to the coupling nature and intricate interactions of the flow and magnetic field. We consider some particular steady states of MHD and investigate the long term behavior of the perturbed system around such steady states.

A Hamiltonian Dysthe equation for hydroelastic waves in a compressed ice sheet.

Schedule: December 20 14:30-15:00 Conference Hall B (D)

Adilbek Kairzhan
Nazarbayev University
Kazakhstan

Co-Author(s): Philippe Guyenne, Catherine Sulem

Abstract:

In this talk we consider nonlinear hydroelastic waves along a compressed ice sheet lying on top of a two-dimensional fluid of infinite depth. Based on a Hamiltonian formulation of this problem and by applying techniques from Hamiltonian perturbation theory, a Hamiltonian Dysthe equation is derived for the slowly varying envelope of modulated wavetrains. The derivation is complicated by the presence of cubic resonances. A Birkhoff normal form transformation is introduced to eliminate non-resonant triads while accommodating resonant ones. We also test the newly obtained Dysthe model against direct numerical simulations of the full Euler equations, and very good agreement is observed.

Grounded shallow ice sheets melting as an obstacle problem

Schedule: December 20 14:00-14:30 Conference Hall B (D)

Paolo Piersanti
The Chinese University of Hong Kong Shenzhen
Peoples Rep of China

Co-Author(s): Roger Temam

Abstract:
In this talk, which is the result of a joint work of the speaker with Roger Temam (Indiana University), we will study a model describing the evolution of the thickness of a grounded shallow ice sheet. Since the thickness of the ice sheet is constrained to be nonnegative, the problem under consideration is an obstacle problem. A rigorous modelling exercise shows that this model, which is time-dependent, is governed by a set of variational inequalities that involve nonlinearities in the time derivative and in the elliptic term. In order to establish the existence of solutions for the time-dependent model we recovered, formally, upon completion of the aforementioned modelling exercise, we first depart from a penalized relaxation, and we show - by resorting to a discretization in time - that the corresponding relaxed problem admits at least one solution. Secondly, by means of Dubinskii`s lemma and other new results and new inequalities, we extract compactness for the family of solutions of the relaxed problems and we show that this family of solutions converges to a solution of a doubly nonlinear parabolic variational inequality akin to the one that was recovered formally.

Special Session 22 : Recent advances in mean field games for crowd dynamics

Introduction: The purpose of the proposed special session is to bring together experts in the area of Mean Field Games (MFGs) to present their progress on this topic. MFG systems play important roles in modeling crowd dynamics, where the evolution of a pedestrian depends on the surrounding crowd. The field has witnessed significant recent advances in the study of mathematical analysis and long-term behavior. The goal of the session is to gather participants working on various aspects of the Mean Field Games field, including both application-oriented and theoretical aspects. By bringing together both young and experienced researchers, we aim to stimulate and initiate expedient future developments in this active field of study at the intersection of partial differential equation analysis and applications

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A Stationary First-Order Mean-Field Games with Novel Mixed Boundary Conditions

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Schedule: December 17 15:45-16:15 Conference Hall B (A)

AbdulRahman M Alharbi
Islamic University at Al-Madinah / King AbdUllah University of Science and Technology
Saudi Arabia

Co-Author(s): AbdulRahman, Diogo Gomes, and Yuri Ashrafyan

Abstract:
In this presentation, I will discuss recent joint work with Diogo Gomes and Yuri Ashrafyan, where we investigate a first-order mean-field game (MFG) model with a novel mixed boundary condition. The new boundary conditions split the boundary into two parts: an entrance with an inflow Neumann boundary condition and an exit with a relaxed Dirichlet condition and a relaxed outflow Neumann condition. We further impose an auxiliary contact-set condition on the exit portion of the boundary that links the other two conditions. This approach offers three advantages. It indicates the exit/entry regions of the boundary based on the general structure without the need to know the exact values of boundary data, addresses the lack of uniqueness issues associated with Neumann boundary conditions, and prevents the artificial inflow of virtual agents through the exit boundary caused by an excessively high Dirichlet condition. The interior behavior of our model adheres to the standard MFG structure, consisting of a coupled system of a first-order separable Hamilton-Jacobi equation and a stationary transport equation. We exploit the separability of the Hamiltonian to establish a corresponding variational formulation for the MFG, which we use to prove the existence of solutions and the uniqueness of the gradient of the value function.

Nonseparable mean field games with pseudomeasure initial distributions

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Schedule: December 17 13:00-13:30 Conference Hall B (A)

David M. Ambrose
Drexel University
USA

Abstract:
In order to use solutions of the mean field games PDE system to control solutions of N-player games as N goes to infinity, we must be able to take initial distributions which are the sum of Dirac masses. Relatedly, the natural space of data is probability measures. In a number of works (including those by the speaker), instead, subsets of the set of probability measures are used, such as probability measures induced by smooth functions. In this work, we instead take a larger space of data than probability measures, considering pseudomeasures as initial distributions. We give a class of nonseparable Hamiltonians for which we can prove existence of solutions of the mean field games PDE system with pseudomeasure initial data. This includes joint work with Milton Lopes Filho, Anna Mazzucato, and Helena Nussenzveig Lopes.

On quasi-stationary Mean Field Games of Controls

Schedule: December 17 8:00-8:30 Conference Hall B (A)

Fabio Camilli
Sapienza Universita` di Roma
Italy

Co-Author(s): Claudio Marchi

Abstract:
We consider quasi-stationary Mean Field Games of Controls. In these problems, the strategy-choice mechanism of the agent differs from the classical one: the generic agent cannot predict the evolution of the population and instead chooses its strategy based solely on the information available at the current moment, without anticipating future developments. Furthermore, the dynamics of an individual agent is influenced not only by the distribution of agents but also by the distribution of their optimal strategies. We demonstrate the existence and uniqueness of the solution for the corresponding quasi-stationary Mean Field Games system under various sets of hypotheses and provide examples of models that fall within these parameters.

Algorithm for Deterministic Mean Field Games

Schedule: December 17 9:00-9:30 Conference Hall B (A)

Elisabetta Carlini
Sapienza University
Italy

Abstract:
We propose a numerical scheme to approximate deterministic Mean Field Games based on semi-Lagrangian and Lagrange-Galerkin methods. We discuss a convergence result of the nonlinear discrete system, obtained by discretization, to the MFGs system in general dimension. We also propose a Policy Algorithm to solve the nonlinear discrete system and present some numerical results.

Degenerate Fully Nonlinear Mean Field Game with Nonlocal Diffusion

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Schedule: December 17 13:30-14:00 Conference Hall B (A)

Indranil Chowdhury
Indian Institute of Technology, Kanpur
India

Co-Author(s): Espen R. Jakobsen and Milosz Krupski

Abstract:
We consider a strongly degenerate and fully nonlinear MFG system. Our MFG involves a controlled pure jump (nonlocal) Levy diffusion of order less than one, and monotone, smoothing couplings. We study the existence and uniqueness results of such problems. We discuss the key difficulty in obtaining uniqueness for the corresponding Fokker--Planck equation which has degenerate and low regularity diffusion coefficients: since the regularity of the coefficient and the order of the diffusion are interdependent, it holds when the order is sufficiently low.

Weak-strong uniqueness for solutions to MFGs

Schedule: December 17 17:00-17:30 Conference Hall B (A)

Rita Ferreira
KAUST
Saudi Arabia

Co-Author(s): Diogo Gomes and Vardan Voskanyan

Abstract:
In this talk, we address the question of uniqueness of weak solutions for stationary first-order Mean-Field Games (MFGs). Despite well-established existence results, establishing uniqueness, particularly for weaker solutions in the sense of monotone operators, remains an open challenge. Building upon the framework of monotonicity methods, we introduce a linearization method that enables us to prove a weak-strong uniqueness result for stationary MFG systems on the d-dimensional torus. In particular, we give explicit conditions under which this uniqueness holds.

A mean-field-game approach to overfishing

Schedule: December 17 15:15-15:45 Conference Hall B (A)

Ziad Kobeissi
Inria Saclay, CentraleSupelec, University Paris-Saclay
France

Co-Author(s): Idriss Mazari-Fouquer, Domenec Ruiz-Ballet

Abstract:
In this presentation, we propose a novel model for managing fisheries, described by a system of three coupled partial differential equations. The first is a reaction-diffusion equation representing the dynamics of the fish population, which follows standard approaches in the mathematical literature on spatial ecology. The other two equations are derived using a mean-field-game framework to model a large population of fishermen, where the number of fishermen is assumed to be large enough to be treated as infinite. Each fisherman aims to maximize their individual profit, calculated as the revenue from selling fish minus the cost of moving their boat. Under two different structural assumptions about the nonlinearities in the fish dynamics, we prove theoretical results illustrating the tragedy of the commons. Specifically, we show that a lack of coordination among fishermen can significantly harm, or even lead to the extinction of, the fish population. Our findings are supported by several numerical simulations.

One`s experience vs. population`s knowledge in mean field games and control

Schedule: December 17 14:00-14:30 Conference Hall B (A)

Hicham Kouhkouh
University of Graz
Austria

Abstract:
I shall present a novel viewpoint on ergodic Mean-Field Games and ergodic Mean-Field Control (or control of McKean-Vlasov processes), showing that an equilibrium and an optimal strategy of a large number of interacting agents can be obtained by one ``experienced`` agent.

Machine Learning For Master Equations in Mean Field Games

Schedule: December 17 18:30-19:00 Conference Hall B (A)

Mathieu Lauriere
NYU Shanghai
Peoples Rep of China

Co-Author(s): Asaf Cohen, Ethan Zell

Abstract:
Mean field games have been introduced to study games with many players. Since their introduction, they have found numerous potential applications and the theory has been extensively developed. While forward-backward systems of partial or stochastic differential equations can be used to characterize Nash equilibria with a fixed initial distribution, the Master equation introduced by P.-L. Lions provides a tool to solve the problem globally, for any initial condition. However this equation is a partial differential equation posed on the space of measures, which raises significant challenges to solve it numerically. In this talk, we will present several computational methods that have been proposed to tackle Master equations. Theoretical convergence results and numerical experiments will be presented. Mostly based on joint work with Asaf Cohen and Ethan Zell.

Minimal solutions of master equations for extended mean field games

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Schedule: December 17 18:00-18:30 Conference Hall B (A)

Chenchen Mou
City University of Hong Kong
Peoples Rep of China

Co-Author(s): Jianfeng Zhang

Abstract:
In an extended mean field game, the vector field governing the flow of the population can be different from that of the individual player at some mean field equilibrium. This new class strictly includes the standard mean field games. It is well known that, without any monotonicity conditions, mean field games typically contain multiple mean field equilibria and the wellposedness of their corresponding master equations fails. In this paper, a partial order for the set of probability measure flows is proposed to compare different mean field equilibria. The minimal and maximal mean field equilibria under this partial order are constructed and satisfy the flow property. The corresponding value functions, however, are in general discontinuous. We thus introduce a notion of weak-viscosity solutions for the master equation and verify that the value functions are indeed weak-viscosity solutions. Moreover, a comparison principle for weak-viscosity semi-solutions is established and thus these two value functions serve as the minimal and maximal weak-viscosity solutions in appropriate sense. In particular, when these two value functions coincide, the value function becomes the unique weak-viscosity solution to the master equation. The novelties of the work persist even when restricted to the standard mean field games. This is based on a joint work with Jianfeng Zhang.

Monotone inclusion methods for a class of second-order non-potential mean-field games

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Schedule: December 17 8:30-9:00 Conference Hall B (A)

Levon Nurbekyan
Emory University
USA

Co-Author(s): Siting Liu (UCR), Yat Tin Chow (UCR)

Abstract:
We propose a monotone splitting algorithm for solving a class of second-order non-potential mean-field games. Following [Achdou, Capuzzo-Dolcetta, Mean Field Games: Numerical Methods, SINUM (2010)], we introduce a finite-difference scheme and observe that the scheme represents first-order optimality conditions for a primal-dual pair of monotone inclusions. Based on this observation, we prove that the finite-difference system obtains a solution that can be provably recovered by an extension of the celebrated primal-dual hybrid gradient (PDHG) algorithm.

Analysis and Numerical Approximation of Mean Field Game Partial Differential Inclusions

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Schedule: December 17 9:30-10:00 Conference Hall B (A)

Yohance Osborne
Durham University
England

Co-Author(s): Iain Smears

Abstract:
The Mean Field Game (MFG) system of Partial Differential Equations (PDE), introduced by Lasry \& Lions in 2006, models Nash equilibria of large population stochastic differential games of optimal control where the players of the game have unique optimal controls, and the convex Hamiltonian of the underlying optimal control problem is differentiable. In this talk, we introduce a new class of model problems called Mean Field Game Partial Differential Inclusions (MFG PDI), which extend the MFG system of Lasry and Lions to situations where players may have possibly nonunique optimal controls, and the resulting Hamiltonian of the underlying optimal control problem is not required to be differentiable. We prove the existence of unique weak solutions to MFG PDI for a broad class of Hamiltonians that are convex, Lipschitz, but possibly nondifferentiable, under a monotonicity condition similar to one considered previously by Lasry \& Lions. Moreover, we introduce a class of monotone finite element discretizations of the weak formulation of MFG PDI and present theorems on the strong convergence of the approximations to the value function in the $L^2(H_0^1)$-norm and the strong convergence of the approximations to the density function in $L^p(L^2)$-norms. We conclude the talk with discussion of numerical experiments involving non-smooth solutions.

Stability Analysis of a Non-Separable Mean-Field Games for Pedestrian Flow in Large Corridors

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Schedule: December 17 16:15-16:45 Conference Hall B (A)

Eliot Pacherie
CNRS & Cergy University
France

Co-Author(s): Mohamed Ghattassi and Nader Masmoudi

Abstract:
We investigate the existence and stability of small perturbations of constant states of the generalized Hughes model for pedestrian flow in an infinitely large corridor. We show that constant flows are stable under a condition on the density. Our findings indicates that when the density is less than half of the maximum density, which is the Lasry-Lions monotonicity condition, we can control the perturbation and prove postive stability results for the nonlinear Generalized Hughes model.

Existence of Solutions to MFG Problems via Monotone Operators

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Schedule: December 17 17:30-18:00 Conference Hall B (A)

Melih Ucer
King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): Rita Ferreira, Diogo Gomes

Abstract:
The theory of monotone operators is the basis of a standard method of proving existence of solutions to Dirichlet problems involving a second-order elliptic PDE of the divergence form. In this context, it generalizes the direct method in the calculus of variations as well as the Lax-Milgram theorem. On the other hand, presence of a monotonicity structure in mean field games has been known since the early papers of Lions et al. Moreover, this monotonicity property was exploited by Ferreira et al for proving existence of solutions in a weak sense, to various MFG problems. More recently, in ongoing joint work with Ferreira and Gomes, we discovered how to systematize the aforementioned existence proofs using the abstract machinery of the monotone operator theory. Consequently, we achieve simpler and unified proofs for a wider range of problems. Furthermore, with new a priori bounds based on a novel idea, we obtain solutions in a stronger sense.

Special Session 23 : New trends in pattern formations and dynamics for dissipative systems and related topics

Introduction: Many biological and physical phenomena can be described by mathematical models with a dissipative structure. These include nonlinear reaction-diffusion systems and other partial differential equation models, nonlocal evolution models and functional differential equation models. In this session, we will bring together recent studies on solutions of various dissipative dynamical systems related to spatial-temporal pattern formation, propagation dynamics, and symmetry breaking bifurcations, presenting new aspects of solutions capturing nonlinear phenomena together with underlying solution structures.

Coexistence of two strongly competitive species in a reaction-advection-diffusion system

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Schedule: December 18 8:00-8:30 Capital Suite 15

Inkyung Ahn
Korea University
Korea

Co-Author(s): Wonhyung Choi

Abstract:
The main focus of this article is to investigate the behavior of two strongly competitive species in a spatially heterogeneous environment using a Lotka-Volterra-type reaction-advection-diffusion model. The model assumes that one species diffuses at a constant rate while the other species moves toward a more favorable environment through constant diffusion and directional movement. The study finds that no stable coexistence can be guaranteed when both species disperse randomly. In contrast, stable coexistence between the two species is possible when one of the species exhibits advection-diffusion. The study also reveals the existence of unstable coexistence imposed by bistability in a strongly competitive system, regardless of the diffusion type. The study concludes that the species moving toward a better environment has a competitive advantage, allowing them to survive even when their population density is initially low. Finally, the study identifies the unique globally asymptotically stable coexistence steady states of the system at high advection rates.

Pulse dynamics on a star-shaped metric graph with different widths

Schedule: December 18 15:15-15:45 Capital Suite 15

Shin-Ichiro Ei
Josai University
Japan

Co-Author(s): Ryota Asami, Haruki Shimatani

Abstract:
The motion of pulses is considered on a star-shaped metric graph composed of paths with different widths. We derive the equation that describes the motion of a pulse based on these widths. As applications, we demonstrate the motion towards the junction for pulses described by the FitzHugh-Nagumo equation and the Gierer-Meinhardt equation.

Pattern formation in IGP-communities with anti-predator behavior

Schedule: December 18 15:45-16:15 Capital Suite 15

Gaetana Gambino
University of Palermo, Department of Mathematics and Computer Science
Italy

Abstract:
A wide variety of predatory relationships are possible in ecological communities and ecosystems. Intraguild predation, or IGP, represents a combination of predation and competition in which species rely on the same prey resources and benefit from preying on each other. In this talk we shall describe the spatiotemporal dynamics of a three-species reaction-diffusion system, in which the IGP local interaction is of Lotka-Volterra type and the IG-Prey exhibits anti-predator behavior, dispersing along local gradients in predator density. We first show that the local dynamics support the bistability of the spatially homogeneous coexistence equilibrium with oscillations due to a subcritical Hopf bifurcation. We demonstrate that the predator avoidance strategy ignites cross-diffusion-driven Turing instability, leading to the emergence of stationary patterns. Via weakly nonlinear analysis, we derive asymptotic profiles of emergent stationary patterns, revealing that anti-predator behavior can account for the IG-prey and IG-predator segregation patterns observed in the ecology literature. We also prove that the predator avoidance strategy can stabilize coexistence states in IGP communities beyond the conditions imposed by the corresponding spatially homogeneous model. Finally, we investigate the dynamics near a codimension-two Turing-Hopf point, reproducing the time-oscillatory inhomogeneous structures supported in this regime.

Some blow-up problems in delay differential equations

Schedule: December 18 18:00-18:30 Capital Suite 15

Tetsuya Ishiwata
Shibaura Institute of Technology
Japan

Co-Author(s): Yukihiko Nakata

Abstract:
It is well known that time lags or histories sometimes cause instability or oscillation. In this talk, we focus on delay differential equations and discuss the effects of time delay for such instabilities from the viewpoint of a finite time blow-up of the solutions. We also show some numerical examples and give our observations.

On hot spots conjecture for domain with n-axes of symmetry

Schedule: December 18 17:30-18:00 Capital Suite 15

Yi Li
John Jay College of Criminal Justice, CUNY
USA

Co-Author(s): Dr. Hongbin Chen

Abstract:
In this talk, we prove the hot spots conjecture for rotationally symmetric domains in $\mathbb{R}^n$ by the continuity method. More precisely, we show that the odd Neumann eigenfunction in x_n associated with lowest nonzero eigenvalue is a Morse function on the boundary, which has exactly two critical points and is monotone in the direction from its minimum point to its maximum point. As a consequence, we prove that the Jerison and Nadirashvili`s conjecture 8.3 holds true for rotationally symmetric domains and are also able to obtain a sharp lower bound for the Neumann eigenvalue. We will also discuss some recent results on n-axes symmetry or hyperbolic drum type domains.

Role of chemotaxis in some SIS PDE epidemic model with singular sensitivity

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Schedule: December 18 14:45-15:15 Capital Suite 15

Yuan Lou
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Rachidi Salako, Youshan Tao, Shenggao Zhou

Abstract:
We consider a repulsive chemotaxis SIS epidemic model with logarithmic sensitivity and mass-action transmission. The global existence and boundedness of smooth solutions to the corresponding no-flux initial boundary value problem in the spatially one-dimensional setting are established. Furthermore, the asymptotic analysis of the steady states reveal that the susceptible populations move to low-risk regions, whereas the infected individuals become spatially homogeneously distributed when the repulsive-taxis coefficient goes to infinity. This talk is based on joint work with R. Salako, Y.S. Tao and S.G. Zhou.

Singular limit of mathematical models related to controlling invasive alien species

Schedule: December 18 12:30-13:00 Capital Suite 15

Harunori Monobe
Osaka Metropolitan University
Japan

Co-Author(s): H. Izuhara, C.-H. Wu and S. Iwasaki

Abstract:
We consider the dynamics of some Lotka-Volterra competition reaction-diffusion systems with the effect of controlling species. Our purpose in this talk is to investigate how the species behave depending on the effect of controlling species is large. In particular, we study the singular limit of the model and show that some free boundary problems appears. This is a joint work with H. Izuhara, C.-H. Wu and S. Iwasaki.

Segregation pattern in a mass conserved reaction-diffusion system from a model of asymmetric cell division

Schedule: December 18 16:15-16:45 Capital Suite 15

Yoshihisa Morita
Ryukoku Joint Research Center Sci & Tech
Japan

Abstract:
We study a four-component reaction-diffusion system with mass conservation in a bounded domain with the Neumann boundary condition. This system models the segregation pattern during the maintenance phase of asymmetric cell devision. Utilizing the mass conservation, we reduce the stationary problem of the system to a two-component elliptic system with nonlocal terms, formulating it as the Euler-Lagrange equation of an energy functional. In this talk we focus on the existence of equilibrium solutions with segregation pattern in a cylindrical domain. This result is based on the joint work with Prof. Y. Oshita (Okayama Univ.).

Reaction-diffusion type modeling of the self-propelled motion.

Schedule: December 18 13:30-14:00 Capital Suite 15

Masaharu Nagayama
Hokkadio University
Japan

Co-Author(s): Natsume Motohashi, Hiroyuki Kitahata, Yasuaki Kobayashi, Ken-Ichi Nakamura, Koya Sakakibara, Keisuke Takasao, Harunori Monobe

Abstract:
A mathematical model was developed that included self-propelled objects in motion with deformation, such as droplets, and self-propelled objects without deformation, such as camphor. This study represents the self-propelled object by a volume-conserving Phase-Field equation derived from the L^2 gradient flow. The self-propelled object shape during motion is successfully controlled depending on the parameters included in the model equations. Moreover, adding a spatially inhomogeneous function to the potential term made it possible to represent the self-propelled object motion in elliptical and dumbbell shapes.

The speed of bistable traveling fronts in the Lotka-Volterra competition-diffusion system

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Schedule: December 18 8:30-9:00 Capital Suite 15

Ken-Ichi Nakamura
Meiji University
Japan

Co-Author(s): Toshiko Ogiwara

Abstract:
We consider front propagation in the classical 2-species Lotka-Volterra competition-diffusion system under strong competition conditions. The system has a unique traveling front solution (up to translation) connecting two stable states. The sign of the front speed gives us significant information about which species prevails over the other, and identifying the sign is still a challenging problem. In this talk, we give some new results on the sign of the speed of bistable traveling fronts based on comparison arguments. The results determine the propagation direction of the front for a much broader range of parameters than previous results.

Forced waves for an epidemic model of West-Nile virus with climate change effect

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Schedule: December 18 9:30-10:00 Capital Suite 15

Toshiko Ogiwara
Josai University
Japan

Co-Author(s): Jong-Shenq Guo, Wonhyung Choi, Chin-Chin Wu

Abstract:
In this talk, we deal with the existence of forced waves for an epidemic model of West-Nile virus in a shifting environment. Here a forced wave is a traveling wave whose wave speed is the same as the environmental shifting speed. The forced waves we constructed have the property that the waves tend to the positive endemic state of the epidemic model as the time tends to infinity. The derivation of these forced waves relies on a careful construction of a suitable lower solution with the help of Schauder`s fixed point theorem.

Cytokine-induced coherent structures in a reaction-diffusion-chemotaxis model of Multiple Sclerosis

Schedule: December 18 14:00-14:30 Capital Suite 15

Rossella Rizzo
University of Palermo
Italy

Co-Author(s): Francesco Gargano, Maria Carmela Lombardo, Marco Sammartino, Vincenzo Sciacca

Abstract:
In this work, we develop a model for the evolution of the Multiple Sclerosis pathology that considers the modulatory influence of cytokines on the activation rate of macrophages. Our starting point is the reaction-diffusion-chemotaxis model proposed in (Lombardo, Barresi, Bilotta, Gargano, Pantano, Sammartino, J.Math.Biol. (2017)), and we modify the macrophage activation mechanism. We explore the hypothesis, e.g., Lassmann, (2018), that cytokines mediate the activation mechanism. Through a weakly nonlinear analysis, we characterize the chemotaxis-driven Turing instability and construct the stationary patterns that emerge from this instability. Using biologically relevant parameter values, we show that the asymptotic solutions of our model system reproduce the concentric demyelinating rings, confluent plaques, and preactive lesions observed in Bal\`{o} sclerosis and type III Multiple Sclerosis. Furthermore, we explore the initiation and progression of demyelinated plaques through extensive numerical simulations on two-dimensional domains. Our findings reveal that the alternative scenario proposed here results in a less aggressive pathology and slower disease progression. Under the appropriate regularity conditions on the initial data, we prove the existence of a unique global solution to our proposed system. This study provides insights into the role of cytokines in the pathogenesis of Multiple Sclerosis and offers potential avenues for therapeutic interventions.

Stability of traveling waves in non-cooperative systems with nonlocal dispersal of equal diffusivities

Schedule: December 18 17:00-17:30 Capital Suite 15

Masahiko Shimojo
Tokyo Metropolitan University
Japan

Co-Author(s): Jong-Shenq Guo

Abstract:
We explore the stability of traveling waves in a class of non-cooperative reaction-diffusion systems with nonlocal dispersal, when the diffusivities are equal. Our stability criterion for traveling waves is based on measuring initial perturbations by a weighted relative entropy. To demonstrate the practical applications of this theory, we will present several examples from ecology and epidemiology.

The dynamics of the coupled reaction-diffusion Lengyel-Epstein system with two layers modeling CIMA chemical reactions

Schedule: December 18 13:00-13:30 Capital Suite 15

Fengqi Yi
Dalian University of Technology
Peoples Rep of China

Co-Author(s): Qidong Wu

Abstract:
In this talk, I will report our recent works on the dynamics of the two-coupled reaction-diffusion Lengyel-Epstein system incorporating distributed-delay couplings in activators. For one hand, we are mainly concerned with the existence and stability of the non-constant steady state solutions for the one-layered diffusive Lengyel-Epstein system. It is found that as the system parameter changes, the stability of the nonconstant steady state solutions of the one-layered system changes. This leads to the emergence of the periodic solutions via Hopf bifurcations. On the other hand, we are interested in studying Turing instability of the symmertric non-constant steady state solutions driven by inter-reactor diffusions.

Special Session 24 : Optimal control and parameter estimation in biological models

Introduction: Biological models often result in complex systems of nonlinear PDE`s. Understanding their behavior is crucial for advancements in fields ranging from medicine to ecology. This mini-symposium seeks to bring together experts in the field and possibly practitioners to explore the innovative techniques and approaches used in optimizing and refining biological models. We will showcase recent developments in mathematical modeling and computational techniques, describing how these tools can enhance our understanding of biological phenomena and improve the design of interventions and treatments. We will highlight the state-of-the-art techniques and mathematical methods for estimating model parameters, even in presence of noisy or limited data.

Solvability and optimal control for an epidemic propagation model with heterogeneous diffusion

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Schedule: December 18 14:00-14:30 Capital Suite 21 B

Pierluigi Colli
University of Pavia
Italy

Abstract:
Compartmental models are often applied to the mathematical modelling of infectious diseases. The population is assigned to compartments with labels. In this talk, we are concerned with an epidemic Susceptible - Exposed - Infected - Recovered mathematical model in which the dynamics develops in a spatially heterogeneous environment. The four unknown functions s, e, i, r, which represent the four types of population, have to solve a nonlinear system of reaction-diffusion partial differential equations, complemented with homogeneous Neumann boundary conditions and initial conditions. The well-posedness of the problem is discussed and a control problems is studied with some details: for this problem the controls are the diffusion coefficients, which are supposed to be piece-wise constant. In fact, the existence of an optimal control can be shown and significant necessary conditions for optimality are derived. The tallk reports on joint works with Gianni Gilardi, Gabriela Marinoschi and Elisabetta Rocca.

On a diffuse interface model for the electrically-driven self-assembly of copolymers

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Schedule: December 18 15:45-16:15 Capital Suite 21 B

Andrea Di Primio
Politecnico di Milano
Italy

Co-Author(s): Helmut Abels, Harald Garcke

Abstract:
Self-assembling is an ubiquitous phenomenon in several applications, ranging from biology to materials science. In this talk, we consider a diffuse interface model describing a ternary system, constituted by a diblock copolymer and a homopolymer acting as solvent, interacting with an electric field. The dynamics of the ternary system is fully coupled with that of the electric field, hence the whole system is modeled by two Cahn--Hilliard--Oono equations for the copolymer blocks, accounting for long-range interactions; a classical Cahn--Hiliard equation for the homopolymer and, finally, the Maxwell equation for the electric displacement field. A multiphase singular potential is employed in order to ensure physical consistency. First, we show existence of global weak solutions in two and three dimensions. Uniqueness of weak solutions is estabilished in the constant mobility case, and a conditional result is given in the general case. Instantaneous regularization and long-time behavior are also investigated, the latter in the case of affine-linear electric permittivity, showing in particular that solutions converge to a single stationary state.

Maximal regularity and optimal control for a non-local Cahn-Hilliard tumour growth model

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Schedule: December 18 17:00-17:30 Capital Suite 21 B

Matteo Fornoni
University of Pavia
Italy

Abstract:
We consider a non-local tumour growth model of phase-field type, describing the evolution of tumour cells through proliferation in the presence of a nutrient. The model consists of a coupled system, incorporating a non-local Cahn-Hilliard equation for the tumour phase variable and a reaction-diffusion equation for the nutrient. Non-local cell-to-cell adhesion effects are included through a convolution operator with appropriate spatial kernels. First, we establish novel regularity results for such a model, by applying maximal regularity theory in weighted L^p spaces. Such a technique enables us to prove the local existence and uniqueness of a regular solution, including also chemotaxis effects. By leveraging time-regularisation properties and global boundedness estimates, we further extend the solution to a global one. These results provide the foundation for addressing an optimal control problem, aimed at identifying a suitable therapy, which can guide the tumour towards a predefined target. Specifically, we prove the existence of an optimal therapy and, by studying the Fr\`echet-differentiability of the control-to-state operator and introducing the adjoint system, we derive first-order necessary optimality conditions.

Global Well-posedness of a Navier-Stokes-Cahn-Hilliard System with Chemotaxis and Singular Potential

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Schedule: December 18 17:30-18:00 Capital Suite 21 B

Jingning He
Hangzhou Normal University
Peoples Rep of China

Co-Author(s): Hao Wu

Abstract:
In this talk, we discuss a diffuse interface model that describes the dynamics of incompressible two-phase flows with chemotaxis effect. The PDE system couples the Navier-Stokes equations for the fluid velocity, a convective Cahn-Hilliard equation for the phase field variable with an advection-diffusion-reaction equation for the nutrient density. In the analysis, we consider a singular (e.g., logarithmic type) potential in the Cahn-Hilliard equation and prove the existence of global weak solutions in both two and three dimensions. In the two dimensional case, we establish a continuous dependence result that implies the uniqueness of global weak solutions. Furthermore, we prove the existence and uniqueness of global strong solutions that are strictly separated from the pure states over time in 2D.

Coefficient identification in nonlinear reaction-diffusion systems

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Schedule: December 18 12:30-13:00 Capital Suite 21 B

Barbara Kaltenbacher
University of Klagenfurt
Austria

Co-Author(s): William Rundell

Abstract:
Reaction-diffusion equations / systems appear in many applications. Often the coefficients or the nonlinearity itself is unknown and for the sake of generality one aims for a non-parametric form of the nonlinearity. In this talk we consider inverse problems of recovering potentials and/or state-dependent source terms in a reaction-diffusion system from overposed data consisting of the values of the state variables either at a fixed finite time (census-type data) or a time trace of their values at a fixed point on the boundary of the spatial domain. The basic idea of an iteration scheme that can be applied in many cases relies on projecting the data onto the observation manifold. We can then express those parts of the differential operators in the PDE that are tangential to this manifold via the data; and those parts that are perpendicular to the manifold via PDE solutions. This leads to a fixed point formulation and thus to a reconstructive method and we shall demonstrate its effectiveness by several illustrative examples.

Optimal control for an epidemic model

Schedule: December 18 14:45-15:15 Capital Suite 21 B

Gabriela Marinoschi
Gheorghe Mihoc-Caius Iacob Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy
Romania

Co-Author(s): Gabriela Marinoschi

Abstract:
We present a general problem of optimally controlling of an epidemic outbreak of a disease structured by age since exposure, with the aid of two types of control instruments, namely social distancing and vaccination. We prove the existence of at least one optimal control pair, derive the first-order necessary conditions for optimality and prove some useful properties of such optimal solutions. This general model can be specialized to include a number of subcases relevant for epidemics (e.g., like COVID-19), such as, the arrival of vaccines in a second stage of the epidemic, and vaccine rationing, making social distancing the only optimizable instrument in the first stage. The control problem takes also into account the indirect epidemic cost, namely the broader societal and economic cost due to the impact of social distancing on overall social and relational activities. The presentation is based on a joint paper with Alberto D`Onofrio, Mimmo Iannelli and Piero Manfredi.

Nonlinear oscillations in Fluid Mechanics

Schedule: December 18 13:00-13:30 Capital Suite 21 B

RICCARDO MONTALTO
University of Milan
Italy

Abstract:
In this talk I shall discuss some recent results about the construction of quasi-periodic waves in Euler equations and other hydro-dynamical models in dimension greater or equal than two. I shall discuss quasi-peridic solutions and vanishing viscosity limit for forced Euler and Navier-Stokes equations and the problem of constructing quasi-periodic traveling waves bifurcating from Couette flow (and connections with inviscid damping). Time permitting, I also discuss some results concerning the construction of large amplitude quasi-periodic waves in MHD system and rotating fluids. The techniques are of several kinds: Nash-Moser iterations, micro-local analysis, analysis of resonances in higher dimension, normal form constructions and spectral theory.

Lipid rafts formation on cell membranes: modeling and mathematical analysis

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Schedule: December 18 16:15-16:45 Capital Suite 21 B

Andrea Poiatti
University of Vienna
Austria

Co-Author(s): Helmut Abels, Harald Garcke

Abstract:
In this talk I would like to present a model concerning lipid rafts formation on cell membranes (lipid bilayers). This phenomenon consists in the separation of lipids composing the cell membrane into two immiscible liquid phases, leading to the formation of heterogeneous liquid-ordered phase platforms (rafts). These rafts are believed to play important roles in the biology of the cell. I will focus on a diffuse interface model for incompressible viscous two-phase fluids with different densities, known as Abels-Garcke-Gr\{u}n model, over an evolving surface. After briefly showing the derivation of the model, I will introduce a suitable framework of evolving families of Banach and Hilbert spaces, and explain some recent results concerning the well-posedness of strong solutions to the problem, when the surface evolution is a priori prescribed. Namely I will first focus on the existence of a local strong solution, which is separated from pure phases, and then on how to extend this solution to a global-in-time unique separated strong solution. I will also present some new techniques for obtaining the validity of the strict separation property from pure phases on two-dimensional surfaces, under very weak assumptions on the behavior of the singular potential.

Analysis and simulations of a stochastic phase-field model for tumour growth

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Schedule: December 18 13:30-14:00 Capital Suite 21 B

Luca Scarpa
Politecnico di Milano
Italy

Co-Author(s): Marvin Fritz

Abstract:
We consider a stochastic phase-field model for tumour growth, coupling a Cahn-Hilliard equation for the order parameter, i.e. the difference in volume fractions between the tumour and healthy cells, with a reaction-diffusion equation for the nutrient. Both equations take into account the possible unpredictable model-oscillations via suitable stochastic forcing terms. First, the mathematical analysis of the system is performed in wide generality, including non-constant mobilities and chemotaxis. Secondly, numerical computations are performed in order to visualise the effect of the noise on the tumour growth and shape. In conclusion, possible developments towards optimal control problems are discussed. This study is based on a joint work with Marvin Fritz (Johann Radon Institute, Linz, Austria).

Optimal control of Cahn-Hilliard-Keller-Segel tumor growth models

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Schedule: December 18 15:15-15:45 Capital Suite 21 B

Andrea Signori
Politecnico di Milano
Italy

Abstract:
This presentation examines optimal control problems for two Cahn-Hilliard-Keller-Segel tumor growth models that capture key biological processes such as chemotaxis, angiogenesis, and nutrient consumption. These models combine a Cahn-Hilliard system for tumor and healthy cell segregation with a Keller-Segel equation for nutrient dynamics and chemotaxis. The goal is to minimize deviations in tumor cell distribution from target configurations while optimizing control costs. We establish the existence of optimal controls and derive first-order necessary optimality conditions under suitable assumptions.

Special Session 29 : Mean field stochastic control problems and related topics

Introduction: Mean-field (or, McKean-Vlasov) SDEs have been studied for a long time and have found a lot of applications in different domains. Roughly speaking, in a more general sense, mean-field problems study strategic decision making by small interacting agents in very large populations, modeled by equations not only depending on the controlled state process and its control but also on their law. Recently, with their pioneering seminal papers (2006-2007) on mean-field games and their applications in economics, finance and game theory, Lasry and Lions have given with a ground-breaking novel approach new impulses to this research topic, opened the way to new applications and attracted many researchers to this topic. One of these applications is the study of mean-field stochastic optimal control problems and mean-field games. Our symposium will mainly be devoted to optimal control problems for mean-field forward-backward stochastic differential equations.

Optimal control problems with generalized mean-field dynamics and viscosity solution to Master Bellman equation

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Schedule: December 18 8:00-8:30 Capital Suite 10

Rainer Buckdahn
Universite de Bretagne Occidentale
France

Abstract:
In this talk we study an optimal control problem of generalized mean-field dynamics with open loop controls, where the coefficients depend not only on the state processes and controls, but also on the joint law of them. The value function V defined in a conventional way, but it does not satisfy the Dynamic Programming Principle (DPP for short). For this reason we introduce subtly a novel value function ϑ, which is closely related to the original value function V, such that, a description of ϑ, as a solution of a partial differential equation (PDE), also characterizes V. We establish the DPP for ϑ. By using an intrinsic notion of viscosity solutions, we show that the value function ϑ is a viscosity solution to a Master Bellman equation on a subset of Wasserstein space of probability measures. The uniqueness of viscosity solution is proved for coefficients which depend on the time and the joint law of the control process and the controlled process. The talk is based on joint work with Juan Li (SDU, China), Zhanxin Li (SDU, China).

Stochastic PDEs driven by $G-$Brownian motion and the associated Backward Doubly Stochastic Differential Equations

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Schedule: December 18 8:30-9:00 Capital Suite 10

Laurent Denis
Le Mans University
France

Abstract:
We study the well-posedness of quasilinear stochastic partial differential equations driven by $G-$ Brownian motion (GSPDEs for short) and the associated backward doubly stochastic differential equations (BDSDEs for short). We first prove the existence and uniqueness of weak solution to GSPDEs by analytical approach, and then solve the corresponding BDSDEs. Finally, we establish the relation between GSPDEs and BDSDEs.

Doubly Reflected Backward SDEs Driven by G-Brownian Motions and Fully Nonlinear PDEs with Double Obstacles

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Schedule:

Hanwu Li
Shandong University
Peoples Rep of China

Co-Author(s): Ning Ning

Abstract:
In this talk, we introduce a new method to study the doubly reflected backward stochastic differential equation driven by G-Brownian motion (G-BSDE). Our approach involves approximating the solution through a family of penalized reflected G-BSDEs with a lower obstacle that are monotone decreasing. By employing this approach, we establish the well-posedness of the solution of the doubly reflected G-BSDE with the weakest known conditions, and uncover its relationship with the fully nonlinear partial differential equation with double obstacles for the first time.

Mean field stochastic control problems under sublinear expectation

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Schedule: December 18 9:00-9:30 Capital Suite 10

Juan Li
Shandong University
Peoples Rep of China

Abstract:
In this talk we study Pontryagin`s stochastic maximum principle for a mean-field optimal control problem under Peng`s G-expectation. The dynamics of the controlled state process is given by a stochastic differential equation driven by a G-Brownian motion, whose coefficients depend not only on the control, the controlled state process but also on its law under the G-expectation. Also the associated cost functional is of mean-field type. Under the assumption of a convex control state space we study the stochastic maximum principle, which gives a necessary optimality condition for control processes. Under additional convexity assumptions on the Hamiltonian it is shown that this necessary condition is also a sufficient one. The main difficulty which we have to overcome in our work consists in the differentiation of the G-expectation of parameterized random variables. Based on a joint work with Rainer Buckdahn (UBO, France), Bowen He (SDU, China).

Mean Field Games of Major-Minor Agents with Recursive Functionals

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Schedule: December 18 15:45-16:15 Capital Suite 10

Wenqiang Li
Shandong University
Peoples Rep of China

Abstract:
This paper studies a general class of mean field games involving a major agent and a large number of minor agents, whose payoff functionals are \emph{recursive} and represented in terms of the solution of backward stochastic differential equations, referred to as recursive major-minor (RMM) problems. Our RMM modeling encompasses weak couplings of empirical averages into the recursive functionals and dynamics of both major and minor agents and incorporates general non-additive functionals. The auxiliary limiting game of RMM is constructed via a novel mixed triple-agent leader-follower-Nash games. The associated consistency system is derived and related asymptotic major-minor equilibrium is constructed. In addition, linear-quadratic settings of RMM problems are studied to illustrate our results.

Fractional BSPDEs with Applications to Optimal Control of Partially Observed Systems with Jumps

Schedule: December 18 14:45-15:15 Capital Suite 10

Yunzhang Li
Fudan University
Peoples Rep of China

Abstract:
In this talk, we consider the Cauchy problem for backward stochastic partial differential equations (BSPDEs) involving fractional Laplacian operator. By employing the martingale representation theorem and the fractional heat kernel, we construct an explicit form of the solution, thereby demonstrating the existence and uniqueness of a strong solution in Holder space. Utilizing the freezing coefficients method as well as the continuation method, we establish Holder estimates for general BSPDEs with random coefficients dependent on space time variables. As an application, we use the fractional adjoint equation to study stochastic optimal control of the partially observed systems driven by Levy processes. This work is jointed with Yuyang Ye and Shanjian Tang.

On Some Generic Properties of Mean-Field Stochastic Differential Equations

Schedule: December 18 9:30-10:00 Capital Suite 10

Brahim Mezerdi
King Fahd University of Petroleum and Minerals
Saudi Arabia

Abstract:
We investigate Mean-Field Stochastic Differential Equations (MFSDEs), where the coefficients depend on both the state and the marginal distribution of the solution. Under the assumption of global Lipschitz continuity of the coefficients in both arguments, the existence and uniqueness of a strong solution are well-established. This paper addresses the topological structure of the set of continuous coefficients that yield unique strong solutions and convergent successive approximations. We prove that this set is residual within the Baire space of uniformly continuous functions, implying its genericity in a topological sense. Moreover, we establish the generic property of convergence of Picard successive approximations and the Euler numerical scheme using similar techniques.

Linear-Quadratic Optimal Control Problem for Mean-Field Stochastic Differential Equations with a Type of Random Coefficients

Schedule: December 18 13:30-14:00 Capital Suite 10

Qingmeng Wei
Northeast Normal Univeristy
Peoples Rep of China

Co-Author(s): Hongwei Mei, Jiongmin Yong

Abstract:
Motivated by linear-quadratic optimal control problems (LQ problems, for short) for mean-field stochastic differential equations (SDEs, for short) with the coefficients containing regime switching governed by a Markov chain, we consider an LQ problem for an SDE with the coefficients being adapted to a filtration independent of the Brownian motion driving the control system. Classical approach of completing the square is applied to the current problem and obvious shortcomings are indicated. Open-loop and closed-loop solvability are introduced and characterized.

Path-dependent controlled mean-field coupled forward-backward SDEs. The associated stochastic maximum principle

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Schedule: December 18 16:15-16:45 Capital Suite 10

Chuanzhi Xing
Shandong University
Peoples Rep of China

Abstract:
In the present paper we discuss a new type of mean-field coupled forward-backward stochastic differential equations (MFFBSDEs). The novelty consists in the fact that the coefficients of both the forward as well as the backward SDEs depend not only on the controlled solution processes (X_t, Y_t, Z_t) at the current time t, but also on the law of the paths of (X, Y, u) of the solution process and the process by which it is controlled. The existence for such a MFFBSDE which is fully coupled through the law of the paths of (X, Y) in the coefficients of both the forward and the backward equations is proved under rather general assumptions. The main part of the work is devoted to the study of Pontryagin`s maximal principle for such a MFFBSDE. The dependence of the coefficients of the law of the paths of the solution processes and their control makes that a completely new and interesting criterion for the optimality of a stochastic control for the MFFBSDE is obtained. Furthermore, we show that this necessary optimality condition is, under the assumption of convexity of the Hamiltonian, also sufficient. The talk is based on joint work with Rainer Buckdahn (UBO, France), Juan Li (SDU, China), Junsong Li (SDU, China).

Exact Controllability for Linear Stochastic Game-Based Control Systems

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Schedule: December 18 12:30-13:00 Capital Suite 10

Zhiyong Yu
Shandong University
Peoples Rep of China

Abstract:
This talk is concerned with the exact controllability of a linear stochastic game-based control system (SGBCS) with time-variant random coefficients. A Gram-type criterion is obtained. At the same time, the equivalence between the exact controllability of this SGBCS and the exact observability of a dual system is established. Moreover, an admissible control that can steer the state from any initial vector to any terminal random variable is constructed in closed form.

Backward Stochastic Partial Differential Equations with Conormal Boundary Conditions

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Schedule: December 18 14:00-14:30 Capital Suite 10

Jing Zhang
Fudan University
Peoples Rep of China

Abstract:
We prove the existence and uniqueness of strong solution to backward stochastic partial differential equations (BSPDEs for short) with conormal boundary conditions in high dimensional case. We apply our results to the linear-quadratic optimal control problems for stochastic partial differential equations (SPDEs for short) and obtain a maximum principle of Pontryagin`s type. This is a joint work with Jinniao Qiu (University of Calgary, Canada) and Xue Yang (Tianjin University, China).

Some New Results on Entropy Regularized Backward Stochastic Control Systems

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Schedule: December 18 13:00-13:30 Capital Suite 10

Qi Zhang
Fudan University
Peoples Rep of China

Co-Author(s): Ziyue Chen, Qi Zhang

Abstract:
The entropy regularization is inspired by information entropy from machine learning and the ideas of exploration and exploitation in reinforcement learning, which appears in the control problem to design an approximating algorithm for the optimal control. I will introduce our new results on the optimal exploratory control for backward stochastic system, generated by the backward stochastic differential equation and with the entropy regularization in its cost functional. We give the theoretical depict of the optimal relaxed control so as to lay the foundation for the application of such a backward stochastic control system to mathematical finance and algorithm implementation.

Special Session 30 : Recent Development in Advanced Numerical Methods for Partial Differential Equations

Introduction: The aim of this special session is to offer a platform for experts, researchers, and scholars to present and discuss the latest innovations and breakthroughs in the field of numerical methods for PDEs, exchange ideas, share their recent research findings, and foster collaborations and connections. Topics to be addressed include, but are not limited to: adaptive methods, high-order numerical methods, parallel and distributed Computing, multiscale and multiphysics problems, uncertainty quantification, applications in various fields, and the integration of machine learning with PDE solvers.

Shearlet Scattering Transform and Its Applications

Schedule:

Wei Guo
Hebei Normal University
Peoples Rep of China

Co-Author(s): Wei Guo

Abstract:
Convolutional neural networks have achieved significant success in in signal processing and computer vision, but its underlying mechanisms are not well understood. Recently, the understanding of convolutional neural networks has received more and more attention. The wavelet scattering transform is the pioneering work presented by Mallat who is one the founders of wavelet analysis. It can be proved that it has the properties of translation invariance and deformation stability. In this talk, we will introduce our proposed shearlet scattering transform. It combines the advantages of scattering transform and shearlet. In addition, we construct a hybrid shearlet scattering network by fusing the shearlet scattering transform with an appropriate convolutional neural network, and apply it to COVID-19 detection and fake news detection tasks, both of which achieve good application performance.

Characteristic block-centered finite difference methods for Darcy-Forchheimer compressible miscible displacement problem

Schedule: December 16 19:00-19:30 Conference Hall B (D)

Jian Huang
Xiangtan University, CHINA
Peoples Rep of China

Abstract:
In this talk, we present characteristic block-centered finite difference methods for solving the nonlinear Darcy-Forchheimer compressible miscible displacement problem in porous media. The block-centered finite difference method is used to discretize the miscible problem, where the pressure equation is described by the nonlinear Darcy-Forchheimer model, and the transport equation is addressed with the help of the characteristic method. Two-grid methods are developed for the nonlinear system. The nonlinear system is linearized using Newton`s method with a small positive parameter to ensure the differentiability of the nonlinear term in the Darcy-Forchheimer equation. A modified two-grid algorithm is proposed to further reduce the computational cost of the time-dependent problem. The proposed methods are rigorously analyzed, and a priori error estimates are provided for the rates of convergence of the velocity, pressure, concentration, and its flux. Finally, numerical experiments are conducted to demonstrate the effectiveness of the proposed methods by comparing the efficiency with that of other solvers, especially in terms of CPU time.

High order conservative arbitrary Lagrangian-Eulerian schemes for two-dimensional radiation hydrodynamics equations

Schedule: December 16 19:00-19:30 Conference Hall B (D)

Nuo Lei
Academy of Mathematics and Systems Science, CAS
Peoples Rep of China

Abstract:
Radiation hydrodynamics equations (RHE) refer to the study of how interactions between radiation and matter influence thermodynamic states and dynamic flow, which has been widely applied to high temperature hydrodynamics, such as inertial confinement fusion (ICF). The equations exhibit strong nonlinearity, multi-scale characteristics, and sharp discontinuities, presenting considerable challenges for high-order numerical solutions. To address these, we develop a two-dimensional high-order conservative arbitrary Lagrangian-Eulerian (ALE) scheme. We first design a high-order explicit Lagrangian scheme under the equilibrium diffusion limit based on multi-resolution weighted essentially non-oscillatory (WENO) reconstruction for spatial discretization, strong stability-preserving Runge-Kutta time discretization, and HLLC numerical fluxes, with a focus on discussing the positivity-preserving property of the high-order scheme. In the meantime, to overcome the severe time step restrictions of explicit schemes, we propose a high-order Explicit-Implicit-Null (EIN) Lagrangian scheme by adding linear artificial diffusion terms to the equations, treating nonlinear terms explicitly and handling linear diffusion terms implicitly. Finally, to address the challenges posed by mesh distortion and deformation in Lagrangian methods, we incorporate mesh rezoning and remapping algorithms to develop a high-order conservative ALE scheme suitable for handling complicated RHE. Additionally, we extended the high-order conservative ALE scheme to the non-equilibrium three-temperature RHE. Numerical experiments demonstrate that these schemes are high-order accurate, conservative, non-oscillatory, and can capture the interfaces automatically.

Parametric finite element methods for anisotropic axisymmetric flows

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Schedule: December 16 17:30-18:00 Conference Hall B (D)

Meng Li
Zhengzhou University
Peoples Rep of China

Abstract:
This report considers parametric finite element methods for anisotropic flows in axisymmetric settings, including surface diffusion, conserved mean curvature, power mean curvature and intermediate evolution flows. We introduce novel weak formulations, and different approximating methods are constructed and studied. Computational experiments are presented to demonstrate the efficiency of the proposed methods.

A general collocation analysis for weakly singular Volterra integral equations with variable exponent

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Schedule: December 16 15:15-15:45 Conference Hall B (D)

Hui Liang
Harbin Institute of Technology, Shenzhen
Peoples Rep of China

Abstract:
Piecewise polynomial collocation of weakly singular Volterra integral equations (VIEs) of the second kind has been extensively studied in the literature. Variable-order fractional-derivative differential equations currently attract much research interest, and in Zheng and Wang SIAM J. Numer. Anal. 2020 such a problem is transformed to a weakly singular VIE whose kernel has the variable exponent, then solved numerically by piecewise linear collocation, but it is unclear whether this analysis could be extended to more general problems or to polynomials of higher degree. In the present paper the general theory (existence, uniqueness, regularity of solutions) of variable-exponent weakly singular VIEs is developed, then used to underpin an analysis of collocation methods where piecewise polynomials of any degree can be used. This error analysis is also novel--it makes no use of the usual resolvent representation, which is a key technique in the error analysis of collocation methods for VIEs in the current research literature. Furthermore, all the above analysis for a scalar VIE can be extended to certain nonlinear VIEs and to systems of VIEs. The sharpness of the theoretical error bounds obtained for the collocation methods is demonstrated by numerical examples.

Maximum bound principle and original energy dissipation of arbitrarily high-order rescaled exponential time differencing Runge--Kutta schemes for Allen--Cahn equations

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Schedule: December 16 18:00-18:30 Conference Hall B (D)

Chaoyu Quan
The Chinese University of Hong Kong (Shenzhen)
Peoples Rep of China

Co-Author(s): Xiaoming Wang, Pinzhong Zheng, Zhi Zhou

Abstract:
The energy dissipation law and the maximum bound principle are two critical physical properties of the Allen--Cahn equations. While many existing time-stepping methods are known to preserve the energy dissipation law, most apply to a modified form of energy. In this work, we demonstrate that, when the nonlinear term of the Allen--Cahn equation is Lipschitz continuous, a class of arbitrarily high-order exponential time differencing Runge--Kutta (ETDRK) schemes preserve the original energy dissipation property, under a mild step-size constraint. Additionally, we guarantee the Lipschitz condition on the nonlinear term by applying a rescaling post-processing technique, which ensures that the numerical solution unconditionally satisfies the maximum bound principle. Consequently, our proposed schemes maintain both the original energy dissipation law and the maximum bound principle and can achieve arbitrarily high-order accuracy. We also establish an optimal error estimate for the proposed schemes. Some numerical experiments are carried out to verify our theoretical results.

Multiscale Model Reduction for Heterogeneous Perforated Domains based on CEM-GMsFEM

Schedule: December 16 16:15-16:45 Conference Hall B (D)

Yin Yang
Xiangtan University
Peoples Rep of China

Abstract:
In this presentation, we unveil a robust framework for addressing multiscale complexities in diverse perforated domains, employing the Constraint Energy Minimizing - Generalized Multiscale Finite Element Method (CEM-GMsFEM). Simulating within such domains is computationally intensive due to varying perforation and domain scales. Our method addresses both the Poisson equation and linear elastic problems within these domains. Our approach comprises two main steps: firstly, solving an eigenvalue problem within a coarse block, and secondly, resolving a minimization problem within an oversampled domain. Furthermore, we demonstrate the variability of oversampling layers in controlling exponential decay.

Error estimates of finite element methods for nonlocal problems with exact or approximated interaction neighborhoods

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Schedule: December 16 15:45-16:15 Conference Hall B (D)

Xiaobo Yin
Central China Normal University
Peoples Rep of China

Co-Author(s): Qiang Du, Hehu Xie and Jiwei Zhang

Abstract:
In this talk, we report our recent study on the asymptotic error between the finite element solutions of nonlocal models with a bounded interaction neighborhood and the exact solution of the limiting local model. The limit corresponds to the case when the horizon parameter, the radius of the spherical nonlocal interaction neighborhood of the nonlocal model, and the mesh size simultaneously approach zero. Two important cases are discussed: one involving the original nonlocal models and the other for nonlocal models with polygonal approximations of the nonlocal interaction neighborhood. Results of numerical experiments are also reported to substantiate the theoretical studies.

An Alternating Direction Implicit Method for Mean Curvature Flows

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Schedule: December 16 14:45-15:15 Conference Hall B (D)

Wenjun Ying
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Han Zhou

Abstract:
In this talk, we present a Cartesian grid-based method for solving mean curvature flows in two and three space dimensions. The mean curvature flows describe the dynamics of a hypersurface whose normal velocity is determined by local mean curvature. The proposed method embeds a closed hypersurface into a fixed Cartesian grid and decomposes it into multiple overlapping subsets. For each subset, extra tangential velocities are introduced such that marker points on the hypersurface only moves along grid lines. By utilizing an alternating direction implicit (ADI)-type time integration method, the subsets are evolved alternately by solving scalar parabolic partial differential equations on planar domains. The method removes the stiffness using a semi-implicit scheme and has no high-order stability constraint on time step size. Numerical examples in two and three space dimensions are presented to validate the proposed method.

An operator/direction splitting approach to a class of dissipative systems

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Schedule: December 16 17:00-17:30 Conference Hall B (D)

Zhen Zhang
Southern University of Science and Technology
Peoples Rep of China

Co-Author(s): Nan Lu, Chenxi Wang, Zhen Zhang

Abstract:
In this work, we present a novel operator/direction splitting approach for numerically solving a class of dissipative systems. The proposed methods enjoy the properties of second-order accuracy, energy stability and computationally efficiency. These are validated for many models including Cahn-Hilliard-Navier-Stokes system, phase-field surfactant system, Poisson-Nernst-Planck model, etc.

Addressing complex boundary conditions of miscible flow and transport with application to optimal control

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Schedule: December 16 18:30-19:00 Conference Hall B (D)

Xiangcheng Zheng
Shandong University
Peoples Rep of China

Co-Author(s): Yiqun Li, Hong Wang, Xiangcheng Zheng

Abstract:
We investigate complex boundary conditions of the miscible displacement system in two and three space dimensions with the commonly-used Bear-Scheidegger diffusion-dispersion tensor, which describes, e.g., the porous medium flow processes in petroleum reservoir simulation or groundwater contaminant transport. Specifically, we incorporate the no-flux boundary condition for the Darcy velocity to prove that the general no-flux boundary condition for the transport equation is equivalent to the normal derivative boundary condition of the concentration, based on which we further prove several complex boundary conditions by the Bear-Scheidegger tensor and its derivative. The derived boundary conditions provide new insights and properties of the Bear-Scheidegger diffusion-dispersion tensor, facilitate the application of classical methods and results without technical treatments for complex boundary conditions, and accommodate the coupling and the nonlinearity of the miscible displacement system and the Bear-Scheidegger tensor in deriving the first-order optimality condition of the corresponding optimal control problem for practical application.

Special Session 31 : Regularity of partial differential equations

Introduction: Regularity of partial differential equations

Interior pointwise regularity for elliptic and parabolic equations in divergence form and applications to nodal sets

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Schedule: December 20 8:00-8:30 Capital Suite 4

Yuanyuan Lian
Department of Mathematical Analysis, University of Granada
Spain

Abstract:
In this talk, we obtain the interior pointwise $C^{k,\alpha}$ $(k \geq 0, 0 < \alpha < 1)$ regularity for weak solutions of elliptic and parabolic equations in divergence form. The compactness method and perturbation technique are employed. The pointwise regularity is proved in a very simple way and the results are optimal. In addition, these pointwise regularity can be used to characterize the structure of the nodal sets of solutions.

The dynamical behavior and coexistence of a predator-prey model in the chemostat

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Schedule: December 20 8:30-9:00 Capital Suite 4

Jianhua Wu
Shaanxi Normal University
Peoples Rep of China

Abstract:
This paper deals with a diffusive predator-prey system in the chemostat which describes the growth of planktonic rotifers, feeding on unicellular green algae. The dynamical behavior and coexistence of this system is characterized by using the diffusion rate.

Log BMO matrix weights and quasilinear elliptic equations with Orlicz growth

Schedule: December 20 9:00-9:30 Capital Suite 4

Rui Yang
Central South University
Peoples Rep of China

Co-Author(s): Sun-Sig Byun

Abstract:
We study a very general quasilinear elliptic equation with the nonlinearity with Orlicz growth subject to a degenerate or singular matrix-valued weight on a bounded nonsmooth domain. The nonlinearity satisfies a nonstandard growth condition related to the associated Young function, and the logarithm of the matrix-valued weight in BMO is constrained by a smallness parameter which has a close relationship with the Young function. We establish a global Calder\`{o}n-Zygmund estimate for the weak solution of such a degenerate or singular problem in the setting of a weighted Orlicz space under a minimal geometric assumption that the boundary of the domain is sufficiently flat in the Reifenberg sense.

Boundary regularity for elliptic equations

Schedule: December 20 14:30-15:00 Capital Suite 4

Kai Zhang
University of Granada
Spain

Co-Author(s): Yongpan Huang, Guanghao Hong, Dongsheng Li, Yuanyuan Lian, Duan Wu

Abstract:
In this talk, we introduce a series of boundary pointwise regularity for elliptic equations, including boundary H�lder regularity, boundary Lipschitz regularity, boundary differentiability, boundary $C^{k,\alpha}$ regularity for any $k \geq 1, 0 < \alpha < 1$. This talk is a combination of our several work in recent years.

Liouville-type theorems and existence of solutions for quasilinear elliptic equations with nonlinear gradient terms

Schedule: December 20 14:00-14:30 Capital Suite 4

Zhengce Zhang
Xi`an Jiaotong University
Peoples Rep of China

Co-Author(s): Caihong Chang, Bei Hu

Abstract:
In this talk, we consider two properties of positive weak solutions of quasilinear elliptic equations, $-\Delta_m u = u^q|\nabla u|^p \text{ in } \mathbb{R}^N$, with nonlinear gradient terms. First, we show a Liouville-type theorem for positive weak solutions of the equation involving the m-Laplacian operator. The technique of Bernstein gradient estimates is ultilized to study the case $p

Special Session 32 : Propagation Dynamics in Nonlocal Dispersal Systems

Introduction:

Dynamics of Nonlocal Dispersal SIS Models in Heterogeneous Environments

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Schedule: December 16 17:00-17:30 Capital Suite 2

Wan-Tong Li
Lanzhou University
Peoples Rep of China

Abstract:
In this talk we consider a nonlocal dispersal SIS epidemic model, where the spatial movement of individuals is described by a nonlocal diffusion operator, the transmission rate and recovery rate are spatially heterogeneous. We first define the basic reproduction number R_0 and discuss the existence, uniqueness and stability of steady states of the nonlocal dispersal SIS epidemic model in terms of R_0. Then we study the asymptotic profiles of the endemic steady states for large and small diffusion rates to illustrate the persistence or extinction of the infectious disease. We also observe the concentration phenomenon which occurs when the diffusion rate of the infected individuals tends to zero. The obtained results indicate that the nonlocal movement of the susceptible or infectious individuals will enhance the persistence of the infectious disease. In particular, our analytical results suggest that the spatial heterogeneity tends to boost the spread of the infectious disease.

The propagation dynamics for three species competitive-cooperative reaction-diffusion systems

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Schedule: December 16 18:30-19:00 Capital Suite 2

Yan Li
Xidian University
Peoples Rep of China

Co-Author(s): Xiaoqiang Zhao

Abstract:
In this talk, we will introduce the sign of bistable wave speed and spreading properties of solutions for a class of three species competitive-cooperative reaction-diffusion systems. We first establish sufficient conditions for a species to be the winner, and then show that the species with large invasion speed can always establish a wave moving into open space with its own speed, while the others will be driven out or invade successfully, depending on the parameters, at a lower speed. This is the co-work with professor Xiaoqiang Zhao in Memorial University of Newfoundland.

Spatial dynamics for a time-periodic epidemic model in discrete media

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Schedule: December 16 17:30-18:00 Capital Suite 2

Shi-Liang Wu
Xidian University
Peoples Rep of China

Abstract:
This talk considers the spreading speed and periodic traveling waves for a time-periodic epidemic model in discrete media. We first characterize the spreading speed of the system which can be used to estimate how fast the disease spreads. Then, based on constructing two different pairs of explicit subsolutions and supersolutions, we establish the existence of supercritical and critical periodic traveling waves. We further derive the non-existence of periodic traveling waves when the wave speed is smaller than the spreading speed.

The stability of monostable traveling waves for a class of asymmetric diffusion system with nonlocal effects and delay

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Schedule: December 16 18:00-18:30 Capital Suite 2

Yun-Rui Yang
Lanzhou Jiaotong University
Peoples Rep of China

Abstract:
In this talk, the stability of monostable traveling waves for a class of asymmetric diffusion system with nonlocal effects and delay is considered, where the system can be quasi-monotone or non-quasimonotone and the kernel functions in diffusion terms and nonlocal reactions can both be asymmetric. Firstly, the global stability of monostable wavefronts for the asymmetric nonlocal diffusion system is established by the Fourier transform and the anti-weighted energy method, and a new technique is developed to control the real part of the Fourier transform of the asymmetric kernels by a bounded function, which is different from the case of symmetric kernels. Secondly, if the system can be non-quasimonotone, the global stability of monostable waves with the decay rate of the form an exponential function multiplying by an algebraic function is also obtained. Moreover, some concrete examples and numerical stimulations are included to confirm the theoretical conclusions.

Special Session 36 : Complexity in dynamical systems and applications in biology

Introduction: This special session will bring together researchers, who are experts and at the heart of the areas of dynamical systems and mathematical biosciences, and students to share ideas and methods for the study of complexity in dynamical systems and applications in biology. Potential topics of interest include qualitative analysis, bifurcation theory, population dynamics, gene expression, infectious diseases and tumor growth.

Impact of Intraspecific Competition of Predator on Coexistence of a Predator-prey Model with Additive Predation on Prey

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Schedule: December 18 13:00-13:30 Capital Suite 2

Dingyong Bai
Guangzhou University
Peoples Rep of China

Abstract:
In this talk, we consider a predator-prey model incorporating intraspecific competition in the predator and additive predation on the prey. The additive predation can elicit strong/weak Allee effects in prey, leading to complex dynamics in the model. Our goal is to examine how predator competition affects the species` coexistence. Analyzing the model with the predator competition coefficient as the bifurcation parameter, we reveal the existence and stability of equilibria, and various bifurcation phenomena such as Hopf, saddle-node, and Bogdanov-Takens bifurcations, as well as heteroclinic and homoclinic bifurcations. These bifurcations identify critical thresholds in the competition coefficient, indicating behavioral transitions. Our findings indicate that the strong Allee effect heightens the extinction risk for both species, but predator intraspecific competition reduces this risk and promotes coexistence. Especially when the ratio of the predator`s mortality to conversion rate is low, there are competition thresholds that trigger a range of initial values conducive to coexistence, which widens as competition intensifies. Additionally, our analysis shows that reducing the predation pressure on the prey from other potential predators can foster coexistence by inducing a weak Allee effect or eliminating the Allee effect altogether.

Investigating Multi-Disease Models with Coinfection Coupled with Networks

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Schedule: December 18 12:30-13:00 Capital Suite 2

Christine M Craib
University of California, Los Angeles (UCLA)
USA

Co-Author(s): Mason A. Porter, Maximillian Eisenberg

Abstract:
When considering the effects of related diseases in a population, it is useful to create models that incorporate the dynamics of both diseases. However, it is difficult to derive algebraic expressions for the coexistence of multiple diseases in ODE models. We present an ODE model of 2 non-lethal diseases, each without conferred immunity, with coinfection and universal recovery. Our ODE model assumes homogeneous mixing and instantaneous contacts. We calculate the basic reproductive numbers of each disease and of the system as a whole. We explore all possible equilibria, and we determine necessary and sufficient existence criteria and the linear-stability conditions of those that exist under the conditions of our model. We perform both local and global sensitivity analyses of our model. We relax the ODE assumptions of homogeneous mixing and instantaneous contacts by coupling the ODE system with a contact network. The simplest network maintains the homogeneous-mixing assumption, but it involves prolonged lengths of contact. We then increase network complexity, consider bipartite networks and heterogeneous mixing. We perform local and global sensitivity analyses on all ODE and network parameters and discuss how increasing the complexity of the model affects the projected prevalences of the diseases.

Longtime behavior for solutions to a temporally discrete diffusion equation with a free boundary

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Schedule: December 18 15:15-15:45 Capital Suite 2

Zhiming Guo
Guangzhou University
Peoples Rep of China

Co-Author(s): Yijie Li, Zhiming Guo, Jian Liu

Abstract:
In this talk, we will investigate the longtime behavior of solutions to a temporally discrete diffusion equation with a fixed boundary and a free boundary respectively in one space dimension. Such equation can be equivalent to an integrodifference equation, another important time discrete equation that provides powerful tools for the study of dispersal phenomena. We first discuss the global dynamics of the equation in a fixed bounded domain. With a Stefan type free boundary, we then give a new well-posedness proof and the regular spreading-vanishing dichotomy for the corresponding problem. Moreover, a modified comparison principle for the time discrete free boundary problem is proved in an effort to provide the sufficient conditions for dichotomy. It is the first attempt to study the temporally discrete diffusive phenomenon with a free boundary.

Periodic solutions for second-order difference equations with continuous time

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Schedule: December 18 16:15-16:45 Capital Suite 2

Genghong Lin
Guangzhou University
Peoples Rep of China

Abstract:
Due to the essential difficulty of establishing an appropriate variational framework on a suitable working space, how to apply the critical point theory for showing the existence and multiplicity of periodic solutions of continuous-time difference equations remains a completely open problem. New ideas are introduced to overcome such a difficulty. This enables us to employ the critical point theory to construct uncountably many periodic solutions for a class of superlinear continuous-time difference equations without assuming symmetry properties on the nonlinear terms. The obtained solutions are piecewise differentiable in some cases, distinguishing continuous-time difference equations from ordinary differential equations qualitatively. This is a joint work with Zhan Zhou, Zupei Shen, and Jianshe Yu.

Destabilization, stabilization, and multiple attractors in saturated mixotrophic environments

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Schedule: December 18 17:00-17:30 Capital Suite 2

Torsten A Lindstroem
Linnaeus University
Sweden

Co-Author(s): T. Lindstr\{o}m, Y. Cheng, and S. Chakraborty

Abstract:
The ability of mixotrophs to combine phototrophy and phagotrophy is now well recognized and found to have important implications for ecosystem dynamics. In this paper, we examine the dynamical consequences of the invasion of mixotrophs in a system that is a limiting case of the chemostat. The model is a hybrid of a competition model describing the competition between autotroph and mixotroph populations for a limiting resource, and a predator-prey type model describing the interaction between autotroph and herbivore populations. Our results show that mixotrophs are able to invade in both autotrophic environments and environments described by interactions between autotrophs and herbivores. The interaction between autotrophs and herbivores might be in equilibrium or cycle. We find that invading mixotrophs have the ability to both stabilize and destabilize autotroph-herbivore dynamics depending on the competitive ability of mixotrophs. The invasion of mixotrophs can also result in multiple attractors.

Threshold dynamics of a Wolbachia-driven mosquito suppression model on two patches

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Schedule: December 18 18:00-18:30 Capital Suite 2

Xiaoke Ma
Harbin Institute of Technology
Peoples Rep of China

Co-Author(s): Ying Su

Abstract:
Releasing {\it Wolbachia}-infected mosquitoes to control wild mosquitoes is a promising avenue. Many studies have been devoted to using mathematical tools to find the optimal control strategy. However, the impact of diffusion of uninfected/infected mosquitoes is less understood. To describe the discretization of release sites, a two-patch mosquito suppression model with time delay and impulsive release is investigated in this paper. Particularly, we assume that the waiting period between two consecutive releases is equal to the sexual lifespan of infected males. We confirm the well-posedness and monotonicity of the solution and explore the existence and stability of equilibria. For some parameter regimes, we give sufficient conditions for a bistable structure. Based on this, we establish the existence of the separatrix with some sharp estimates when choosing constant functions as initial values. More interestingly, the monotonicity of the separatrix in the release number is proved, implying the existence of an optimal release strategy. We also found that the higher the cytoplasmic incompatibility intensity, the more likely wild mosquitoes are suppressed, and releasing infected males at as many spots as possible is more effective.

Periodic solutions for differential equations with distributed delay

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Schedule: December 18 15:45-16:15 Capital Suite 2

Huafeng Xiao
Guangzhou University
Peoples Rep of China

Co-Author(s): Zhiming Guo, Wieslaw Krawcewicz, Jianshe Yu et. al.

Abstract:
In 1934, Volterra poineered the use of an integro-differential equation to model the laboratory populations of some species of small organisms with short generation time. Since then, numerous differential equations incorporating distributed delay have been constructed. Utilizing tools such as fixed point theory, the existence of periodic solutions for these rypes of equations has been established. Recently, Nakata investigated a differential eqution with distributed delay, establishing the existence of at least one periodic solution. However, subsequent numerical simulations have intriguingly revealed the presence of the existence of two periodic solutions. Recognizing the significance of this discovery, our report delves into the matter further, exploring the multiplicity of periodic solutions in differential equations with distributed delay. We achieve this by making use of the critical point theory, equivariant degree theory and Kaplan-Yorke`s method. This is jointed work with Prof. Zhiming Guo, Wieslaw Krawcewicz, Jianshe Yu, et. al.

Geometric theory of distribution shapes for autoregulatory gene circuits

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Schedule: December 18 14:00-14:30 Capital Suite 2

Sheng Ying
Guangzhou university
Peoples Rep of China

Co-Author(s): Genghong Lin, Feng Jiao, Chen Jia

Abstract:
In this study, we provide a complete mathematical characterization of the phase diagram of distribution shapes in an extension of the two-state telegraph model of stochastic gene expression in the presence of positive or negative autoregulation. Using the techniques of second-order difference equations and nonlinear discrete dynamical systems, we prove that the feedback loop can only produce three shapes of steady-state protein distributions (decaying, bell-shaped, and bimodal), corresponding to three distinct parameter regions in the phase diagram. The boundaries of the three regions are characterized by two continuous curves, which can be constructed geometrically by the contour lines of a series of ratio operators. Based on the geometric structure of the phase diagram, we then provide some simple and verifiable sufficient and/or necessary conditions for the existence of the bimodal parameter region, as well as the conditions for the steady-state distribution to be decaying, bell-shaped, or bimodal. Finally, we also investigate how the phase diagram is affected by the strength of positive or negative feedback.

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wStri spread dynamics in Nilaparvata lugens via discrete mathematical models

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Schedule: December 18 17:30-18:00 Capital Suite 2

Bo Zheng
Guangzhou University
Peoples Rep of China

Co-Author(s): Huichao Yang, Saber Elaydi, Jianshe Yu

Abstract:
{\it Wolbachia}, an intracellular bacterium, is well-known for inducing cytoplasmic incompatibility, which has become a promising and environmentally sustainable strategy for controlling pest populations. The strain {\it w}Stri, specifically identified in {\it Nilaparvata lugens} (brown planthopper), has shown potential for such biocontrol applications. In this study, we develop a comprehensive discrete mathematical model to analyze the dynamics of {\it w}Stri spread in a mixed population of {\it w}Stri-infected, {\it w}Lug-infected, and uninfected {\it Nilaparvata lugens} under both constant and periodically varying environmental conditions. Under a constant environment, the model identifies the critical threshold necessary for the successful establishment of {\it w}Stri within the population. Our analysis reveals that the model exhibits a strong Allee effect, where a population must exceed a certain critical density, the Allee threshold, for the {\it w}Stri strain to persist and spread. Below this threshold, the {\it w}Stri strain is likely to be eliminated, failing in pest control efforts. When the environment varies periodically, the model transforms into a non-autonomous periodic discrete model, introducing additional complexity. In this scenario, we derive sufficient conditions that ensure the composition of finitely many Allee maps continues to function as an Allee map. Furthermore, we prove that a unique periodic orbit exists within such a periodic environment. This orbit is characterized as unstable and acts as a threshold, determining whether {\it w}Stri will establish itself in the population or die out over time. The findings from this model provide critical insights into the conditions under which {\it w}Stri can be effectively used to control {\it Nilaparvata lugens}, particularly in environments that are not constant but fluctuate periodically. These insights have significant implications for the practical deployment of {\it Wolbachia}-based biocontrol methods in pest management strategies.

Positive solutions for discrete boundary value problems involving the mean curvature operator

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Schedule: December 18 14:45-15:15 Capital Suite 2

Zhan Zhou
Guangzhou University
Peoples Rep of China

Abstract:
In this talk, we will introduce some results on the positive solutions for some nonlinear discrete Dirichlet boundary value problems involving the mean curvature operator by using critical point theory. Sufficient conditions on the existence of infinitely many positive solutions are given. We show that, the suitable oscillating behavior of the nonlinear term near at the origin and at infinity will lead to the existence of a sequence of pairwise distinct nontrivial positive solutions. The existence of at least two positive solutions is also established when the nonlinear term is not oscillatory both at the origin and at infinity. Examples are given to illustrate our main results at last.

Special Session 38 : Recent advances in the n-body problem

Introduction: The n-body problem is a classic topic in mathematics and physics with long history. With developments of mathematical and computational tools, there are exciting progresses during the past two decades. These progresses include variational constructions, stability, chaotic phenomena, integrability, central configurations, among others. In this special session we aim at providing a forum for researchers in this field to share latest developments and exchange ideas.

On behavior of solutions near collision singularities

Schedule: December 19 8:00-8:30 Capital Suite 15

Kuo-Chang Chen
National Tsing Hua University
Taiwan

Abstract:
Near an isolated collision cluster, classical estimates by Sundman (1913) and Sperling (1970) are well-known to the celestial mechanics community. In this talk we will show a simpler approach based on some ODE techniques, and show some connections with elliptic partial differential equations.

Melnikov Method for Non-Conservative Perturbations of the Restricted Three-Body Problem

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Schedule: December 19 13:30-14:00 Capital Suite 15

Marian Gidea
Yeshiva University
USA

Co-Author(s): Rafael de la Llave; Maxwell Musser

Abstract:
We study the effect of small, time-dependent, non-conservative perturbations on homoclinic orbits to a normally hyperbolic invariant manifold in the planar circular restricted three-body problem. The homoclinic orbits can be described via the scattering map, which gives the future asymptotics of an orbit as a function of the past asymptotics. We add a time-dependent, non-conservative perturbation, and provide explicit formulas, in terms of convergent integrals, for the perturbed scattering map. The motivation of this work comes from astrodynamics. Low-energy space missions are often designed to follow hyperbolic invariant manifolds at constant energy. Applying an orbital maneuver amounts to adding a time-dependent non-conservative perturbation. We are interested in quantifying the effect of the maneuver on the orbit.

Braids, metallic ratios and periodic solutions of the 2n-body problem

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Schedule: December 19 15:15-15:45 Capital Suite 15

Yuika Kajihara
Kyoto University
Japan

Co-Author(s): Eiko Kin and Mitsuru Shibayama

Abstract:
Periodic solutions of the planar N-body problem determine braids through the trajectory of N bodies. Braid types can be used to classify periodic solutions. According to the Nielsen-Thurston classification of surface automorphisms, braids fall into three types: periodic, reducible and pseudo-Anosov. To a braid of pseudo-Anosov type, there is an associated stretch factor greater than 1, and this is a conjugacy invariant of braids. In 2006, Shibayama discovered a family of multiple choreographic solutions of the planar 2n-body problem. We prove that braids obtained from the solutions in the family are of pseudo-Anosov type, and their stretch factors are expressed in metallic ratios.

Existence of transit orbits in the planar restricted 3-body problem via variational methods

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Schedule: December 19 15:45-16:15 Capital Suite 15

Taiga Kurokawa
Kyoto University
Japan

Co-Author(s): Mitsuru Shibayama

Abstract:
We study the planar restricted 3-body problem (PR3BP). Although many numerical studies suggest the existence of transit orbits, few mathematical results have demonstrated their existence. For the case of two bodies in circular motion (PCR3BP), Moeckel (2005) provided a sufficient condition for their existence by minimizing Maupertuis` functional. However, in the case of elliptic motion (PER3BP), this variational structure does not apply because the system is non-autonomous, and no variational results had been known. We provide a different sufficient condition for PCR3BP by minimizing Lagrange`s functional without fixing time. Furthermore, we found that this variational structure is also applicable to non-autonomous systems, allowing us to establish a sufficient condition for PER3BP. We also numerically confirm that these sufficient conditions hold in specific cases where the two bodies have equal mass. In this talk, we will present these results.

Existence and nonexistence of first integrals near integral curves with finite time

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Schedule: December 19 9:00-9:30 Capital Suite 15

Shoya Motonaga
Ritsumeikan University
Japan

Abstract:
We consider existence and nonexistence of first integrals near integral curves with finite time for autonomous dynamical systems. We characterize how many first integrals can exist near periodic orbits. This characterization is an improvement of Poincar\`{e}`s classical criterion using the variational equation near periodic orbits. Moreover, we show that there is a flow-box coordinate for non-periodic integral curves with finite time.

Distance estimates for action-minimizing solutions of the n-body problem

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Schedule: December 19 16:15-16:45 Capital Suite 15

Bo-Yu Pan
Department of Applied Mathematics, National Chung Hsing University, Taiwan
Taiwan

Co-Author(s): Kuo-Chang Chen

Abstract:
In this talk, we estimate mutual distances of action minimizing solutions for the n-body problem. We will present some quantitative estimates for these solutions, including their action values and bounds for their mutual distances. These estimates will facilitate numerical explorations to locate and search for new orbits effectively.

Longterm inspection of orbits of a highly inclined triples system: a hierarchy exchange process including the ZKL mechanism

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Schedule: December 19 13:00-13:30 Capital Suite 15

Masaya Saito
University of Nagasaki, Siebold
Japan

Co-Author(s): Masaya M Saito, Kiyotaka Tanikawa

Abstract:
The gravitationally interacting three bodies are called hierarchical when their orbits are well approximated by double Kepler orbits which do not intersect each other. The presence of the mean motion resonances (MMRs), which have overlapped part, contributes the chaotic nature of the system. In highly inclined systems another process comes to the system, called the von Zeipel-Kozai-Lidov (ZKL) oscillation, that is, anti-correlated oscillation between the inner orbitfs eccentricity e_1 and mutual inclination I. Potentially, a configuration of higher e_1 and lower I would lead a close approach and a member-change of hierarchy. In order to understand how systems lose their hierarchical stability under both the effects of MMRs and the ZKL mechanism, we will carry out a detailed inspection of a single orbit. Introducing three auxiliary quantities about the two outer bodies, which account the closeness, the alignment of two pericenters, and synchronous rotation around the central, we found via timecourse analysis that the ZKL mechanism and secular drift of the pericenters finally broke the hierarchy of the system.

Variational Construction of Orbits Realizing Symbolic Sequences in the Planar Sitnikov Problem

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Schedule: December 19 16:45-17:15 Capital Suite 15

Mitsuru Shibayama
Kyoto University
Japan

Abstract:
We study the limiting case of the Sitnikov problem. By using the variational method, we show the existence of various kinds of solutions in the planar Sitnikov problem. For a given symbolic sequence, we show the existence of orbits realizing it.

Some results of the enumeration problems for point vortex equilibria

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Schedule: December 19 14:00-14:30 Capital Suite 15

Ya-Lun Tsai
National Chung Hsing University
Taiwan

Abstract:
Point vortices in a plane form a dynamical system introduced by Helmholtz in 1858. A vortex equilibrium according to O`Neil is a solution where all vortices move with a common velocity, where the configuration formed by the vortices is stationary or translating depending on whether the velocity is zero or not. In this talk, we will present some results of the enumeration problems for n-vortex translating configurations and n-vortex stationary configurations. Especially, for $n \geq 4$, we will show there exist circulations yielding no translating configurations. Similarly, for $n \geq 5$, there are circulations yielding no stationary configurations. Then, such circulations satisfying the necessary conditions for vortex equilibria but yielding no vortex equilibria will be generalized.

Progress on four-body central configurations

Schedule: December 19 14:30-15:00 Capital Suite 15

Zhifu Xie
The University of Southern Mississippi
USA

Co-Author(s): Shanzhong Sun and Peng You

Abstract:
Central configurations play crucial roles in comprehending the solution structure and dynamic behavior of the N-body problem. The renowned Chazy-Wintner-Smale conjecture states that, for any given positive masses, there exists only a finite number of central configurations. While the conjecture has been verified for the planar 4-body problem and partially for the planar 5-body problem, its generalization remains a formidable challenge for 21st-century mathematicians. The precise enumeration of central configurations for the 4-body problem remains an ongoing pursuit. Particularly the classifications of planar 4-body central configurations have attracted numerous researchers exploring various notions of symmetry within configuration and mass spaces. In this presentation, we will review the findings regarding central configurations for the four-body problem, as well as our recent contributions to this field.

Nonintegrability of dynamical systems near degenerate equilibria

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Schedule: December 19 8:30-9:00 Capital Suite 15

Kazuyuki Yagasaki
Kyoto University
Japan

Abstract:
In this talk, we prove that general three- or four-dimensional systems are real-analytically nonintegrable near degenerate equilibria in the Bogoyavlenskij sense under additional weak conditions when the Jacobian matrices have a zero and pair of purely imaginary eigenvalues or two incommensurate pairs of purely imaginary eigenvalues at the equilibria. For this purpose, we reduce their integrability to that of the corresponding Poincar\{e}-Dulac normal forms and further to that of simple planar systems, and use a novel approach for proving the analytic nonintegrability of planar systems. Our result also implies that general three- and four-dimensional systems exhibiting fold-Hopf and double-Hopf codimension-two bifurcations, respectively, are real-analytically nonintegrable under the weak conditions. To demonstrate these results, we give two examples for the R\{o}ssler system and coupled van der Pol oscillators.

Special Session 41 : Global and Blowup Solutions for Nonlinear Evolution Equations

Introduction: The special session is devoted to the recent developments in global or/and blow-up solutions for nonlinear evolution equations and their applications, including fluid dynamics, delay, localized, non-local, degenerate evolution equations, steady states and their properties.

Blow-up solutions for nonlinear parabolic equations

Schedule: December 16 18:00-18:30 Capital Suite 10

Shaohua Chen
Cape Breton University
Canada

Abstract:
In this talk, we will present a blow-up problem for nonlinear parabolic equations. We introduce a new method to improve the existing results and present some numerical results to support theoretical results.

High energy blowup and blowup time for a class of semilinear parabolic equations with singular potential on manifolds with conical singularities

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Schedule: December 16 16:15-16:45 Capital Suite 10

Yuxuan Chen
Heilongjiang University
Peoples Rep of China

Co-Author(s): Vicentiu D. Radulescu, Runzhang Xu

Abstract:
We consider a class of semilinear parabolic equations with singular potential on manifolds with conical singularities. At high initial energy level $J(u_0) > d$, we present a new sufficient condition to describe the global existence and nonexistence of solutions, respectively. Moreover, by applying the Levine`s concavity method, we give some affirmative answers to finite time blow up of solutions at arbitrary positive initial energy $J(u_0) > 0$, including the upper bound of blowup time. Finally, we show a lower bound of the blowup time and blowup rate under arbitrary initial energy level.

Global non-existence of a coupled parabolic-hyperbolic system of thermoelastic type with history

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Schedule: December 16 13:00-13:30 Capital Suite 10

Jorge A Esquivel-Avila
Universidad Autonoma Metropolitana
Mexico

Abstract:
We consider two abstract systems of parabolic-hyperbolic type that model thermoelastic problems. We study the influence of the physical constants and the initial data on the nonexistence of global solutions that in our framework are produced by the blow-up in finite time of the norm of the solution in the phase space. We employ a differential inequality to find sufficient conditions that produce the blow-up. To that end, we construct a set that is positive invariant for any positive value of the initial energy. As a result we found that the coupling with the parabolic equation stabilizes the system, as well as the damping term in the hyperbolic equation. Moreover, for any pair of positive values (ξ, ϵ), there exist initial data such that the corresponding solution with initial energy ξ blows-up at a finite time less than ϵ. Our purpose is to improve results previously published in the literature.

Nonlinear stability of shock profiles to Burgers equation with critical fast diffusion and singularity

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Schedule: December 16 14:45-15:15 Capital Suite 10

Jingyu Li
Northeast Normal University
Peoples Rep of China

Co-Author(s): Xiaowen Li, Ming Mei, Jean-Christophe Nave

Abstract:
We are interested in the Burgers` equation featuring critical fast diffusion in form of $u_t + f(u)_x = (\ln u)_{xx}$. The solution possesses a strong singularity when $u = 0$ hence bringing technical challenges. We investigate the asymptotic stability of viscous shocks, particularly those with shock profiles vanishing at the far field $x = +\infty$. To overcome the singularity, we introduce some weight functions and show the nonlinear stability of shock profiles through the weighted energy method.

Longtime dynamics for a class of strongly damped wave equations with variable exponent nonlinearities

Schedule: December 16 15:15-15:45 Capital Suite 10

Yanan Li
Harbin Engineering University
Peoples Rep of China

Co-Author(s): Yamei Li; Zhijian Yang

Abstract:
This talk considers the global well-posedness and the longtime dynamics for a class of strongly damped wave equations with evolutional $p(x,t)$-Laplacian, $q(x,t)$-growth source term, and the perturbed parameter $\lambda \in [0,1]$. By using the monotone operator technique and the quasi-stability method, we show the global well-posedness of weak solutions in the time-dependent phase space $[W_0^{1,p(\cdot,t)}(\Omega) \cap L^{q(\cdot,t)}(\Omega)] \times L^2(\Omega)$ and the existence of pullback $\mathscr{D}$-attractor and pullback $\mathscr{D}$-exponential attractor, which are also continuous concerning the parameter λ. This work also establishes the additional regularity of weak solutions and attractors in the semilinear case, which extends the analysis and the results for these types of models with constant exponent nonlinearities.

Qualitative properties of solution for a class of heat equations

Schedule: December 16 13:30-14:00 Capital Suite 10

Junmiao Liu
Harbin Engineering University
Peoples Rep of China

Co-Author(s): Yanbing Yang

Abstract:
This paper delves into the initial-boundary value problem of the ``Euclidean Bosonic Heat Equation``, conducting a comprehensive analysis within the framework of potential wells. In this paper, the asymptotic behavior of the solution is significantly improved from the polynomial form to the stronger exponential decay form. Furthermore, in the range of parameters, the finite time blowup of the solution at any high energy level is proved.

Global existence for aggregation-diffusion systems with irregular kernels

Schedule: December 16 17:00-17:30 Capital Suite 10

Yurij Salmaniw
University of Oxford
England

Co-Author(s): J. Carrillo; J. Skrzeczkowski

Abstract:
Aggregation-diffusion equations and systems have grow rapidly in their population. Models featuring nonlocal interactions through spatial convolution have been applied to several areas, including the physical, chemical, and biological sciences. A typical strategy to establish well-posedness is to use regularity properties of the kernels themselves; however, for many model problems such regularity is not available. One such example is the top-hat kernel which is discontinuous. In this talk, I will present recent progress in establishing a robust well-posedness theory for a class of nonlocal aggregation-diffusion models with minimal regularity requirements on the interaction kernel in any spatial dimension on either the whole space or the torus. Starting with the scalar equation, we first establish the existence of a global weak solution in a small mass regime for merely bounded kernels. Under some additional hypotheses, we show the existence of a global weak solution for any initial mass. In typical cases of interest, these solutions are unique and classical. I will then discuss the generalisation to the n-species system for the regimes of small mass and arbitrary mass. We will conclude with some consequences of these theorems for several models typically found in ecological applications. This is joint work with Dr. Skrzeczkowski and Prof. Jose Carrillo.

Global quantitative stability of wave equations with strong and weak dampings

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Schedule: December 16 17:30-18:00 Capital Suite 10

Runzhang Xu
Harbin Engineering University
Peoples Rep of China

Abstract:
In this talk, we are concerned with the description of global quantitative stability of wave equations with linear strong damping and linear or nonlinear weak damping. By giving some energy decay estimates, we obtain several conclusions about the continuous dependence of the global solution on the initial data and the coefficients of the strong damping term and linear or nonlinear weak damping term. This work also establishes a new idea to use the dissipative effect to obtain the better continuous dependence conclusions, which also reflect the dissipative properties of the solution.

Recent progresses on stochastic Zakharov systems

Schedule: December 16 15:45-16:15 Capital Suite 10

Deng Zhang
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Deng Zhang

Abstract:
In this talk we review very recent progresses on stochastic Zakharov systems in dimensions three and four. The Zakharov system couples Schroedinger and wave equations, and reaches the energy criticality in dimension four. We will mainly show the global well-posedness below the ground state and the noise regularization effects on blow-up and scattering dynamics. This talk is based on joint works with Sebastian Herr, Michael Roeckner and Martin Spitz.

Special Session 42 : High-order complex systems structure and modeling

Introduction: High-order complex systems refer to systems that exhibit intricate interconnections and dynamics among their components. These systems can be found in various domains, such as biology, ecology, social sciences, and computer networks. Modeling high-order complex systems is a crucial task to understand their behavior and make predictions. It is important to note that modeling high-order complex systems is a challenging task due to their inherent complexity and the uncertainties involved. Models may need to be refined and validated using empirical data to ensure their accuracy and reliability. Additionally, advances in computational power and data analysis techniques have significantly contributed to improving our understanding of high-order complex systems. In summary, this special session welcome all the related researchers on high-order complex systems to report their recents works and exchange brilliant ideas, including but not limited to modeling approaches, network modeling, agent-based modeling, and mathematical modeling techniques.

On Poles and Zeros of Linear Quantum Systems

Schedule: December 19 14:00-14:30 Capital Suite 11 A

Zhiyuan Dong
Harbin Institute of Technology, Shenzhen
Peoples Rep of China

Co-Author(s): Guofeng Zhang, Heung-wing Joseph Lee

Abstract:
The non-commutative nature of quantum mechanics imposes fundamental constraints on system dynamics, which in the linear realm are manifested by the physical realizability conditions on system matrices. These restrictions endow system matrices with special structure. The purpose of this paper is to study such structure by investigating zeros and poses of linear quantum systems. In particular, we show that $-s_0^*$ is a transmission zero if and only if s_0 is a pole, and which is further generalized to the relationship between system eigenvalues and invariant zeros. Additionally, we study left-invertibility and fundamental tradeoff for linear quantum systems in terms of their zeros and poles.

Complex network-based information fusion theory and its applications

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Schedule: December 19 8:00-8:30 Capital Suite 11 A

Zhongke Gao
Tianjin University
Peoples Rep of China

Co-Author(s): Xinlin Sun, Gavin Gao, Mengyu Li, Zhongke Gao

Abstract:
Multi-source information fusion is a multidisciplinary research field. Complex network-based information fusion explores the evolutionary relationships between units within the complex systems, providing a fresh perspective for real complex system analysis through the lens of topological dynamics. This report mainly introduces the development and application of this theory in two typical complex scenarios: the petroleum industry and human-machine hybrid intelligence. In the petroleum industry, by integrating multi-source sensor information through complex network, the challenges of high water cut, high gas void fraction, and non-steady-state flow in oil well output fluids are addressed. This technology enables effective monitoring of oil well output status, aiding in reservoir management and enhancing oil recovery rates. In the human-machine hybrid intelligence scenario, the focus is on tasks such as fatigue monitoring, emotional computing, and motor imagery rehabilitation. By constructing brain functional networks to integrate multi-source physiological data, the brain`s cognitive differences under various tasks are analyzed from a topological perspective, leading to more accurate and efficient brain state decoding. These advancements have been implemented in several tertiary hospitals.

Variable Convergence Rate Control of Nonlinear Impulsive Systems: A Fully Actuated System Approach

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Schedule: December 19 9:00-9:30 Capital Suite 11 A

Xuefang Li
Sun Yat-sen University
Peoples Rep of China

Co-Author(s): Yuanen Li, Xuefang Li, Wanquan Liu, Xiao-Dong Li

Abstract:
This paper investigates the variable convergence rate stability of nonlinear impulsive systems utilising the fully actuated system (FAS) method. Different from most of the existing methods, this work eliminates the nonlinearities by using the full-actuation property of the system, based on which the idea of generalized pole assignment is employed to ensure the convergence of the target system with regulable convergence rate. According to the definition of global exponential stability, a variable convergence rate stability theorem for nonlinear impulsive systems is given using the FAS approach. Finally, the validity and feasibility of the method are verified by numerical simulations of a single-link flexible joint robotic system.

A Large-Population Stochastic Differential Game with Terminal State Constraint and Common Noise

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Schedule: December 19 13:00-13:30 Capital Suite 11 A

Shujun Wang
Shandong University
Peoples Rep of China

Co-Author(s): Pengyan HUANG, Guangchen WANG

Abstract:
In this paper, we focus on a type of linear-quadratic (LQ) mean-field game of stochastic differential equation (SDE) with terminal state constraint and common noise, where a coupling structure enters state equation, cost functional and constraint condition. First, by virtue of mean-field method, we introduce an auxiliary problem of the original game, which is a constrained optimal control problem. Second, by virtue of Lagrangian multiplier method and stochastic maximum principle, a decentralized control strategy depending on the optimal Lagrangian multiplier is derived. Finally, we prove that the decentralized control strategy obtained is an ϵ-Nash equilibrium of the LQ mean-field game. As an application, we solve a financial problem and give some numerical results.

A higher-order dynamical model based on simplicial complexes

Schedule:

Yi Zhao
Harbin Institute of Technology, Shenzhen
Peoples Rep of China

Abstract:
The introduction of higher-order structures results in two significant changes in propagation dynamics: non-linear effects and discontinuous mechanisms. Non-linearity arises because group behaviors exhibit emergent properties that are not merely the sum of individual actions. Discontinuity refers to abrupt changes in system dynamics, where minor perturbations can lead to large-scale shifts in behavior, especially when critical thresholds are crossed. To address these complex dynamics, this report develops a higher-order dynamical model based on simplicial complexes. Simplicial complexes allow for the representation of multi-body interactions, extending the modeling framework beyond traditional graph-based approaches. This model captures the non-linear propagation dynamics observed in complex systems and provides insights into how these interactions influence the overall spread of phenomena across networks. Additionally, to manage the discontinuous nature of higher-order interactions, the report proposes a threshold-based control model using differential complementarity systems. This model is designed to describe the discontinuous behaviors emerging from higher-order interactions, enabling the evaluation of intervention strategies aimed at controlling the spread. By incorporating threshold dynamics, the model can assess the effectiveness of various control measures and optimize intervention strategies.

Synchronization of a high-dimensional Kuramoto model with nonidentical oscillators

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Schedule: December 19 8:30-9:00 Capital Suite 11 A

Jiandong Zhu
Nanjing Normal University
Peoples Rep of China

Abstract:
For a high-dimensional Kuramoto model with nonidentical oscillators, a necessary and sufficient condition for complete phase synchronization is presented. Matrix differential equations describing the synchronisation errors are constructed for commutative oscillators and a class of non-commutative oscillators, respectively. Exponential synchronization and the exponential synchronization rate are obtained.structed. Exponential synchronization and the exponential synchronization rate are achieved.

Prescribed-time stabilization of a class of nonlinear systems based on fully actuated system approach

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Schedule: December 19 13:30-14:00 Capital Suite 11 A

Yingqi Zhu
Harbin Institute of Technology, Shenzhen
Peoples Rep of China

Co-Author(s): Zhiyuan Dong,Yuzhong wang

Abstract:
This article investigates the prescribed-time control problem for a class of nonlinear systems with disturbances. Using general backstepping and state scaling techniques to deal with high-order systems with disturbances may lead to differential explosion and complicate stability analysis. To avoid these problems, this paper proposes a prescribed-time control scheme based on fully actuated system (FAS) approach. Transform the nonlinear system into FAS with disturbances, giving the system a more concise structure, and then use a state scaling function to transform the original system state. Using strictly bounded robust controllers to achieve asymptotic stability of new FAS with amplified disturbances, thereby achieving prescribed-time stability of the original system. Finally, the effectiveness of the algorithm was verified through numerical examples.

Special Session 43 : Hamiltonian Dynamics and Celestial Mechanics

Introduction: This special session will concentrate on the latest developments in the fields of Hamiltonian Dynamics and Celestial Mechanics.The study of the N-body problem, which laid the foundations for the birth of dynamical systems, continues to attract researchers from a wide range of fields such as variational calculus, algebraic and symplectic geometry, ergodic theory, topology, numerical analysis, and KAM theory. This session will include topics related to central configurations, the N-body problem in spaces of constant curvature, new periodic solutions, regularization of collisions, index theory and symplectic invariants, stability and instability of solutions, and applications to spacecraft orbital design. Leaders in the field, experts in different areas of dynamical systems, as well as young researchers, will have the opportunity to build an active and stimulating framework to exchange ideas, identify new research directions, and initiate new collaborations. If the schedule permits, we anticipate ending the session with a discussion on open problems.

Weak Compactness Criterion in $W^{k,1}$ with an Existence Theorem of Minimizers

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Schedule: December 19 18:00-18:30 Capital Suite 21 A

Cheng Chen
Sichuan University
Peoples Rep of China

Co-Author(s): Mattie Ji, Yan Tang and Shiqing Zhang

Abstract:
Nelson Dunford and Billy James Pettis [{\em Trans. Amer. Math. Soc.}, 47 (1940), pp. 323--392] proved that relatively weakly compact subsets of L^1 coincide with equi-integrable families. We expand it to the case of $W^{k,1}$ - the non-reflexive Sobolev spaces - by a tailor-made isometric operator. Herein we extend an existence theorem of minimizers from reflexive Sobolev spaces to non-reflexive ones.

On finiteness of central configurations by symbolic computations

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Schedule: December 18 13:00-13:30 Capital Suite 21 A

Kuo-Chang Chen
National Tsing Hua University
Taiwan

Co-Author(s): Ke-Ming Chang

Abstract:
Self-similar solutions for the n-body problem, whose configurations are known as central configurations, are of special importance in celestial mechanics. Its finiteness is a long standing open problem. In this talk we will briefly outline some breakthroughs in the past two decades, in particular Hampton-Moeckel`s work for the case n=4 by (Invent. Math. 2006), and Albouy-Kaloshin`s work for the case n=5 (Ann. Math. 2012). In this talk we will report our recent progress for the case n=6 by symbolic computations.

Exploration of billiards with Keplerian potential

Schedule: December 18 14:00-14:30 Capital Suite 21 A

Anna Maria Cherubini
University of Salento
Italy

Co-Author(s): Vivina L. Barutello and Irene De Blasi

Abstract:
We study a class of elliptic billiards with a Keplerian potential inside, considering two cases: a reflective one, where the particle reflects elastically on the boundary, and a refractive one where the particle can cross the billiard`s boundary entering a region with a harmonic potential. In the latter case, the dynamics is given by concatenations of inner and outer arcs, connected by a refraction law. In recent papers these billiards have been extensively studied in order to identify which conditions give rise to either regular or chaotic dynamics. We complete the study by analysing the non focused reflective case. We then analyse the focused and non focused refractive case, where no results on integrability are known except from the centred circular case, by providing an extensive numerical analysis. We present also a theoretical result regarding the linear stability of homotetic equilibrium orbits in the reflective case for general ellipses, highlighting the possible presence of bifurcations even in the integrable case.

An efficient approach to the design of low-energy transfers in n-body systems

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Schedule: December 19 18:30-19:00 Capital Suite 21 A

Elena Fantino
Khalifa University of Science and Technology
United Arab Emirates

Abstract:
The invariant structures of the circular restricted three-body problem (CR3BP) have been used successfully to design transfers in the Earth-Moon-Sun system and tours of giant planet moons. At the same time, space mission concept studies often seek the computational efficiency and the geometrical insight offered by the two-body problem. Merging the two approaches leads to a design technique, known as the patched three-body/two-body model, that facilitates the design of low-energy transfers in n-body systems. Trajectories associated with hyperbolic invariant manifolds of orbits around the L_1 and L_2 libration points are propagated in the CR3BP until they reach the surface of an {\it ad hoc} sphere of influence where the state vectors are transformed to osculating orbital elements relative to the larger primary. In this way, computing transfers between CR3BPs with a common primary turns into the search for intersections between confocal elliptical orbits. The contribution analyses this methodology and its benefits, and presents applications to the design of a tour of the Saturn system and rendezvous missions to Near Earth Objects.

Geometric properties of normally hyperbolic invariant manifolds for conformally symplectic systems

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Schedule: December 18 18:00-18:30 Capital Suite 21 A

Marian Gidea
Yeshiva University
USA

Co-Author(s): Rafael de la Llave; Tere M-Sera

Abstract:
Normally hyperbolic invariant manifolds (NHIMs) are ubiquitous in Hamiltonian systems, including models from celestial mechanics. However, real-life systems are often subject to dissipative forces. Examples from celestial mechanics include tidal forces, Stokes drag, Poynting-Robertson effect, Yarkowski/YORP effects, atmospheric drag. Adding a dissipation to a Hamiltonian system is a singular perturbation that radically changes its long term behavior. In this work, we study geometric properties of NHIMs for conformally symplectic systems, which model mechanical systems with friction proportional to velocity. We show that certain conditions among rates and the conformal factor are equivalent to the NHIM being symplectic. Specifically, we show that the hyperbolicity rates for symplectic NHIMs satisfy pairing rules similar to those for Lyapunov exponents and eigenvalues of periodic orbits.

A generalized mountain pass lemma with a closed subset for locally Lipschitz functionals

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Schedule: December 19 16:45-17:15 Capital Suite 21 A

Fengying Li
Southwestern University of Finance and Economics
Peoples Rep of China

Co-Author(s): Fengying Li, Bingyu Li, Shiqing Zhang

Abstract:
The classical Mountain Pass Lemma of Ambrosetti-Rabinowitz has been studied, extended and modified in several directions. Notable examples would certainly include the generalization to locally Lipschitz functionals by K. C. Chang, analyzing the structure of the critical set in the mountain pass theorem in the works of Hofer, Pucci-Serrin and Tian, and the extension by Ghoussoub-Preiss to closed subsets in a Banach space with recent variations. In this paper, we utilize the generalized gradient of Clarke and Ekeland`s variatonal principle to generalize the Ghoussoub-Preiss`s Theorem in the setting of locally Lipschitz functionals. We give an application to periodic solutions of Hamiltonian systems.

On the uniqueness of the planar 5-body central configuration with a trapezoidal convex hull

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Schedule: December 18 13:30-14:00 Capital Suite 21 A

Yangshanshan Liu
Chern Institute of Mathematics at Nankai University
Peoples Rep of China

Co-Author(s): Yangshanshan Liu&Shiqing Zhang

Abstract:
In order to apply Morse`s critical point theory, we use mutual distances as coordinates to discuss a kind of central configuration of the planar Newtonian 5-body problem with a trapezoidal convex hull, i.e., four of the five bodies are located at the vertices of a trapezoid, and the fifth one is located on one of the parallel sides. We show that there is at most one central configuration of this geometrical shape for a given cyclic order of the five bodies along the convex hull. In addition, if the parallel side containing the three collinear bodies is strictly shorter than the other parallel side, the configuration must be symmetric, i.e., the trapezoid is isosceles, and the last body is at the midpoint of the shorter parallel side.

The symplectic geometry of the restricted three-body problem

Schedule: December 18 14:45-15:15 Capital Suite 21 A

Agustin Moreno
Heidelberg University
Germany

Abstract:
In this talk, I will survey recent advances in the classical (circular, restricted) three-body problem, from the perspective of symplectic geometry, and discuss applications to trajectory design. Based on joint work with several authors: Otto van Koert, Urs Frauenfelder, Dan Scheeres, Cengiz Aydin, Dayung Koh, Gavin Brown.

Real-analytic nonintegrability of nearly integrable systems and Melnokov method

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Schedule: December 18 17:00-17:30 Capital Suite 21 A

Shoya Motonaga
Ritsumeikan University
Japan

Co-Author(s): Kazuyuki Yagasaki

Abstract:
We study necessary conditions for existence of real-analytic first integrals and real-analytic integrability for perturbations of integrable systems in the sense of Bogoyavlenskij including non-Hamiltonian ones. Moreover, we compare our results with classical results of Poincar\`{e} and Kozlov for systems written in action and angle coordinates and discuss their relationships with Melnikov methods for periodic perturbations of single-degree-of-freedom Hamiltonian systems. The latter discussion reveals that the perturbed systems can be real-analytically nonintgrable even if there exists no transverse homoclinic orbit to a periodic orbit. This is a joint work with Kazuyuki Yagasaki (Kyoto University).

Semi-analytical exploration of drift trajectories near L_1 in the Spatial RTBP

Schedule: December 18 15:15-15:45 Capital Suite 21 A

Pablo Roldan
Universitat Politecnica de Catalunya
Spain

Co-Author(s): Amadeu Delshams and Marian Gidea

Abstract:
Consider the spatial restricted three-body problem, as a model for the motion of a spacecraft relative to the Sun-Earth system. We focus on the dynamics near the equilibrium point L_1, located between the Sun and the Earth. We show that we can make the spacecraft transition from an orbit that is nearly planar relative to the ecliptic, to an orbit that has large inclination, at zero energy cost. (In fact, the final orbit has the maximum inclination that can be obtained through the particular mechanism that we consider. Moreover, the transition can be made through any prescribed sequence of inclinations in between). We provide several explicit constructions of such orbits, and also develop an algorithm to design orbits that achieve the \emph{shortest transition time} for this particular mechanism. Our main new tool is the `Standard Scattering Map` (SSM), a series representation of the exact scattering map. The SSM can be used in many other situations, from Arnold diffusion problems to transport phenomena in applications.

Computational symplectic topology and the restricted three-body problem

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Schedule: December 18 15:45-16:15 Capital Suite 21 A

Otto van Koert
Seoul National University, Department of Mathematics
Korea

Co-Author(s): Chankyu Joung

Abstract:
In this talk we will give an overview of applications of methods from symplectic topology to Hamiltonian dynamical systems. In particular, we describe how information about periodic orbits and global surfaces of section can be obtained. After that we will outline how to apply validated numerics to get concrete results concerning the restricted three-body problem. This is joint work with Chankyu Joung.

Investigation of Bifurcations of Central Configurations

Schedule: December 18 12:30-13:00 Capital Suite 21 A

Zhifu Xie
The University of Southern Mississippi
USA

Co-Author(s): Shanzhong Sun, Peng You, Xiaodong Wang

Abstract:
The system of central configuration equations includes invariants such as scaling, rotation, and translation, which introduce trivial zero eigenvalues to the Jacobian matrix for a central configuration. To determine if a central configuration undergoes a bifurcation, it is crucial to identify if there is a non-trivial zero eigenvalue. In this talk, we will discuss methods to isolate these trivial zero eigenvalues, allowing us to compute the determinant of the remaining matrix. If this determinant is non-zero, it indicates that no bifurcation occurs.

Global dynamics of the N-body problem.

Schedule: December 19 19:00-19:30 Capital Suite 21 A

Jinxin Xue
Tsinghua University
Peoples Rep of China

Co-Author(s): Guan Huang, J. Gerver

Abstract:
We explain our construction of noncollision singularities and superhyperbolic orbits and show that how these special orbits play an role in understanding the generic global dynamics of the N-body problem.

Nonintegrability of the restricted three-body problem

Schedule: December 18 17:30-18:00 Capital Suite 21 A

Kazuyuki Yagasaki
Kyoto University
Japan

Abstract:
The problem of nonintegrability of the circular restricted three-body problem is very classical and important in the theory of dynamical systems. It was partially solved by Poincar\`{e} in the nineteenth century: He showed that there exists no real-analytic first integral which depends analytically on the mass ratio of the second body to the first one and is functionally independent of the Hamiltonian. When the mass of the second body becomes zero, the restricted three-body problem reduces to the two-body Kepler problem. We prove the nonintegrability of the restricted three-body problem both in the planar and spatial cases for any nonzero mass of the second body. Our basic tool of the proofs is a technique developed here for determining whether perturbations of integrable systems which may be non-Hamiltonian are not meromorphically integrable near resonant periodic orbits such that the first integrals and commutative vector fields also depend meromorphically on the perturbation parameter. The technique is based on generalized versions due to Ayoul and Zung of the Morales-Ramis and Morales-Ramis-Sim\`{o} theories.

A symplectic dynamics approach to the spatial isosceles three-body problem

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Schedule: December 19 17:30-18:00   Capital Suite 21 A

Guowei Yu
Chern Institute of Math, Nankai University
Peoples Rep of China

Co-Author(s): Xijun Hu, Lei Liu, Yuwei Ou, Pedro Salomao

Abstract:
In this talk, we consider the spatial isosceles three body problem. For certain choices of energy and angular momentum, the dynamics on the energy surface is equivalent to a Reeb flow on the tight three-sphere. We find a Hopf link formed by the Euler orbit and a symmetric brake orbit, which spans an open book decomposition whose pages are annulus-like global surfaces of section. The convexity and non-convexity of the energy surface will also be discussed. Then we will adress the dynamical consequences of these facts, in particular the existence of periodic solutions.

Selection principle of generalized Hamilton-Jacobi equations

Schedule: December 18 16:15-16:45   Capital Suite 21 A

Jianlu ZHANG
Academy of Mathematics and Systems Science
Peoples Rep of China

Abstract:
In 1987, Lions firstly proposed the homogenization for Hamilton-Jacobi equations, which revealed the significance of effective Hamiltonian in controlling the large time behavior of solutions. He also pointed out a vanishing discount procedure which is equivalent in obtaining the effective Hamiltonian, yet the convergence of solutions in this procedure was unknown until recently. In a bunch of joint works, we verified this convergence by using dynamical techniques.

Special Session 44 : The theory of cluster algebras and its applications

Introduction: Cluster algebra was introduced by Fomin and Zelevinskyin 2002, since then it has beenrelated to various areas in mathematics and physics, such as Combinatorics, Representation Theory, Topology, Algebraic Geometry,Poisson Geometry, Teichmuller Theory, Dynamical System and Mathematical Physics. The theory of cluster algebras has developed into one of the most active research fields in mathematics and has influenced the development of canonical bases of Lie theory, Representation Theory of Quivers, Categorification, Quantum Groups and KLR Algebras, etc. We are eager to extend invitations to both seasoned experts and emerging talents in the field of cluster algebras and related areas, broadly construed. Our focus will center on the latest developments in the theory of cluster algebra and its applications. This gathering is set to offer an ideal platform for fostering collaboration across diverse domains, propelling our collective understanding of these subjects and their profound interconnections to newer horizons. Potential topics for discussion encompass advancements in cluster algebras, quantum cluster algebras, cluster categories, monoidal categories, cohomological Hall algebras, and the interplay between cluster theory and Lie theory. We expect that this conference will promote the progress of some key issues in the frontier of mathematics.

On the acyclic quantum cluster algebras with principle coefficients

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Schedule: December 16 18:30-19:00 Conference Hall B (C)

Xueqing Chen
University of Wisconsin-Whitewater
USA

Co-Author(s): Ming Ding, Junyuan Huang and Fan Xu

Abstract:
We study a new lower bound quantum cluster algebra which is generated by the initial quantum cluster variables and the quantum projective cluster variables of an acyclic quantum cluster algebra with principle coefficients. We show that the lower bound quantum cluster algebra coincides with the corresponding acyclic quantum cluster algebra. Moreover, the dual PBW basis of this algebra is obtained. This is a joint work with M. Ding, J. Huang and F. Xu.

Fixed points of the Fomin-Zelevinsky twist

Schedule: December 17 13:00-13:30 Conference Hall B (C)

Antoine de Saint Germain
the University of Hong Kong
Hong Kong

Co-Author(s): Jiang-Hua Lu

Abstract:
In this talk, we study fixed points of the Fomin-Zelevinsky twist of cluster algebras of finite type. We show that the Fomin-Zelevinsky twist admits a unique totally fixed point. Using this, we obtain a formula relating the exponents (which we will define) of the Fomin-Zelevinsky twist to the number of cluster variables in the underlying cluster algebra. Finally, we provide an interpretation of this result as a tropical analog of Kostant`s classical theorem relating exponents of Coxeter elements and the number of positive roots. This is based on work in progress joint with Jiang-Hua Lu

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Cluster-concealed algebras and intersection matrix Lie algebras

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Schedule: December 17 9:00-9:30 Conference Hall B (C)

Shengfei Geng
Sichuan University
Peoples Rep of China

Co-Author(s): Changjian Fu, Pin Liu

Abstract:
Let B be a concealed algebra, denoted by $\mathfrak{im}(B)$ the corresponding (Slowdowy) intersection matrix Lie algebra defined by the matrix of the quadratic form of B. Let $C = B \ltimes \mathrm{Ext}^2_B(DB, B)$ be the corresponding cluster-concealed algebra. Based on Ringle`s work on cluster concealed algebras, it is proved that the each real Schur root of $\mathfrak{im}(B)$ can be realized by certain decomposition of some indecomposable τ-rigid C-modules when viewed as B-module. Moreover, we give a bijection between the positive roots of $\mathfrak{im}(B)$ and the indecomposable B-modules. This is a joint work with Changjian Fu and Pin Liu.

Casimir Actions of Parabolic Positive Representations

Schedule: December 17 13:30-14:00 Conference Hall B (C)

Ivan Chi Ho Ip
Hong Kong University of Science and Technology
Hong Kong

Co-Author(s): Ryuichi Man, Gus Schrader

Abstract:
The parabolic positive representations of $\mathcal{U}_q(\mathfrak{g}_\mathbb{R})$ were previously constructed by quantizing the classical parabolic induction corresponding to arbitrary parabolic subgroups, such that the Chevalley generators act by positive self-adjoint operators on a Hilbert space. This generalizes the (standard) positive representations introduced earlier corresponding to the minimal parabolic (i.e. Borel) subgroup. In this talk, we will show how one can study the scalar actions of the generalized Casimir operators by certain reductions from the standard representations to the parabolic cases.

On the categorifications of Goncharov--Shen`s basic triangle

Schedule: December 18 8:00-8:30 Conference Hall B (C)

Bernhard Keller
Universite Paris Cite
France

Co-Author(s): Miantao Liu

Abstract:
With each pair consisting of a marked surface S and a split simple Lie group G, Goncharov--Shen have associated a cluster algebra governing the higher Teichmuller space corresponding to S and G. In the case where S is a triangle, work by Miantao Liu allows to categorify this cluster algebra using the Higgs category associated to a canonical quiver with potential (constructed uniformly using a relative Calabi--Yau completion). Merlin Christ has conjectured two alternative descriptions of this Higgs category: 1) as a cosingularity category and 2) as the category of triangles in a 1-cluster category. We will sketch a proof of his conjectures. This is a report on part of Miantao Liu`s ongoing Ph. D. thesis.

Maximal green sequences and q-characters of Kirillov-reshetikhim modules

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Schedule: December 17 16:15-16:45 Conference Hall B (C)

Gleb Koshevoy
IITP Russian Academy of Sciencies
Russia

Co-Author(s): Yuki Kanakubo, Toshiki Nakashima

Abstract:
We show that a q-character of a Kirillov-Reshetikhin module (KR-modules) might be obtained from a specific cluster variable of a seed obtained by applying a maximal green sequence to the initial (infinite) quiver the Hernandez-Leclerc cluster algebra. For a collection of KR-modules with nested supports, we show an explicit construction of a cluster seed which has cluster variables corresponding to the q-characters of KR-modules of such a collection. We prove that the product of KR-modules of such a collection is a simple module. We also construct cluster seeds with cluster variables corresponding to q-characters of KR-modules of some non-nested collections. We make a conjecture that tensor products of KR-modules for such non-nested collections are simple. We also show that the cluster Donaldson-Thomas transformations for double Bruhat cells can be computed the Frenkel-Mukhin algorithm and our algorithm.

Cluster symmetry and Diophantine equations

Schedule: December 16 18:00-18:30 Conference Hall B (C)

Fang Li
Zhejiang University
Peoples Rep of China

Co-Author(s): Fang Li

Abstract:
In this talk, we will introduce the method of cluster symmetry motivated by cluster algebras and apply it to discuss the soluations of Diophantine equations.

Derived equivalences between one-branch extensions of rectangles

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Schedule:

Yanan Lin
Xiamen University
Peoples Rep of China

Co-Author(s): Qiang Dong, Yanan Lin and Shiquan Ruan

Abstract:
This is joint work with Qiang Dong and Shiquan Ruan. We investigate the incidence algebras arising from one-branch extensions of rectangles. There are four different ways to form such extensions, and all four kinds of incidence algebras turn out to be derived equivalent. We provide realizations for all of them by tilting complexes in a Nakayama algebra. As an application, we obtain the explicit formulas of the Coxeter polynomials for a half of Nakayama algebras.

Denominator Conjecture and string algebras

Schedule: December 17 12:30-13:00 Conference Hall B (C)

Pin Liu
Southwest Jiaotong University
Peoples Rep of China

Co-Author(s): Difan Deng, Changjian Fu and Shengfei Geng

Abstract:
This is based on joint work with Difan Deng, Changjian Fu and Shengfei Geng. We show that most string algebras have the τ-reachable property and Fomin-Zelevinsky`s denominator conjecture holds for cluster algebras of type $\mathbb{ABC}$.

Dual canonical bases of quantum groups

Schedule: December 17 14:45-15:15 Conference Hall B (C)

Ming Lu
Sichuan University
Peoples Rep of China

Co-Author(s): Xiaolong Pan

Abstract:
There are two important ways to realize quantum groups, one is Hall algebra given by Ringel and Bridgeland, the other one is the convolution algebra of perverse sheaves given by Lusztig, Nakajima and Qin. In this talk, we shall compare these two realizations. The perverse sheaves give the dual canonical basis of quantum groups by Hernandez-Leclerc and Qin. We prove that dual canonical basis is invariant under braid group actions, and the transition matrix from the dual canonical basis to the basis of Hall algebra is integral and positive, which extend Lusztig`s result. We also compute the rank 1 dual canonical bases, which coincide with the double canonical bases defined by Bernstein and Greenstein, so we expect that there two bases coincide. This is joint work with Xiaolong Pan.

Additive categorification of positroid cluster structures

Schedule: December 18 8:30-9:00 Conference Hall B (C)

Matthew Pressland
Universit\\\\'{e} de Caen-Normandie
France

Abstract:
An open positroid variety is a geometric object appearing in Postnikov`s stratification of the totally non-negative Grassmannian, and a result of Galashin and Lam is that the homogeneous coordinate ring of such a variety has two natural cluster algebra structures. Muller and Speyer conjectured a precise relationship (quasi-coincidence) between these two cluster structures, implying in particular that they define the same positive part of the variety. In this talk, I will explain how to understand the cluster structures and prove Muller and Speyer`s conjecture using the techniques of additive categorification.

Deformed 3-Calabi-Yau categories and Euclidean Artin braid groups

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Schedule: December 18 9:00-9:30 Conference Hall B (C)

Yu Qiu
Tsinghua University
Peoples Rep of China

Abstract:
We introduce a new family of quivers with potential for triangulated marked surfaces with punctures. We show that the deformation of the associated 3-Calabi-Yau categories corresponds to the partial compactification (with orbifolding) of the associated moduli spaces. As an application, we calculate the fundamental groups of these moduli spaces (of framed quadratic differentials), which in particular produces Euclidean Artin braid groups of type A, B, C and D.

Cluster algebras for Symplectic groupoid and Teichhmuller space of closed genus 2 surfaces

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Schedule: December 16 19:00-19:30 Conference Hall B (C)

Michael Shapiro
Michigan State University
USA

Co-Author(s): L.Chekhov

Abstract:
A symplectic groupoid of real unipotent upper-triangular matrices was introduced by A.Bondal. It consists of pairs of nondegenerate matrix B and unipotent upper-triangular matrix A such that BAB^t is also unipotent upper-triangular. The symplectic groupoid possesses a natural symplectic structure that induces a natural Poisson structure on the space of unipotent upper-triangular matrices. This Poisson structure appeared earlier in papers by B.Dubrovin, M.Ugaglia, M.Mazzocco and other in relation to isomonodromic deformations. We discuss a cluster structure compatible with this Poisson structure and use it to describe a cluster structure on Teichmuller space of closed genus 2 curve.

Cluster realizations of i-quantum groups

Schedule: December 17 15:45-16:15 Conference Hall B (C)

Jinfeng Song
National University of Singapore
Singapore

Abstract:
The i-quantum groups arising from quantum symmetric pairs are significant generalizations of quantum groups. In this talk, I will present a cluster realization of i-quantum groups, specifically an algebra embedding of an i-quantum group into a quantum cluster algebra. This embedding allows fundamental constructions of i-quantum groups to be interpreted within a cluster-theoretic framework. As an application, we derive a (dual) integral form of the i-quantum group that is invariant under braid group symmetries.

Group actions on relative cluster categories and Higgs categories

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Schedule: December 17 8:30-9:00 Conference Hall B (C)

Yilin Wu
University of Science and Technology of China
Peoples Rep of China

Abstract:
Let G be a finite group acting on an ice quiver with potential (Q, F, W). In this talk, we will discuss the associated G-action on the relative cluster category and on the Higgs category, and provide the construction of G-equivariant relative cluster category and G-equivariant Higgs category, generalizing the work of Demonet, Paquette-Schiffler, and Le Meur. In the non-simply laced case, the G-equivariant Higgs category can provide an additive categorification for cluster algebras with principal coefficients.

The multiplication formulas of quantum cluster algebras

Schedule: December 17 8:00-8:30 Conference Hall B (C)

Jie xiao
beijing normal university
Peoples Rep of China

Co-Author(s): Zhimin Chen, Fan Xu and Fang Yang

Abstract:
By applying the property of Ext-symmetry and the vector bundle structures of certain fibres, we introduce the notion of weight function and prove the multiplication formulas for weighted quantum cluster characters (functions) associated to abelian categories with the property of Ext-symmetry and 2-Calabi-Yau triangulated categories with cluster-tilting objects. This is joint work with Zhimin Chen, Fan Xu and Fang Yang.

Bott-Samelson atlas and Lusztig`s total positivity on a flag variety

Schedule: December 17 15:15-15:45 Conference Hall B (C)

Shizhuo Yu
Nankai University
Peoples Rep of China

Abstract:
The Bott-Samelson atlas is an atlas on a flag variety constructed via Kazhdan-Lusztig maps. When equipping with the standard Poisson structure, the Bott-Samelson atlas makes a flag variety covered by of symmetric CGL extensions. Moreover, all shifted big cells can be realized as cut of a symmetric CGL extensions, which induce the Lusztig`s total positivity simultaneously but different cluster structures separately. In particular, each coordinate function inside the Bott-Samelson atlas is positive. This is a joint work with Jiang-Hua Lu.

Special Session 45 : Partial differential equations from fluids and waves

Introduction: This session will serve to promote and disseminate recent developments on nonlinear PDEs in fluids and waves. The fundamental prototypes are the Navier-Stokes (NS), Euler equations, Schrodinger equations, and so on. These equations appear, with fixed or moving interfaces, either alone or coupled with other equations, in the study of many phenomena in aerodynamics, geophysics, meteorology, plasma physics, etc. This session will focus on (but not restricted to) issues regarding modeling, local well/ill-posedness, gobal well-poseness/finite-time blowup, and stability.

The qualitative behavior for one-dimensional sixth-order Boussinesq equation with logarithmic nonlinearity

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Schedule: December 17 16:15-16:45 Capital Suite 5

Zhuang Han
Harbin Engineering University
Peoples Rep of China

Co-Author(s): Runzhang Xu, Yanbing Yang

Abstract:
The Cauchy problem for the nonlinear one-dimensional sixth-order Boussinesq equation with logarithmic nonlinearity is concerned in this paper. This model describes the propagation of long waves on the surface of water within small amplitude. The main motivation of this paper is to reveal how logarithmic nonlinearity $u\ln|u|^k$ along with the higher-order dispersive term u_{xxxxxx} affects the qualitative properties of the solution. Some of the efforts on results of global existence and exponential growth of the solution are shown. The main tools to obtain these results include the logarithmic Sobolev inequality, Galerkin method and the concave method. The initial energy is divided into different cases by the depth of the potential well, and corresponding results for subcritical and critical energy levels are both given.

Characteristics of wave propagation in Pre-stressed Viscoelastic Timoshenko Nanobeams with Surface Stress and Magnetic Field Influences

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Schedule: December 17 18:00-18:30 Capital Suite 5

Sunita Kumawat
BITS-Pilani, Hyderabad
India

Co-Author(s): Sunita Kumawat, Kalyan Boyina, Sumit Kumar Vishwakarma, Raghu Piska

Abstract:
The current investigation explores the behavior of pre-stressed viscoelastic Timoshenko nanobeams under the influence of surface effects and a longitudinal magnetic field. Utilizing a modified version of non-local strain gradient theory through the Kelvin-Voigt viscoelastic model, a closed-form dispersion relation using a suitable analytical approach has been derived. To account for surface stresses, Gurtin-Murdouch surface elasticity theory has been employed. Additionally, the study delves into the impact of a longitudinal magnetic field on a single-walled carbon nanotube, considering Lorentz magnetic forces. The validity of the findings is established by deriving results in the absence of surface effects and magnetic fields, aligning well with existing literature. The investigation indicates that pre-stress has marginal effects on flexural and shear waves, while surface effects, magnetic fields, non-locality, characteristic length, and nanotube diameter significantly influence the phase velocity. Additionally, the Threshold velocity and blocking diameter are discussed for the model.

Flexibility results for the Monge-Ampere system

Schedule: December 17 14:45-15:15 Capital Suite 5

Marta Lewicka
University of Pittsburgh
USA

Abstract:
We study flexibility of weak solutions to the Monge-Ampere system (MA) via convex integration. This new system of Pdes is an extension of the Monge-Ampere equation in d=2 dimensions, naturally arising from the prescribed curvature problem and closely related to the classical problem of isometric immersions. Our main results achieve density in the set of subsolutions, of the Holder $\mathcal{C}^{1,\alpha}$ solutions to the Von Karman system which is the weak formulation of (MA). We will present a panorama of recent results in this context, exhibiting regularity dependence on the dimension and codimension of the problem.

Transverse instability of line periodic waves to the KP-I equation

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Schedule: December 17 15:15-15:45 Capital Suite 5

Wei Lian
Lund university
Sweden

Co-Author(s): Erik Wahlen

Abstract:
This is a joint work with Prof. Erik Wahlen (Lund University, Lund, Sweden). The passage from linear instability to nonlinear instability has been shown for 1D solitary waves under 2D perturbations. Although transverse instability of periodic waves to the KdV equation under the KP-I flow has been expected to be true from spectral instability for a long time, it has not been clear how to adapt the general instability theory for solitary waves to periodic waves until now. In this talk, we present how such an adaptation works with the aid of exponential trichotomies and multivariable Puiseux series.

Stability on 3D anisotropic incompressible MHD system near the background magnetic field

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Schedule: December 17 18:30-19:00 Capital Suite 5

Hongxia Lin
Chendu University of Technology
Peoples Rep of China

Co-Author(s): Jiahong Wu, Yi Zhu

Abstract:
The small data global well-posedness of the 3D incompressible Navier-Stokes equations with only one-directional dissipation in the whole space remains an outstanding open problem. Motivated by this Navier-Stokes open problem and by experimental observations on the stabilizing effects of background magnetic fields, we investigate the global well-posedness, the stability and large-time behavior of a special 3D magnetohydrodynamic (MHD) system with only one-directional velocity dissipation and horizontal magnetic diffusion near a background magnetic field in the whole space. Firstly, by discovering the mathematical mechanism of the experimentally observed stabilizing effect and introducing several new techniques to unearth the hidden structure in the nonlinearity, we overcome the derivative loss difficulties and solve the desired global well-posedness and stability problem. Furthermore, by initiating new strategies and developing innovative tools for stability and large-time behavior problems on anisotropic models, we improve the stability to the weaker Sobolev setting . Meanwhile, explicit decay rates are also obtained.

Global well-posedness of 3D inhomogenous Navier-Stokes system with variable viscosity

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Schedule: December 17 17:00-17:30 Capital Suite 5

Dongjuan Niu
Capital Normal University
Peoples Rep of China

Co-Author(s): Wang,Lu

Abstract:
In this talk, I will present the global well-posedness of 3D inhomogenous Navier-Stokes system with variable viscosity only under the smallness assumptions of initial velocity fields in critical spaces. Compared with the previous results, we remove the small conditions on the initial density by virtue of the velocity decomposition method. In addition, the decay rate of the velocity fields is necessary.

A Cell-Centered Implicit Finite Difference Scheme to Study Wave Propagation in Acoustic Media

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Schedule: December 17 17:30-18:00 Capital Suite 5

Sumit K Vishwakarma
Birla Institute of Technology and Science, Pilani
India

Co-Author(s): Sunita Kumawat, Ajay Malkoti

Abstract:
we present a Cell-Centered Implicit Finite Difference (CCIFD) operator-based numerical scheme for the propagation of acoustic waves that is very effective, accurate, and small in size. This scheme requires fewer estimation points than the traditional central difference derivative operator. Any numerical simulation is significantly impacted by the precision of a numerical derivative. Long stencils can deliver excellent accuracy while also minimising numerical anisotropy error. However, a long stencil requires a lot of computational resources, and as these derivatives get bigger, they could start to look physically unrealistic due to contributions from nodes located extremely far, wherein the derivative is local in nature. Furthermore, using such lengthy stencils at boundary nodes may result in errors. The present article investigates a cell-centered fourth order finite difference scheme to model acoustic wave propagation which utilises a lesser number of nodes in comparison to the traditional Central Difference (CD) operator. However, in general the implicit derivative operator has high computational cost and therefore despite its significant advantages it is generally avoided to be implemented in applications. This serves as a motivation for the present paper to explore a technique called CCIFD that significantly decreases the computational expense by nearly fifty percent. Additionally, spectral characterization of the CCIFD derivative operator has been analysed and discussed. Finally, the wave propagation has been numerically simulated in 2-dimensional homogeneous and Marmousi model using CCIFD scheme to validate the applicability and stability of the scheme.

Well-posedness for p(x)-Laplacian parabolic equations with multiple regime on an annulus

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Schedule: December 17 15:45-16:15 Capital Suite 5

Yitian Wang
Harbin Engineering University
Peoples Rep of China

Co-Author(s): Runzhang Xu, Chao Yang

Abstract:
This study investigates the well-posedness of solutions to the initial boundary value problem for parabolic equations with variable exponents of multiple regime (subcritical, critical, and supercritical) on an annulus. The presence of critical and supercritical regimes disrupts classical Sobolev embeddings, leading to the lack of compactness. To address these issues, we use the Strauss inequality to restore compact Sobolev embeddings for radially symmetric functions. By employing the subdifferential technique with symmetry constraints, we establish local existence of solutions for any radially symmetric initial data and demonstrate uniqueness. We pioneer the application of the potential well theory to classify initial data based on three energy levels: subcritical, critical, and supercritical. For subcritical and critical levels, we analyze cases with non-positive and positive initial energy, obtaining results on finite-time blowup and identifying threshold conditions for global existence versus blowup. Finally, we extend these results to a broader class of locally symmetric domains containing an annulus.

Special Session 46 : Theory, Numerical methods, and Applications of Partial Differential Equations

Introduction: Nonlinear partial differential equations (PDEs) are of fundamental importance in mathematical analysis. The minisymposium aims to discuss recent development of theory, numerical methods, and applications of nonlinear PDEs, which not only reveal inherent fundamental properties of exact solutions, but also preserve certain structures or other continuum behaviors of underlying models. Examples include preservation of bounds, Hamiltonian and energy, asymptotic limits, entropy stability, among many others. High order numerical method is an important tool to resolve complex profile of solutions for different equations. The minisymposium will bring together researchers from various fields to report recent developments, to discuss further challenges and reach out to relevant engineering applications. The topics will span a wide range from theoretical results to novel algorithms, and to a variety of interesting application areas. The workshop will provide a platform for applied mathematicians and application scientists to interact, communicate and foster collaborations.

Variational method and its application in medical image registration

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Schedule: December 20 8:00-8:30 Capital Suite 11 A

Han Huan
Wuhan University of Technology
Peoples Rep of China

Co-Author(s): Ke Chen, Peng Chen, Zhengping Wang, Daoping Zhang, Yimin Zhang

Abstract:
In this talk, I will introduce a class of variational problem in medical image registration. Focus on this variational problem, some recent results on addressing the challenging problems (i.e., mesh folding, large deformation, greedy matching and intensity inhomogeneity) will be introduced. Furthermore, numerical results will also be showed to validate the theoretical results.

Total Curvature-Driven Blind Image Deblurring

Schedule: December 20 8:30-9:00 Capital Suite 11 A

Qiyu Jin
Inner Mongolia University
Peoples Rep of China

Co-Author(s): Caiying Wu, Lulu Zhang, Tingting Zhang, Jiawei Lu, Guoqing Chen, Jun Liu, Tieyong Zeng

Abstract:
Blind image deblurring is an inherently ill-posed problem, requiring the estimation of both blur kernel and the original image from a single blurred image. To achieve accurate estimation, prior knowledge is crucial. In this paper, we introduce the total curvature on image surface regularization prior, utilizing the image`s geometric features. This prior preserves sharp edges in the intermediate latent image and enhances the restoration of the blur kernel. We then propose a total curvature weighted image surface minimization model. The strong enhancement of edge preservation by total curvature allows for replacing L_0 norm with L_p norm, ensuring sparsity in our model. This not only enhances our model`s performance but also improves its mathematical properties, enabling us to demonstrate its theoretical convergence. Furthermore, we incorporate inertial technology to enhance the numerical results of our algorithms. Extensive experiments demonstrate the superior performance of our method in diverse image deblurring scenarios compared to state-of-the-art methods. Notably, our method also extends its capabilities to non-uniform deblurring problems, showcasing its versatility and effectiveness in practical settings.

Superconvergence of the local discontinuous Galerkin method with generalized numerical fluxes for fourth-order equations

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Schedule: December 20 16:15-16:45 Capital Suite 11 A

Linhui Li
Harbin Institute of Technology
Peoples Rep of China

Co-Author(s): Xiong Meng, Boying Wu

Abstract:
In this talk, we concentrate on the superconvergence of the local discontinuous Galerkin method with generalized numerical fluxes for one-dimensional linear time-dependent fourth-order equations. The adjustable numerical viscosity of the generalized numerical fluxes is beneficial for long time simulations with a slower error growth. By using generalized Gauss--Radau projections and correction functions together with a suitable numerical initial condition, we derive, for polynomials of degree k, $(2k+1)$th order superconvergence for the numerical flux and cell averages, $(k+2)$th order superconvergence at generalized Radau points, and $(k+1)$th order for error derivative at generalized Radau points. Moreover, a supercloseness result of order $(k+2)$ is established between the generalized Gauss--Radau projection and the numerical solution. Superconvergence analysis of mixed boundary conditions is also given. Equations with Navier boundary conditions, Dirichlet boundary conditions, discontinuous initial condition and nonlinear convection term are numerically investigated, illustrating that the conclusions are valid for more general cases.

Robust Image Denoising through Out-of-Distribution Typical Set Sampling

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Schedule: December 20 15:00-15:30 Capital Suite 11 A

Yao Li
Harbin Institute of Technology
Peoples Rep of China

Co-Author(s): Jie Ning, Jiebao Sun, Shengzhu Shi, Zhichang Guo, and Yao Li

Abstract:
Deep learning-based image denoising models demonstrate remarkable performance, but their lack of robustness analysis remains a significant concern. A major issue is that these models are susceptible to adversarial attacks, where small, carefully crafted perturbations to input data can cause them to fail. Surprisingly, perturbations specifically crafted for one model can easily transfer across various models, including CNNs, Transformers, unfolding models, and plug\&play models, leading to failures in those models as well. Such high adversarial transferability is not observed in classification models. We analyze the possible underlying reasons behind the high adversarial transferability through a series of hypotheses and validation experiments. By characterizing the manifolds of Gaussian noise and adversarial perturbations using the concepts of the typical set and the asymptotic equipartition property, we prove that adversarial samples deviate slightly from the typical set of the original input distribution, causing the models to fail. Based on these insights, we propose a novel adversarial defense method: the Out-of-Distribution Typical Set Sampling Training strategy (TS). TS not only significantly enhances the model`s robustness but also marginally improves denoising performance compared to the original model.

A Fast Minimization Algorithm for the Euler Elastica Model Based on a Bilinear Decomposition

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Schedule: December 20 14:00-14:30 Capital Suite 11 A

Zhifang Liu
Tianjin Normal University
Peoples Rep of China

Co-Author(s): Baochen Sun, Xue-Cheng Tai, Qi Wang, and Huibin Chang.

Abstract:
Euler elastica (EE), as a regulariser for the curvature and length of the image surface`s level lines, can effectively suppress the staircase artifacts of traditional regulariser and has attracted lots of attention in image processing. However, developing fast and stable algorithms for optimizing the EE energy is a great challenge due to its nonconvexity, strong nonlinearity, and singularity. This talk will present a novel, fast, globally convergent hybrid alternating minimization method (HALM) algorithm for the Euler elastica model based on a bilinear decomposition. The HALM algorithm comprises three sub-minimization problems, and each is either solved in the closed form or approximated by fast solvers, making the new algorithm highly accurate and efficient. Numerical experiments show that the new algorithm produces good results with much-improved efficiency compared to other state-of-the-art algorithms for the EE model. This work is joint with Baochen Sun, Xue-Cheng Tai, Qi Wang, and Huibin Chang.

The second fundamental form: an effective regularizer for multiplicative noise removal

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Schedule: December 20 14:30-15:00 Capital Suite 11 A

Shengzhu Shi
Harbin Institute of Technology
Peoples Rep of China

Abstract:
Incorporating appropriate geometric priors into a variational denoising model has shown superiority in noise elimination while preserving important geometric features of the image, such as contrasts, corners, and edges. In this paper, we propose an effective variational model that utilizes the second fundamental form as the regularizer for multiplicative noise removal.

A class of positive-preserving, energy stable and high order numerical schemes for the Poission-Nernst-Planck system

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Schedule: December 20 9:00-9:30 Capital Suite 11 A

Minqiang Xu
Zhejiang University of Technology
Peoples Rep of China

Co-Author(s): Waixiang Cao,Yuzhe Qing

Abstract:
In this paper, we present a class of efficient, positive-preserving, energy stable and high order numerical schemes are presented and studied for solving the time-dependent Poisson-Nernst-Planck (PNP) system. The numerical scheme is based on the energy variational formulation and the PNP system is reformulated as a non-constant mobility H^1 gradient flow, with singular logarithmic energy potentials involved. The fully discrete numerical scheme is constructed by using the first/second order semi-implicit time discretization coupled with the k-th order direct discontinuous Galerkin (DDG) method or the finite element (FE) method for space discretization. The scheme is shown to be positivity preserving and energy stable. Furthermore, optimal error estimates and some superconvergence results are established for the fully-discrete numerical solution. Numerical experiments are provided to demonstrate the accuracy, efficiency, and robustness of the proposed scheme.

Spectral method based fractional physics-informed neural networks for solving tempered fractional partial differential equations

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Schedule: December 20 16:45-17:15 Capital Suite 11 A

Tianxin Zhang
Harbin Institute of Technology
Peoples Rep of China

Co-Author(s): Dazhi Zhang

Abstract:
Physics-informed Neural Networks (PINNs) have emerged as a popular method for solving both forward and inverse differential equations. However, the automatic differentiation techniques employed by PINNs face challenges when solving fractional-order equations. To address this issue, we propose the spectral method based fractional PINNs, termed spectral-fPINNs. This method adopts a more efficient global discretization approach based on Jacobi polynomials, which reduces the need for auxiliary points. Meanwhile, the transformation between physical value and expansion coefficients is computed efficiently by a standard matrix-vector multiplication, thereby increasing the efficiency of the algorithm. The performance of spectral-fPINNs is validated via several examples. We first consider the accuracy, stability and efficiency of our method for solving steady-state fractional partial differential equations. We also analyze the errors under different parameters. Subsequently, experiments are conducted on more complex time-dependent equations. Additionally, an application of the tempered equations on finance and the inverse problems are presented. These results demonstrate the advantages of spectral-fPINNs in terms of efficiency in solving tempered fractional partial differential equations.

Special Session 47 : Meeting Point of Scientific Computing and Machine Learning

Introduction: In the rapidly evolving landscape of applied and computational mathematics, the integration of scientific computing and machine learning has emerged as a powerful synergy. This minisymposium provides a platform for researchers and practitioners to share insights, methodologies, and breakthroughs that bridge the gap between traditional scientific computing techniques and the transformative capabilities of machine learning.

Deep learning solvers for a couple of fluid dynamic equations

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Schedule: December 20 14:00-14:30 Capital Suite 3

Liwei Xu
University of Electronic Science and Technology of China
Peoples Rep of China

Abstract:
In this talk, we present two hybrid methods for solving fluid dynamic equations, which combine neural network methods and traditional methods. The first is applying the asymptotic-preserving and positive-preserving techniques to physics-informed neural networks, which has advantages in high dimensionality and multiscale characteristics. The second is learning a class of new discretization schemes with neural networks, which has high accuracy in the smooth stencil and maintains essentially non-oscillation near the discontinuity. Numerical simulations are employed to validate our methods.

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pETNNs: Partial Evolutionary Tensor Neural Networks for Solving Time-dependent Partial Differential Equations

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Schedule: December 20 14:30-15:00 Capital Suite 3

Jin Zhao
Capital Normal University
Peoples Rep of China

Co-Author(s): Tunan Kao, He Zhang, and Lei Zhang

Abstract:
In this talk, we will introduce our recent work for solving time-dependent partial differential equations with both of high accuracy and remarkable extrapolation, called partial evolutionary tensor neural networks (pETNNs). Our proposed architecture leverages the inherent accuracy of tensor neural networks, while incorporating evolutionary parameters that enable remarkable extrapolation capabilities. By adopting innovative parameter update strategies, the pETNNs achieve a significant reduction in computational cost while maintaining precision and robustness. Notably, the pETNNs enhance the accuracy of conventional evolutional deep neural networks and empowers computational abilities to address high-dimensional problems. Numerical experiments demonstrate the superior performance of the pETNNs in solving time-dependent complex equations, including the Navier-Stokes equations, high-dimensional heat equation, high-dimensional transport equation and Korteweg-de Vries type equation.

On finite element approximation of the Schroedinger-Poisson model

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Schedule: December 20 15:30-16:00 Capital Suite 3

Weying Zheng
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Tao Cui, Wenhao Lu, and Naiyan Pan

Abstract:
In this paper, we study the finite element approximation of the nonlinear Schr\{o}dinger-Poisson model. The electron density is defined by an infinite series over all eigenvalues of the Hamiltonian operator. To establish the error estimate, we present an abstract theory of error estimates for a class of nonlinear problems. The nonlinear problem is first formulated as a fixed-point equation of a compact mapping $\mathcal{A}$. By constructing an approximate mapping $\mathcal{A}_h$, we prove that $\mathcal{A}_h$ has a fixed point u_h which is the solution to the nonlinear approximate problem. The error estimate between u and u_h is established. We apply the abstract theory to the finite element approximation of the Schr\{o}dinger-Poisson model and obtain optimal error estimate between the numerical solution and the exact solution. Numerical experiments are presented to verify the convergence rates of numerical solutions.

Numerical analysis for manifold-preserving and data-driven algorithms of high-index saddle dynamics

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Schedule: December 20 15:00-15:30 Capital Suite 3

Xiangcheng Zheng
Shandong University
Peoples Rep of China

Co-Author(s): Lei Zhang, Pingwen Zhang, Xiangcheng Zheng

Abstract:
High-index saddle dynamics (HiSD) is a powerful instrument in finding multiple saddle points of complex systems. A critical point in designing numerical algorithms is to preserve the manifold properties of HiSD. We perform numerical analysis for manifold-preserving numerical approximation to HiSD, which not only gives error estimates but provides expatiation for manifold-preserving mechanisms of the continuous HiSD. Furthermore, a data-driven HiSD algorithm is presented and analyzed to improve the applicability of the HiSD.

Special Session 48 : Fluid dynamics and KAM theory

Introduction: The goal of this session is to provide an overview of recent advancements in theoretical fluid mechanics, achieved by employing KAM and Normal form techniques. Particular emphasis will be laid on vortex dynamics, construction of multi-periodic waves, dynamics near shear flows, stability, and long-time behaviors. Bringing together experts from both fluid dynamics and KAM theory paves the way to foster a cross-disciplinary dialogue, exchange ideas and inspire new ones. We believe that this unique opportunity will allow to gain a deeper understanding of how KAM theory can be applied to solve complex problems in fluid dynamics and how fluid dynamics can provide real-world context and challenges for KAM theory.

Unstable vortices and non-uniqueness for 2D Euler and $\alpha-$SQG

Schedule: December 19 13:00-13:30 Capital Suite 21 A

Angel Castro
ICMAT-CSIC
Spain

Co-Author(s): Daniel Faraco, Francisco Mengual, Marcos Solera

Abstract:
In the sixties Yudovich proved global existence and uniqueness of solutions for the 2D Euler incompressible equation in $L^1 \cap L^\infty$. This result extends to the case with a force in $L^1_t(L^1 \cap L^\infty)$. Although global existence in $L^1 \cap L^p$, $1

On the vanishing viscosity limit and propagation of regularity for the 2D Euler equations

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Schedule: December 19 16:15-16:45 Capital Suite 21 A

Gennaro Ciampa
University of L`Aquila
Italy

Abstract:
The goal of this talk is to analyze the Cauchy problem for the 2D Euler equations under very low regularity assumptions on the initial datum. We prove propagation of regularity of logarithmic order in the class of weak solutions with L^p initial vorticity, provided that $p \geq 4$. We also study the inviscid limit from the 2D Navier-Stokes equations for vorticity with logarithmic regularity in the Yudovich class, showing a rate of convergence of order $|\log \nu|^{-\alpha/2}$ with $\alpha > 0$.

Asymptotically full measure sets of almost-periodic solutions for the NLS equation

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Schedule: December 19 17:30-18:00 Capital Suite 21 A

Livia Corsi
University "Roma Tre"
Italy

Abstract:
In the study of close to integrable Hamiltonian PDEs, a fundamental question is to understand the behaviour of `typical` solutions. With this in mind it is natural to study the persistence of almost-periodic solutions and infinite dimensional invariant tori, which are in fact typical in the integrable case. In this talk I shall consider a family of NLS equations parametrized by a smooth convolution potential and prove that for `most` choices of the parameter there is a full measure set of Gevrey initial data that give rise to almost-periodic solutions whose hulls are invariant tori. As a consequence the elliptic fixed point at the origin turns out to be statistically stable in the sense of Lyapunov. This is a joint work with L.Biasco, G.Gentile and M.Procesi.

Onsager conjecture for SQG

Schedule: December 19 15:15-15:45 Capital Suite 21 A

Mimi Dai
University of Illinois at Chicago
USA

Co-Author(s): Vikram Giri, Razvan-Octavian Radu

Abstract:
The Hamiltonian of the surface quasi-geostrophic (SQG) equation is an invariant quantity for regular enough solutions. It is postulated that the critical Holder regularity required to have the Hamiltonian conserved is C^{0}, known as the Onsager type of conjecture for SQG. We give a proof of this conjecture using a two-step scheme of convex integration.

Large amplitude quasi-periodic waves in rotating fluids

Schedule: December 19 18:30-19:00 Capital Suite 21 A

Luca Franzoi
University of Milan
Italy

Co-Author(s): Roberta Bianchini, Riccardo Montalto, Shulamit Terracina

Abstract:
The β-plane equation is a 2D approximation model of the 3D Euler-Coriolis equations for rotating fluid. The goal of this short talk is to give an overview on these equations and to quickly present a recent result that studies the dynamics under the effect of a highly oscillating forcing term of substantial large size, therefore not perturbative. Moreover, we will assume the external forcing term to be traveling quasi-periodic in order to resolve a natural degeneracy arising from the rotation of the fluid. This is a joint work with Roberta Bianchini, Riccardo Montalto and Shulamit Terracina.

Desingularization of corners in the Muskat and Peskin problems

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Schedule: December 19 19:00-19:30 Capital Suite 21 A

Eduardo Garcia-Juarez
Universidad de Sevilla
Spain

Co-Author(s): Javier Gomez-Serrano, Susanna V. Haziot, Benoit Pausader

Abstract:
The Muskat and Peskin problems model very different physical phenomena, but both are described by quasilinear and nonlocal parabolic partial differential equations. The former describes the movement of two immiscible and incompressible fluids filtrating a porous medium, while the latter corresponds to an elastic filament immersed in a Stokesian fluid. We will study the small data critical regularity theory for these two models and show that interfaces with corners desingularize in time.

Asymptotic behavior of perturbations of the Euler equations in Yudovics\`s class

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Schedule: December 19 14:30-15:00 Capital Suite 21 A

Haroune HH Houamed
New York University Abu Dhabi
United Arab Emirates

Abstract:
We illustrate the state of art of a simple, but robust, procedure to study the asymptotic behavior of perturbations of a vorticity solving the Euler equations in Yudovich\`s class. The perturbation can be with/without a vanishing source term and/or a vanishing viscosity parameter (Navier--Stokes equations, for instance), and the setup of the problem can be within the entire two-dimensional space or torus. Broadly speaking, we show how the rate of convergence of the approximate vorticity can be improved by understanding the evanescence of some appropriately post-determined high frequencies. We also comment on another application of our method in the asymptotic analysis of a Plasma model within the non-relativistic regime.

One dimensional energy cascade in a quasi-linear dispersive equation

Schedule: December 19 18:00-18:30 Capital Suite 21 A

Federico Murgante
University of Milan
Italy

Co-Author(s): Alberto Maspero

Abstract:
We investigate the transfer of energy to high frequencies in a quasi-linear Schr\{o}dinger equation with sublinear dispersion relation on the one-dimensional torus. Specifically, we construct initial data that undergo finite but arbitrarily large Sobolev norm explosions: starting with arbitrarily small norms in Sobolev spaces of high regularity, these norms become arbitrarily large at later times. Our analysis introduces a novel instability mechanism. By applying para-differential normal forms, we derive an effective equation that governs the dynamics, whose leading term is a non-trivial transport operator with non-constant coefficients. Using a positive commutator method, inspired by Mourre`s commutator theory, we demonstrate that this operator drives the energy cascade, leading to the observed instability.

Vortex patch motion in bounded domains

Schedule: December 19 14:00-14:30 Capital Suite 21 A

Emeric Roulley
SISSA
Italy

Co-Author(s): Zineb Hassainia and Taoufik Hmidi

Abstract:
We consider the Euler equations within a simply-connected bounded domain. The dynamics of a single point vortex are governed by a Hamiltonian system, with most of its energy levels corresponding to time-periodic motion. We show that for the single point vortex, under certain non-degeneracy conditions, it is possible to desingularize most of these trajectories into time-periodic concentrated vortex patches. We provide concrete examples of domains where these non-degeneracies are satisfied, in particular convex ones. We also present a duplication method to construct synchronized motion of several vortices.

Large amplitude traveling waves for the nonresistive MHD system

Schedule: December 19 16:45-17:15 Capital Suite 21 A

Shulamit Terracina
SISSA
Italy

Co-Author(s): G. Ciampa, R. Montalto

Abstract:
The goal of this talk is to discuss the existence of large amplitude traveling waves of the two-dimensional nonresistive Magnetohydrodynamics (MHD) system with a traveling wave external force. More precisely, we assume that the force is a smooth bi-periodic traveling wave propagating in the direction $\omega = (\omega 1, \omega 2) \in \mathbb{R}^2$, with large amplitude of order $O(\lambda^{1+})$ and with large velocity speed $\lambda\omega$. Then, for most values of ω and for $\lambda \gg 1$ large enough, we construct bi-periodic traveling wave solutions of arbitrarily large amplitude. Due to the presence of small divisors, the proof is based on a nonlinear Nash-Moser scheme adapted to construct nonlinear waves of large amplitude. The main difficulty is that the linearized equation at any approximate solution is an unbounded perturbation of large size of a diagonal operator and hence the problem is not perturbative. The invertibility of the linearized operator is then performed by using tools from micro-local analysis and normal forms together with a sharp analysis of high and low frequency regimes with respect to the large parameter λ. \noindent This is a joint work with G. Ciampa and R. Montalto.

Infinitely many isolas of modulational instability for Stokes waves

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Schedule: December 19 13:30-14:00   Capital Suite 21 A

Paolo Ventura
Universita` degli Studi di Milano
Italy

Co-Author(s): Massimiliano Berti, Livia Corsi, Alberto Maspero

Abstract:
Stokes waves are the simplest nontrivial form of water waves, featuring a periodic profile moving steadily in one direction. In the `70s, Benjamin and Feir discovered through experiments that the steady profile is unstable under long-wave perturbations, i.e. disturbances that, although small in amplitude, have much longer period than the initial wave. In recent years, significant mathematical progress has been made on this `modulational` instability, particularly in the linear approximation, which involves understanding the $L^2(\mathbb{R})$-spectrum of the water wave operator linearized along a Stokes wave. I will present our latest results on the topic, specifically the full description of arbitrary portions of the unstable spectrum. As long conjectured by numerical investigations, this spectrum consists of infinitely many isolated elliptical branchings, called `isolas`, centered on the imaginary axis that become exponentially small as one moves away from the origin of the complex plane. This work was done in collaboration with M. Berti, L. Corsi, and A. Maspero.

Doubly connected V-states for the active scalar equations

Schedule: December 19 15:45-16:15   Capital Suite 21 A

Liutang Xue
Beijing Normal University
Peoples Rep of China

Co-Author(s): Taoufik Hmidi, Liutang Xue, Zhilong Xue

Abstract:
This talk is concerned with the existence of doubly connected V-states (i.e. rotating patches) close to an annulus for the active scalar equations with completely monotone kernels. This provides a general way to unify various results on this topic related to geophysical flows. As some applications, the existence of doubly connected V-states for the gSQG equation and QGSW equation on radial domains are obtained, which are completely new.

Special Session 49 : Stochastic Control, Filtering and Related Fields

Introduction: In various stochastic dynamic systems in the nature and real society, many optimization problems can be encountered, which have been widely researched by the theory of stochastic control and differential games. However, in reality, information obtained by controllers/players is asymmetric, especially in partial observation problems. Stochastic filtering is an important probabilistic tool to solve this kind of problems and have achieved rapid development in recent years. The purposes of this special session are to present the newest developments and to discuss the future directions in stochastic control, filtering and related fields. The main topics are focused on, but are not limited to: (1) stochastic optimal control with partial information and applications, (2) mean-field type control and mean-field game with applications, (3) stochastic filtering, particle filtering and related fields, (5) Stackelberg/leader-follower stochastic differential games with partial/asymmetric information, and so on.

Partially observed mean-field game and related mean-field forward-backward stochastic differential equation

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Schedule: December 18 15:15-15:45 Capital Suite 21 C

Kai Du
Shandong University
Peoples Rep of China

Abstract:
In this talk, we study a linear-convex mean-field game with input constraints for partially observed forward-backward system, where both types of mean-field terms, asynchronous style (state-averages) and synchronous style (state expectations), are considered. The observation is a controlled process, whose drift term is linear with respect to state and control variable. For the general case, by using the mean-field method and the backward separation approach, we obtain the decentralized optimal strategies through a Hamiltonian system and related Consistency Condition (CC), which are given by two types of mean-field forward-backward stochastic differential equations with filtering. In virtue of continuation method and discounting method, the well-posedness of such kind of equations is proved under two different conditions. For the linear-quadratic case under linear subspace constraints, we give the feedback representation of the decentralized optimal strategies, and the Riccati type CC system is also given. As one application, an asset-liability management problem is solved.

Policy Iteration Reinforcement Learning Method for Continuous-time Linear-Quadratic Mean-Field Control Problem

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Schedule: December 18 9:00-9:30 Capital Suite 21 C

Na Li
School of Statistics and Mathematics, Shandong University of Finance and Economics
Peoples Rep of China

Abstract:
This paper employs a policy iteration reinforcement learning (RL) method to study continuous-time linear quadratic mean-field control problems in the infinite horizon. The drift and diffusion terms in the dynamics involve the state as well as the control. We investigate the stability and convergence of the RL algorithm using a Lyapunov Recursion. Instead of solving a pair of coupled Riccati equations, the RL technique focuses on strengthening an auxiliary function and the cost functional as the objective functions and updating the new policy to compute the optimal control via state trajectories. A numerical example sheds light on the established theoretical results.

Indefinite linear-quadratic large population problem with partial observation

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Schedule: December 18 14:45-15:15 Capital Suite 21 C

Tianyang Nie
Shandong University
Peoples Rep of China

Abstract:
We investigate an indefinite linear-quadratic partially observed large population system with common noise, where both the state-average and control-average are considered. All weighting matrices in the cost functional can be indefinite. We obtain the decentralized optimal strategies by the Hamiltonian approach and demonstrate the well-posedness of Hamiltonian system by virtue of relaxed compensator. The related Consistency Condition and the feedback form of decentralized optimal strategies are derived. Moreover, we prove that the decentralized optimal strategies are ε-Nash equilibrium by using the relaxed compensator. The talk is based on the joint work with Dr, Tian Chen and Prof. Zhen Wu.

Sequential Markov Chain Monte Carlo for Filtering

Schedule: December 18 9:30-10:00 Capital Suite 21 C

Hamza Ruzayqat
King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): Alexandros Beskos, Dan Crisan, Ajay Jasra, Nikolas Kantas

Abstract:
We consider the problem of high-dimensional filtering/data assimilation of continuous and discrete state-space models at discrete times. This problem is particularly challenging as analytical solutions are usually not available and many numerical approximation methods can have a cost that scales exponentially with the dimension of the hidden state. We utilize a sequential Markov chain Monte Carlo method to obtain samples from an approximation of the filtering distribution. For certain state-space models, this method is proven to converge to the true filter as the number of samples, N, tends to infinity. We benchmark our algorithms on linear Gaussian state-space models against competing ensemble methods and demonstrate a significant improvement in both execution speed and accuracy (the algorithm cost can range from O(Nd) to O(Nd[d+1]/2) based on the model noise covariance matrix structure, where d is the dimension of the hidden state. We then consider a state-space model with Lagrangian observations such that the spatial locations of these observations are unknown and driven by the partially observed hidden signal. This problem is exceptionally challenging as not only is high-dimensional, but the model for the signal yields longer-range time dependencies through the observation locations. Finally, the algorithm is tested on the high-dimensional rotating shallow water model with real data obtained from drifters in the ocean.

A Risk-Sensitive Global Maximum Principle for Controlled Fully Coupled FBSDEs with Applications

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Schedule: December 18 15:45-16:15 Capital Suite 21 C

Jingtao Shi
Shandong University
Peoples Rep of China

Co-Author(s): Jingtao Lin

Abstract:
This paper is concerned with a kind of risk-sensitive optimal control problem for fully coupled forward-backward stochastic systems. The control variable enters the diffusion term of the state equation and the control domain is not necessarily convex. A new global maximum principle is obtained without assuming that the value function is smooth. The maximum condition, the first- and second-order adjoint equations heavily depend on the risk-sensitive parameter. An optimal control problem with a fully coupled linear forward-backward stochastic system and an exponential-quadratic cost functional is discussed. The optimal feedback control and optimal cost are obtained by using Girsanov theorem and completion-of-squares approach via risk-sensitive Riccati equations. A local solvability result of coupled risksensitive Riccati equations is given by Picard-Lindelof Theorem.

Robust optimal control of Bi-objective LQ system with noisy observation

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Schedule: December 18 13:00-13:30 Capital Suite 21 C

Guangchen Wang
Shandong University
Peoples Rep of China

Co-Author(s): Zhuangzhuang Xing

Abstract:
This talk is concerned with a kind of partially observable LQ control problem, where the coefficients of cost functional are uncertain representing different market conditions. By virtue of backward separation technique, stochastic maximum principle, as well as filtering method, a feedback form of candidate optimal control is designed. Moreover, through some delicate analysis, the existence of maximal reference probability is certified. Finally, a numerical simulation is presented to authenticate the theoretical results.

Mean-field stochastic linear quadratic control problem with random coefficients

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Schedule: December 18 14:00-14:30 Capital Suite 21 C

Xu Wen
Southern University of Science and Technology
Peoples Rep of China

Co-Author(s): Jie Xiong

Abstract:
In this talk, we will present our recent studies on mean-field stochastic linear quadratic (MFSLQ) control problems with random coefficients. We discovered that, despite the presence of terms like $\mathbb{E}[A(\cdot)X(\cdot)]$ in the adjoint equation preventing us from decoupling the optimal system, the MFSLQ problem can still be solved explicitly using an extended Lagrange multiplier method. This method decomposes the MFSLQ control problem into two constrained SLQ control problems without mean-field terms. This talk is based on joint work with Professor Jie Xiong.

Extrapolation Methods for Solving Backward Stochastic Differential Equations

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Schedule: December 18 8:30-9:00 Capital Suite 21 C

Weidong Zhao
Shandong University
Peoples Rep of China

Co-Author(s): Yafei Xu

Abstract:
For the θ-scheme and the Crank-Nicolson scheme for solving backward stochastic differential equations (BSDEs), by using the Adomian decomposition for the nonlinear generator of BSDEs and by introducing a system of new BSDEs, we theoretically obtain their asymptotic expansions. Based on the expansions, we propose extrapolation methods of the two schemes for solving FBSDEs. Our numerical tests verify our theoretical conclusions, and show that the extrapolation algorithms are very efficient and have the capacity of solving complicated physical problems.

On Mean-field super-Brownian motions

Schedule: December 18 13:30-14:00 Capital Suite 21 C

Jiayu Zheng
Shenzhen MSU-BIT University
Peoples Rep of China

Co-Author(s): Yaozhong Hu, Michael A. Kouritzin and Panqiu Xia

Abstract:
The mean-field stochastic partial differential equation (SPDE) corresponding to a mean-field super-Brownian motion (sBm) is obtained and studied. In this mean-field sBm, the branching-particle lifetime is allowed to depend upon the probability distribution of the sBm itself, producing an SPDE whose space-time white noise coefficient has, in addition to the typical sBm square root, an extra factor that is a function of the probability law of the density of the mean-field sBm. This novel mean-field SPDE is thus motivated by population models where things like overcrowding and isolation can affect growth. A two step approximation method is employed to show existence for this SPDE under general conditions. Then, mild moment conditions are imposed to get uniqueness. Finally, smoothness of the SPDE solution is established under a further simplifying condition.

Special Session 50 : Trends in Infinite Dimensional Topological Dynamics

Introduction: Combining the concepts of topological dynamics and infinite dimensional dynamical systems gives rise to a discipline that can be referred to as Infinite Dimensional Topological Dynamics. It focuses on studying the qualitative behavior and structures of dynamical systems that have infinite-dimensional state spaces from a topological perspective. This special session focuses on the recent progress on this theory. These advancements encompass aspects like investigating the topological stability of systems with global attractor, linear operators with generalized hyperbolicity, stability and Gromov-hausdorff stability of linear operators and PDEs, and so on.

Dynamics of Solenoidal Automorphisms

Schedule: December 18 13:30-14:00 Capital Suite 9

Sharan Gopal
BITS-Pilani Hyderabad campus
India

Co-Author(s): Dr. Faiz Imam

Abstract:
This talk is based on a series of papers (mentioned below), which aim at studying the sets of periodic points of automorphisms on a solenoid. In these papers, we attempted to characterise the sets of periodic points of solenoidal automorphisms. In [1], we characterized the sets of periodic points of 1-dimensional solenoids and full solenoids. In the next paper [2], it was extended to some higher dimensional solenoids in terms of inverse limits of certain maps on a torus. Finally, the third paper [3] does this using the concept of adeles. The talk starts with an introduction to some basic notions of topological dynamics that are required to present our results, followed by a summary of the results mentioned above. It is then concluded with the same question for more general dynamical systems than solenoids. [1] Gopal, Sharan and Raja, C.R.E. \textit{Periodic points of solenoidal automorphisms}, Topology Proceedings, 50 (2017), 49-57. [2] Gopal, Sharan and Imam, Faiz. \textit{Periodic points of solenoidal automorphisms in terms of inverse limits}, Appl. Gen. Topology, Vol. 22 (2021), 321-330. [3] Imam, Faiz and Gopal, Sharan. \textit{Periodic points of solenoidal automorphisms in terms of adeles}, Monatsh Math 204 (2024), 501-511.

Dynamical systems and the Diophantine approximation on the Hecke group H4

Schedule: December 18 13:00-13:30 Capital Suite 9

Dong Han Kim
Dongguk University - Seoul
Korea

Abstract:
Diophantine approximation is to find rational numbers that approximate irrationals. It is related to the two kinds of dynamical systems, dynamics on the parameter space and dynamics on the phase space. The Gauss map and geodesic flows are parameter space dynamics. The Diophantine approximation exponent quantifies the rate at which the geodesic approaches the cusp of the fundamental domain of the modular group. It also gives the rate of the recurrence time of irrational rotations and translations on torus which are dynamical systems of the phase space. In this talk we generalize classical results on the Diophantine approximation to the Hecke group H_q. When q=4, the Diophantine approximation on H_4 corresponds to the approximation on the unit circle and it is related with continued fraction algorithms to find best rational approximations of given parities. We also discuss the dynamical systems on the phase space associated with the Diophantine approximation on H_4.

Understanding cut-and-project sets on substitution tilings

Schedule: December 18 15:45-16:15 Capital Suite 9

Jeon-Yup Lee
Catholic Kwandong University
Korea

Co-Author(s): Boris Solomyak

Abstract:
After the discovery of quasicrystals in material sciences, there has been a lot of study to understand the structure of quasicrystals. Mathematically, quasicrystals can be modeled by tilings or point sets, and the structure of quasicrystals can be described by pure discrete spectrum of the tiling dynamics. It is known that a cut-and-project set with a nice window always gives pure discrete spectrum. But the converse is not true in general settings. Here we look at substitution tilings and study the relation between the cut-and-project sets and pure discrete spectrum. We first look at the case that the expansion maps of the substitutions are diagonalizable. And then we will also talk about a recent development on non-diagonalizable case.

Spectral decomposition and skew product for group actions

Schedule: December 18 17:30-18:00 Capital Suite 9

Keonhee Lee
Chungnam National University
Korea

Abstract:
Spectral decomposition which is fundamental in the qualitative theory of dynamical systems delineates that the nonwandering set can be decomposed as a finite number of disjoint compact invariant indecomposable sets. In this talk we establish various types of spectral decomposition for group actions on compact metric spaces. In particular, we use a skew-product associated with a group action to derive the spectral decomposition of the nonwandering set in a given direction. This talk is based on reference [1]. References [1] K.Lee, C. Morales and Y. Tang, Spectral decomposition and skew-product for group actions, preprint. [2] K. Lee and N. Nguyen, Spectral decomposition and Ω-stability of flows with expanding measures, J. Differential Equations 269 (2020), 7574-7604.

Various Shadowing Properties in General Topological Spaces

Schedule: December 18 15:15-15:45 Capital Suite 9

Khundrakpam Binod Mangang
Manipur University
India

Co-Author(s): Khundrakpam Binod Mangang , Thiyam Thadoi Devi and Sonika Akoijam

Abstract:
In this talk, we introduce various shadowing properties such as Hausdorff average shadowing property, Hausdorff ergodic shadowing property, periodic shadowing property when the phase space is a general topological space. We prove some related results. On a compact Hausdorff space, if f has the Hausdorff average shadowing property, we show that f^k has the Hausdorff average shadowing property for every positive integer k. Further, we show that a dynamical system with the Hausdorff ergodic shadowing property is Hausdorff chain transitive if f is surjective. The content of the talk is from the following references. [1]POSITIVE EXPANSIVITY, CHAIN TRANSITIVITY, RIGIDITY, AND SPECIFICATION ON GENERAL TOPOLOGICAL SPACES, Bull. Korean Math. Soc. 59 (2022), No. 2. [2] ON PERIODIC SHADOWING, TRANSITIVITY, CHAIN MIXING AND EXPANSIVITY IN UNIFORM DYNAMICAL SYSTEMS, Gulf Journal of Mathematics Vol 9, Issue 2 (2020). [3] ERGODIC SHADOWING, d-SHADOWING AND EVENTUAL SHADOWING IN TOPOLOGICAL SPACES, Nonlinear Functional Analysis and Applications Vol. 27, No. 4 (2022).

Spectral Decomposition and Topological Stability for Dynamical Systems on Non-metrizable Spaces

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Schedule: December 18 14:00-14:30 Capital Suite 9

Jumi Oh
Sungkyunkwan University
Korea

Co-Author(s): Jumi Oh

Abstract:
In this talk, we introduce the notions of symbolic expansivity and symbolic shadowing for homeomorphisms on non-metrizable spaces which are generalizations of expansivity and shadowing for metric spaces, respectively. The main result is to generalize the Smales spectral decomposition theorem to symbolically expansive homeomorphisms with symbolic shadowing on non-metrizable compact Hausdorff totally disconnected spaces. Furthermore, we consider the topological stability for homeomorphisms on the spaces.

Expansive Minimal Flows

Schedule: December 18 17:00-17:30 Capital Suite 9

Elias Rego
AGH university of Science and Technology
Poland

Abstract:
In this talk we shall discuss the relation between minimality and expansiveness for regular flows. Our main goal is to extend a famous result due Ma\~n\`e which states that if an expansive homeomorphism is minimal, then it must be defined on a zero dimensional space. An attempt of extending this result to flows was made by Keynes and Sears in 1981 with the extra assumption of no spiral points or the flows being Axiom A. Here we will see how remove those extra conditions and obtain a result analogous to Ma\~n\`e`s in full generality. Precisely, we show that a expansive flow is minimal if and only if it is a suspension of a minimal subshift of finite type. We further apply our findings to study the minimal subsets of expansive flows. This is a joint work with Alfonso Artigue.

Measurable spectral decomposition for homeomorphisms

Schedule: December 18 16:15-16:45 Capital Suite 9

Bomi Shin
Sungkyunkwan University
Korea

Co-Author(s): Bomi Shin

Abstract:
The Spectral Decomposition Property (SDP) plays a central role in understanding the structure of nonwandering sets in dynamical systems. In this talk, we extend the classical SDP to a measure-theoretic setting for homeomorphisms on compact metric spaces. We demonstrate that a homeomorphism has the SDP if and only if each Borel probability measure satisfies this property. Additionally, we have the relationship between shadowing properties and spectral decomposition by proving that shadowable measures for expansive homeomorphisms exhibit the SDP. This talk is based on reference \cite{s}. \begin{thebibliography}{20} \bibitem{s} Shin, Bomi A measurable spectral decomposition. Monatsh. Math. 204 (2024), no. 2, 311--322. \end{thebibliography}

Joint ergodicity of piecewise monotone maps

Schedule: December 18 14:45-15:15 Capital Suite 9

Younghwan Son
POSTECH
Korea

Abstract:
Joint ergodicity is a generalization of the notion of ergodicity to a finite number of measure preserving transformations. Berend and Bergelson provided a characterization of joint ergodicity for commuting invertible measure preserving systems. In this talk we present a generalization of their characterization and provide some examples of joint ergodicity of piecewise monotone maps. This result demonstrates that the phenomena of joint ergodicity takes place even when the involved measure preserving transformations are neither commuting nor invertible, and have different invariant measures. This is a joint work of Vitaly Bergelson.

Special Session 51 : Integrable Aspects and Asymptotics of Nonlinear Evolution Equations

Introduction: Integrable systems, which occur frequently in the modelling of various nonlinear phenomena, admit rich solutions, algebraic and geometric structures. Also, the study on interactions of solitary waves is an important part of the modern theory of nonlinear waves. A number of methods have been developed to construct solutions and investigate novel properties of integrable systems. In addition, stability of solitary wave solutions to integrable systems is an interesting topic and attracts much attentions in the past years. Several methods have been established to investigate asymptotic of solutions to integrable systems. The proposed session aims at bringing together the researchers in the fields and at offering an overview of some of the current research activities in this area.

Hamiltonian structures for differential-difference equations: classification and cohomology

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Schedule: December 19 9:00-9:30 Conference Hall B (B)

Matteo Casati
Ningbo University
Peoples Rep of China

Co-Author(s): D.Valeri, J.P.Wang

Abstract:
The Hamiltonian structures of (integrable) differential--difference systems, usually obtained in terms of difference (\emph{shift}) operators, has some remarkable algebraic properties -- some cases have been investigated by Dubrovin many years ago,\footnote{B. A. Dubrovin. Differential-geometric Poisson brackets on a lattice. \emph{Funct. Anal. Appl.}, 23(2):57, 1989.} and more recently it has been shown that they can all be recomprised under the notion of multiplicative Poisson vertex algebras.\footnote{A. De Sole, V. G. Kac, D. Valeri, and M. Wakimoto. Local and Non-local Multiplicative Poisson Vertex Algebras and Differential-Difference Equations. \emph{Commun. Math. Phys.}, 370(3):1019, 2019.} Following a differential-geometrical approach, we introduced the corresponding notion of Poisson bivector and Poisson cohomology.\footnote{MC and J. P. Wang. A Darboux-Getzler theorem for scalar difference Hamiltonian operators. \emph{Commun. Math. Phys.}, 374:1497, 2020.} This allowed us to better understand the classification of bi-Hamiltonian pairs present in De Sole et al., extend the notion to include noncommutative differential-difference systems,\footnote{MC and J. P. Wang. Hamiltonian structures for Integrable Nonabelian Difference Equations. \emph{Commun. Math. Phys.}, 392:219, 2022.} and most recently expand the classification of such structures to multi-component cases.\footnote{MC and D. Valeri, Multi-component Hamiltonian difference operators, \emph{in preparation}}

Dispersive revival phenomena for two-dimensional dispersive evolution equations

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Schedule: December 19 8:30-9:00 Conference Hall B (B)

Jing Kang
Northwest University
Peoples Rep of China

Co-Author(s): Changzheng Qu, Zihan Yin

Abstract:
In this talk, the dispersive revial phenomenon for two-dimensional linear spatially periodic dispersive evolution equations on a rectangle subject to periodic boundary conditions and discontinuous initial profiles are investigated. We analyze a nonvel revial phenomenon for two-dimensional equations with non-polynomial dispersion relations, in the concrete case of the periodic initial-boundary value problem of the linear Kadomtsev-Petviashvili equation on a square with a step function initial data. Revival in this case exhibits a novel characteristic that there appears radically different qualitative behaviors in x and y directions. We give an analytic description of this dichotomous revial phenomenon, and present illustrative numerical simulations.

Construction and solutions of the semi-discrete Toda and sine-Gordon equations

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Schedule: December 19 15:45-16:15 Conference Hall B (B)

Chunxia Li
Capital Normal University
Peoples Rep of China

Abstract:
This talk aims to explore the relations between the Sylvester equation and semi-discrete integrable systems. Starting from the Sylvester equation $KM+ML=rs^\top$, the master function $S^{(i,j)}=s^\top L^jC(I+MC)^{-1}K^ir$ is introduced. By imposing dispersion relations on r and s, the semi-discrete Toda equation, the modified semi-discrete Toda equation and their Miura transformation are established through equations of $S^{(i,j)}$. In addition, Lax pair and solutions are constructed for the semi-discrete Toda equation in a systematic way. Under the symmetric constraint $S^{(i,j)}=S^{(j,i)}$, the semi-discrete sine-Gordon equation, the modified semi-discrete sine-Gordon equation and their Miura transformation are derived. Integrability such as Lax pair, the bilinear form and various types of solutions for the semi-discrete sine-Gordon equation are presented as well.

Theta-function oscillatory solitons of integrable equations

Schedule: December 19 16:15-16:45 Conference Hall B (B)

Ruomeng Li
Zhengzhou University
Peoples Rep of China

Co-Author(s): Xianguo Geng

Abstract:
In this talk, a method to construct oscillatory soliton solutions, expressed with theta-functions, is presented, of integrable equations, that is both Lax and Hirota integrable. The Baker-Akhiezer functions in the field of algebraic solutions and the tau-functions in the filed of the direct method are combined to solve the spectral problems, to construct Darboux transformations, and to derive exact solutions.

Variable Separation Approach and Abundant Nondegenerate Solitons

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Schedule: December 19 15:15-15:45 Conference Hall B (B)

Ji Lin
Zhejiang Normal University
Peoples Rep of China

Co-Author(s): Xueping Cheng

Abstract:
We propose to combine the bilinear method with the variable separation approach to study the nondegenerate multi-soliton solution of the two-component long-wave-short-wave resonance interaction system in (2+1) dimension. We successfully obtain N nondegenerate soliton general solutions for each shortwave component containing N arbitrary functions of the independent variable y. By containing arbitrary functions, rich soliton forms can be easily obtained.

On the progresses on some open problems related to infinitely many symmetries

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Schedule: December 18 17:00-17:30 Conference Hall B (B)

SY Lou
Ningbo University
Peoples Rep of China

Abstract:
The quest to reveal the physical essence of the infinitely many symmetries and/or conservation laws that are intrinsic to integrable systems has historically posed a significant challenge at the confluence of physics and mathematics. This scholarly investigation delves into five open problems related to these boundless symmetries within integrable systems by scrutinizing their multi-wave solutions, employing a fresh analytical methodology. For a specified integrable system, there exist various categories of n-wave solutions, such as the n-soliton solutions, multiple breathers, complexitons, and the n-periodic wave solutions (the algebro-geometric solutions with genus n), wherein n denotes an arbitrary integer that can potentially approach infinity. Each sub-wave comprising the n-wave solution may possess free parameters, including center parameters c_i, width parameters (wave number) k_i, and periodic parameters (the Riemann parameters) m_i. It is evident that these solutions are translation invariant with respect to all these free parameters. We postulate that the entirety of the recognized infinitely many symmetries merely constitute linear combinations of these finite wave parameter translation symmetries. This conjecture appears to hold true for all integrable systems with n-wave solutions. The conjecture intimates that the currently known infinitely many symmetries is not exhaustive, and an indeterminate number of symmetries remain to be discovered. This conjecture further indicates that by imposing an infinite array of symmetry constraints, it becomes feasible to derive exact multi-wave solutions. By considering the renowned Korteweg-de Vries (KdV) equation and the Burgers equation as simple examples, the conjecture is substantiated for the n-soliton solutions. It is unequivocal that any linear combination of the wave parameter translation symmetries retains its status as a symmetry associated with the particular solution. This observation suggests that by introducing a ren-variable and a ren-symmetric derivative which serve as generalizations of the Grassmann variable and the super derivative, it may be feasible to unify classical integrable systems, supersymmetric integrable systems, and ren-symmetric integrable systems within a cohesive hierarchical framework. Notably, a ren-symmetric integrable Burgers hierarchy is explicitly derived. Both the supersymmetric and the classical integrable hierarchies are encompassed within the ren-symmetric integrable hierarchy.

The higher-order μ-Camassa-Holm equations

Schedule: December 19 18:00-18:30 Conference Hall B (B)

Changzheng Qu
Ningbo University
Peoples Rep of China

Co-Author(s): Ying Fu, Hao Wang, Kexin Yan

Abstract:
It is well-known that the Camassa-Holm (CH)-type equations admit peaked solitons. In this talk, we are mainly concerned with the nonlocal μ-CH-type equations. First, we review the known results and properties of μ-CH and modified CH equation. Second, we introduce the higher-order μ-CH equations. Third, stability and instability of periodic peaked solitons to the higher-order CH equations will be studied.

On the long-time asymptotic of the modified Camassa-Holm equation with nonzero boundary conditions in space-time solitonic regions

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Schedule: December 19 13:30-14:00 Conference Hall B (B)

Shoufu Tian
China University of Mining and Technology
Peoples Rep of China

Co-Author(s): Jin-JIe Yang and Zhi-Qiang Li

Abstract:
In this talk, we report the long-time asymptotic behavior for the Cauchy problem of the modified Camassa-Holm (mCH) equation with finite density initial data in different regions. We prove that the soliton resolution conjecture holds, that is, the solution of the mCH equation can be expressed as the soliton solution on the discrete spectrum, the leading term on the continuous spectrum, and the residual error. This work is joint with Jin-JIe Yang and Zhi-Qiang Li.

Self-similar Painlev\`{e} regions in long-time asymptotics of good Boussinesq equation and Sawada-Kotera equation

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Schedule: December 19 14:00-14:30 Conference Hall B (B)

Deng-Shan Wang
Beijing Normal University
Peoples Rep of China

Co-Author(s): Deng-Shan Wang, Xiaodong Zhu

Abstract:
In this talk, we report our recent work on the long-time asymptotics of good Boussinesq equation and Sawada-Kotera equation with decaying initial data. Especially, the self-similar Painlev\`{e} regions in the two integrable systems are investigated in detail. For the good Boussinesq equation, the self-similar region is described by the Painlev\`{e} IV equation, while for the Sawada-Kotera equation, the self-similar region is described by the fourth-order analogues of Painlev\`{e} transcendent. The Miura transformations along with the modified Boussinesq equation and modified Sawada-Kotera equation are used in the asymptotic analysis.

Superintegrability of matrix models

Schedule: December 19 17:30-18:00 Conference Hall B (B)

Rui Wang
China University of Mining and Technology, Beijing
Peoples Rep of China

Co-Author(s): Weizhong Zhao, Fan Liu, etc.

Abstract:
Matrix models have wide applications in mathematics and physics. In the study of matrix models, the superintegrability means that the average of a properly chosen symmetric function is proportional to ratios of symmetric functions on a proper locus, i.e., $\langle$ character $\rangle$~character. W-representations of the matrix models realize the partition functions by acting on elementary functions with exponents of the given W-operators. In this talk, I will introduce our recent works on how to derive the superintegrability of several matrix models from their W-representations. Meanwhile, we construct the partition function hierarchies with W-representations, and present their character expansions with respect to the Schur (Jack) polynomials. For the negative branch of hierarchies, it gives the τ-functions of the KP hierarchy. The W-operators in the positive branch of hierarchies can be related to the many-body systems.

Numerical Computation for long time behavior for derivative nonlinear schrodinger eqution

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Schedule: December 19 14:30-15:00 Conference Hall B (B)

Zhen Wang
Beihang University
Peoples Rep of China

Abstract:
Decay properties of water waves is related to the long time behavior of governing equation. Its leading order asymptotic expression may be given by phase stationary method for linear and by Riemann Hilbert method for nonlinear integrable system. Numerical solution for long time behavior of derivative schrodinger equation is explored, it has advantages on avoiding the error cumulative of long time evolution.

Nonlinear localized excitation on the elliptic periodic wave background

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Schedule: December 19 16:45-17:15 Conference Hall B (B)

Yunqing Yang
Zhejiang University of Science and Technology
Peoples Rep of China

Abstract:
In this talk, we first introduce two types of elliptic functions, namely Jacobi and Weierstrass elliptic functions, and their corresponding properties. Secondly, two types of nonlinear wave solutions on the periodic wave background of elliptic functions have been constructed by using the solution of linear spectral problems and Darboux transformation technique, and the corresponding dynamic properties are also studied. Finally, the relationship between nonlinear wave solutions on constant background and periodic wave background are discussed.

The self-dual Yang-Mills equation: New solutions and related integrable structure

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Schedule: December 19 13:00-13:30 Conference Hall B (B)

Da-jun Zhang
Shanghai University
Peoples Rep of China

Abstract:
It is well-known that the self-dual Yang-Mills (SDYM) equation is a fundamental equation in conformal field theory as well as a general 4D equation in integrable systems. In Yang`s formulation, one can first solve the unreduced SDYM equation in a general complex 4D space and then implement reductions so that solutions meet the reality conditions and gauge conditions in the real 4D spaces. In this talk, I will show that the unreduced SDYM equation can be formulated from the matrix KP hierarchy and the matrix AKNS hierarchy. Such formulations are based on the Cauchy matrix scheme and solutions for the unreduced SDYM equation can be constructed by solving the Sylvester equations. These new structures enable us to obtain new solutions for the SU(N) SDYM equation in the different real 4D spaces (with different signatures) as well as to get some integrable equations arising from reductions of the SDYM equation. I will also introduce the reductions of solutions and connections (with other equations, e.g. the Fokas-Lenells equation). This talk is mainly based on joint works with Shangshuai Li and Changzheng Qu.

Special Session 53 : Mathematical Theory on the Klein-Gordon Equation and Related Models

Introduction: The Nonlinear Klein-Gordon equation is a fundamental model in quantum field theory, which describes the dynamics of quantum fields and serves as a building block for more complex theories like quantum electrodynamics (QED), quantum chromodynamics (QCD), and the Standard Model of particle physics. This session aims to facilitate academic discussions on the mathematical theory of the Nonlinear Klein-Gordon equation and related models, covering topics such as well-posedness theory, scattering theory, soliton dynamics, and non-relativistic limit problems. Researchers are invited to participate in this academic exploration, where they will delve into the mathematical intricacies of the Nonlinear Klein-Gordon equation and contribute to a more profound comprehension of its implications in the context of quantum field interactions.

Asymptotic stability of traveling waves for one-dimensional nonlinear Schrodinger equations

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Schedule: December 17 14:45-15:15 Capital Suite 6

Charles Collot
CY Cergy Paris Universite
France

Co-Author(s): Pierre Germain

Abstract:
We consider one dimensional nonlinear Schrodinger equations around a traveling wave. We prove its asymptotic stability for general nonlinearities, under the hypotheses that the orbital stability condition of Grillakis-Shatah-Strauss is satisfied and that the linearized operator does not have a resonance and only has 0 as an eigenvalue. As a by-product of our approach, we show modified scattering for the radiation remainder. Our proof combines for the first time modulation techniques and the study of space-time resonances. We rely on the use of the distorted Fourier transform, akin to the work of Buslaev and Perelman and, and of Krieger and Schlag, and on precise renormalizations, computations and estimates of space-time resonances to handle its interaction with the soliton. This is joint work with Pierre Germain.

Modified scattering for a non-local derivative NLS

Schedule: December 17 15:45-16:15 Capital Suite 6

Nobu Kishimoto
Kyoto University
Japan

Co-Author(s): Kiyeon Lee

Abstract:
We consider asymptotic behavior of small solutions to a one-dimensional nonlinear Schr\{o}dinger equation with a non-local cubic derivative nonlinear term, which has dissipative effect. In the periodic setting, dissipation becomes prominent and the initial value problem is known to be ill-posed backward in time even for small data. In contrast, on the real line we show global existence of solutions and modified scattering behavior in both time directions for small data in weighted Sobolev space.

Scattering for defocusing energy sub-critical wave equation with inverse square potential

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Schedule: December 17 13:00-13:30 Capital Suite 6

Baoping Liu
Peking University
Peoples Rep of China

Co-Author(s): Haiming Du

Abstract:
We consider the defocusing energy sub-critical nonlinear wave equation with inverse square potential, and prove global wellposedness and scattering for radial data lying in critical Sobolev space. The main ingredients for our proof include the Fourier truncation method, the hyperbolic coordinate transformation, and the radial endpoint Strichartz estimate for wave equations with potential of critical decay.

Instability of standing waves for cubic-quintic NLS with delta potential

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Schedule: December 17 15:15-15:45 Capital Suite 6

Masahito Ohta
Tokyo University of Science
Japan

Abstract:
We consider a nonlinear Schr\{o}dinger equation with the cubic-quintic combination of repulsive and attractive nonlinearities, and an attractive delta potential in one space dimension. The stability and instability of standing wave solutions are studied.

Numerical study of the logarithmic Schrodinger equation with repulsive harmonic potential

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Schedule: December 17 16:15-16:45 Capital Suite 6

Chunmei Su
Tsinghua University
Peoples Rep of China

Abstract:
We consider the nonlinear Schrodinger equation with a logarithmic nonlinearity and a repulsive harmonic potential. Depending on the parameters of the equation, the solution may or may not be dispersive. When dispersion occurs, it does with an exponential rate in time. To control this, we change the unknown function through a generalized lens transform. This approach neutralizes the possible boundary effects, and could be used in the case of the nonlinear Schrodinger equation without potential. We then employ standard splitting methods on the new equation via a nonuniform grid, after the logarithmic nonlinearity has been regularized. We also discuss the case of a power nonlinearity and give some results concerning the error estimates of the first-order Lie-Trotter splitting method for both cases of nonlinearities. Finally extensive numerical experiments are reported to investigate the dynamics of the equations.

Late-time asymptotics for the Klein-Gordon equation on a Schwarzschild black hole

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Schedule: December 17 12:30-13:00 Capital Suite 6

Maxime Van de Moortel
Rutgers University
USA

Co-Author(s): Federico Pasqualotto, Yakov Shlapentokh-Rothman, Maxime Van de Moortel

Abstract:
The late-time behavior of the linear Klein-Gordon equation on a Schwarzschild geometry, which models the simplest black hole in General Relativity, has long posed a significant challenge due to the presence of stable (timelike) trapping. We present our recent resolution of this problem, uncovering an unexpected contrast between solutions with exponentially decaying initial data and those with polynomial decay. These results lay the groundwork for future exploration of the nonlinear dynamics of the Schwarzschild black hole for the Einstein-Klein-Gordon equations.

Energy Transfer and Radiation in Hamiltonian Nonlinear Klein-Gordon Equations

Schedule: December 17 17:30-18:00 Capital Suite 6

Zhaojie Yang
Fudan University
Peoples Rep of China

Co-Author(s): Zhen Lei, Jie Liu, Zhaojie Yang

Abstract:
We consider Klein-Gordon equations with cubic nonlinearity in three spatial dimensions, which are Hamiltonian perturbations of the linear one with potential. It is assumed that the corresponding Klein-Gordon operator admits an arbitrary number of possibly degenerate eigenvalues in $(0, m)$, and hence the unperturbed linear equation has multiple time-periodic solutions known as bound states. In 1999, Soffer and Weinstein discovered a mechanism called Fermi`s Golden Rule for this nonlinear system in the case of one simple but relatively large eigenvalue $\Omega \in (m/3, m)$, by which energy is transferred from discrete to continuum modes and the solution still decays in time. In our first work, we solved the general one simple eigenvalue case. In our second work, we solved this problem in full generality: multiple and simple or degenerate eigenvalues in $(0, m)$. Indeed, we obtained the sharp rate of energy transfer from one discrete state to continuum modes in the general case. The proof is based on a kind of pseudo-one-dimensional cancellation structure in each eigenspace, a renormalized damping mechanism, and an enhanced damping effect. It also relies on a refined Birkhoff normal form transformation and an accurate generalized Fermi`s Golden Rule building upon the results of Bambusi and Cuccagna. This is a joint work with Prof. Zhen Lei and Dr. Jie Liu.

Long time behaviors for damped Klein-Gordon and wave equations

Schedule: December 17 13:30-14:00 Capital Suite 6

Lifeng Zhao
University of Science and Technology of China
Peoples Rep of China

Abstract:
Soliton resolution conjecture is a long standing problem for nonlinear dispersive equations. The soliton resolution results for damped Klein-Gordon and damped energy critical wave equation will be stated. In addition, some specific examples of multi-bubble solutions with precise dynamics are constructed.

Some recent results on vortex patch problems

Schedule: December 17 14:00-14:30 Capital Suite 6

Maolin Zhou
Nankai University
Peoples Rep of China

Abstract:
In this talk, we will discuss some problems about vortex patch problems. It mainly consists of two parts: (1) boundary regularity, especially why the singular angle must be 90 degree; (2) degenerate bifurcation from annulus for particular parameters.

Special Session 54 : Nonlocal dynamics and complex patterns in phase-separation

Introduction: Phase-separation phenomena are experienced in numerous scenarios, such as dynamics of fluid mixtures, pattern formation, image processing, evolution of biomolecular condensates, and tumour growth dynamics. A well-established mathematical analysis of such mechanisms is based on the so-called diffuse-interface approach, and relies on classical models such as the Cahn-Hilliard and Allen-Cahn equations. In the last decades, suitable nonlocal formulations of phase-field systems have specifically allowed to describe long-range interaction effects and have received great attention in the mathematical community. The present session brings forward recent results on nonlocal phase-field models, including qualitative properties of solutions and nonlocal-to-local asymptotic convergence.

A sixth-order Cahn--Hilliard equation for curvature effects in pattern formation

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Schedule: December 17 16:15-16:45 Capital Suite 11 B

Pierluigi Colli
University of Pavia
Italy

Abstract:
This talk is concerned with a sixth-order Cahn--Hilliard system, which represents a higher-order variant of the well-known Cahn--Hilliard equation. In the system, the evolution equation is complemented with a source term, where the control variable enters as a distributed mass regulator. The presence of further spatial derivatives in the sixth-order formulation enables the model to capture curvature effects, for a more accurate description of isothermal phase separation dynamics in complex materials systems. The well-posedness and optimal control are discussed for the related initial and boundary value problem. Well-posedness is shown when assuming a smooth double-well potential as part of the free energy. Then, the optimal control problem is addressed: existence of optimal controls is established, and the first-order necessary optimality conditions are characterized via a suitable variational inequality involving the solution to the adjoint problem. These results have been obtained in a recent collaboration with G. Gilardi (University of Pavia), A. Signori (Polytechnic of Milan) and J. Sprekels (WIAS Berlin).

Stochastic diffuse interface models with conservative noise

Schedule: December 17 15:45-16:15 Capital Suite 11 B

Andrea Di Primio
Politecnico di Milano
Italy

Co-Author(s): Maurizio Grasselli, Luca Scarpa

Abstract:
In this talk, we consider the Cahn--Hilliard and the conserved Allen--Cahn equations with logarithmic type potential and conservative noise in a periodic domain. These features ensure that the order parameter takes its values in the physical range and, albeit the stochastic nature of the problems, that the total mass is conserved almost surely in time. For the Cahn--Hilliard equation, existence and uniqueness of probabilistically-strong solutions is shown up to the three-dimensional case. For the conserved Allen--Cahn equation, under a restriction on the noise magnitude, existence of martingale solutions is proved even in dimension three, while existence and uniqueness of probabilistically-strong solutions holds in dimension one and two. The analysis is carried out by studying the Cahn--Hilliard/conserved Allen--Cahn equations jointly, that is a linear combination of both the equations, which has an independent interest.

Nonlocal to local convergence of the degenerate Cahn-Hilliard equation

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Schedule: December 17 15:15-15:45 Capital Suite 11 B

Charles Elbar
Sorbonne Universite
France

Co-Author(s): Jakub Skrzeczkowski

Abstract:
There has been recently an important interest in deriving rigorously the Cahn-Hilliard equation from the nonlocal equation. Since we are motivated by models for the biomechanics of living tissues, it is useful to include degenerate motilities. In this framework, we present a method to show the convergence of the nonlocal to the local degenerate Cahn-Hilliard equation. The method includes the use of nonlocal Poincare and compactness inequalities.

New results for the Cahn-Hilliard equation

Schedule: December 17 17:00-17:30 Capital Suite 11 B

Andrea Giorgini
Politecnico di Milano
Italy

Abstract:
In this talk I will present some recent results concerning the well-posedness of the Cahn-Hilliard equation. This is a joint work with Monica Conti (Politecnico di Milano), Pietro Galimberti and Stefania Gatti (Universit\`{a} di Modena e Reggio Emilia).

Nonlocal Cahn-Hilliard-Darcy systems

Schedule: December 17 14:45-15:15 Capital Suite 11 B

Maurizio Grasselli
Politecnico di Milano
Italy

Co-Author(s): Cecilia Cavaterra, Sergio Frigeri

Abstract:
A nonlocal Cahn-Hilliard-Darcy system for an incompressible mixture of two fluids consists of a convective nonlocal Cahn-Hilliard equation coupled with a Darcy`s law through the Korteweg force. We will discuss some recent results that have been proven for such system, focusing on the case where the mixing entropy density is of Boltzmann-Gibbs type, the kinematic viscosity depends on the order parameter, and the mobility is degenerate at the pure phases. The main issues will be the existence of different types of solutions, their regularization properties, and the longtime behavior of the associated dynamical system.

Nonlocal-to-local convergence rates for a Navier-Stokes-Cahn-Hilliard system

Schedule: December 17 17:30-18:00 Capital Suite 11 B

Patrik Knopf
University of Regensburg
Germany

Co-Author(s): Christoph Hurm, Andrea Poiatti

Abstract:
We discuss the nonlocal-to-local convergence of strong solutions to a Navier-Stokes-Cahn-Hilliard model (Model H) with singular potential describing immiscible, viscous two-phase flows with matched densities. This means that we show that the strong solutions of the nonlocal Model H converge to the corresponding strong solution of the local Model H as the weight function in the nonlocal interaction kernel approaches the delta distribution. Compared to previous results in the literature, our main novelty is to further establish concrete rates for this nonlocal-to-local convergence.

Convergence of a nonlocal to a local phase field system with inertial term

Schedule: December 17 18:30-19:00 Capital Suite 11 B

Shunsuke Kurima
Tokyo University of Science
Japan

Co-Author(s): Pierluigi Colli, Shunsuke Kurima, Luca Scarpa

Abstract:
There are some studies on local asymptotics for nonlocal problems. For example, Davoli--Scarpa--Trussardi (2021) and Abels--Terasawa (2022) have studied nonlocal-to-local convergence of Cahn--Hilliard equations. On the other hand, regarding phase field systems, in the case of a conserved phase field system related to entropy balance, nonlocal-to-local convergence has already been confirmed (K. (2022)). In this talk, we focus on convergence of a nonlocal phase field system with inertial term to a parabolic-hyperbolic phase field system. This is a joint work with Professors Pierluigi Colli (University of Pavia) and Luca Scarpa (Polytechnic University of Milan).

A Cahn-Hilliard-Darcy system with dynamic boundary conditions

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Schedule: December 17 19:00-19:30   Capital Suite 11 B

Giulio Schimperna
University of Pavia
Italy

Co-Author(s): Pierluigi Colli, Patrik Knopf, Andrea Signori

Abstract:
We will present some mathematical results for a Cahn-Hilliard-Darcy system complemented with dynamic boundary conditions of Cahn-Hilliard type: namely, we wiill assume that the trace of the bulk order parameter also satisfies a suitable fourth order evolutionary equation on the boundary. In particular we will prove existence of weak solutions and investigate the (asymptotic) relations linking together various types of dynamic boundary conditions. Moreover we will discuss the problem of the existence of the trace of the bulk velocity and its connection with the boundary velocity.

Long time behavior of the solution to a stochastic Allen-Cahn-Navier-Stokes system with logarithmic potential.

Schedule: December 17 18:00-18:30   Capital Suite 11 B

Margherita Zanella
Politecnico di Milano
Italy

Abstract:
We consider a stochastic version of the Allen-Cahn-Navier-Stokes system in a smooth two-dimensional domain with random initial data. The system consists of a Navier-Stokes equation coupled with a convective Allen-Cahn equation, with two independent sources of randomness given by general multiplicative-type Wiener noises. In particular, the Allen-Cahn equation is characterized by a singular potential of logarithmic type as prescribed by the classical thermodynamical derivation of the model. We analyze the long-time behavior of the (probabilistically-strong unique) solution: we establish the existence, uniqueness and asymptotic stability of the invariant measure associated to the system. The talk is based on a joint work with A. Di Primio and L. Scarpa.

Special Session 56 : Local and nonlocal diffusion in mathematical biology

Introduction: In recent years, there has been significant interest and progress in the mathematical analysis of diffusion-type partial differential equations, which are ubiquitous in mathematical biology and used to model phenomena at various scales, from cell-cell adhesion to population dynamics. This session will provide an opportunity to present recent advances and discuss new challenges in this field. We focus our attention on both local and nonlocal PDEs, including the mathematical theory of reaction-diffusion, porous media, aggregation-diffusion, Keller-Segel, and Cahn-Hilliard equations. Some of the topics we aim to cover include classical well-posedness theory and qualitative properties of solutions (such as asymptotic behavior, traveling waves, and pattern formation), as well as singular limits, with a particular emphasis on connections between nonlocal equations and their local counterparts. By bringing together researchers at various stages of their careers, we hope to create a platform for exchanging ideas and fostering new collaborations.

Stability of solutions of the porous medium equation with growth with respect to the diffusion exponent

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Schedule: December 19 13:00-13:30 Capital Suite 9

Piotr Gwiazda
University of Warsaw
Poland

Abstract:
We consider a macroscopic model for the growth of living tissues incorporating pressure-driven dispersal and pressure-modulated proliferation. Assuming a power-law relation between the mechanical pressure and the cell density, the model can be expressed as the porous medium equation with a growth term. We prove Lipschitz continuous dependence of the solutions of the model on the diffusion exponent. The main difficulty lies in the degeneracy of the porous medium equations at vacuum.

Asymptotic behaviors of solutions to a reaction-diffusion equation with free boundaries

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Schedule: December 19 14:00-14:30 Capital Suite 9

Yuki Kaneko
Kanto Gakuin University
Japan

Abstract:
This talk is concerned with a reaction-diffusion equation in a one-dimensional interval whose boundaries are unknown and determined together with the density function. We impose one-phase Stefan conditions to the free boundaries with different coefficients as parameters. Then we can observe that a spreading solution converges to some different kinds of propagating terrace, depending on the parameters, as time tends to infinity. We will also discuss future problems.

Spreading phenomenon in a nonlinear Stefan problem with a certain class of multistable nonlinearity

Schedule: December 19 8:30-9:00 Capital Suite 9

Hiroshi Matsuzawa
Kanagawa University
Japan

Co-Author(s): Yuki Kaneko, Yoshio Yamada

Abstract:
In this talk, we discuss a spreading phenomenon described by a nonlinear Stefan problem of a reaction-diffusion equation. In particular, we assume that the reaction term is a positive bistable type nonlinearity class of multi-stable type nonlinearity. We first discuss the classification of asymptotic behaviors of solutions. We next discuss the expanding speeds of the free boundary and the level set of the solution in the spreading case.

A Navier-Stokes-Cahn-Hilliard system in 3D: well-posedness and nonlocal-to-local rates of convergence

Schedule: December 19 13:30-14:00 Capital Suite 9

Andrea Poiatti
University of Vienna
Austria

Co-Author(s): Christoph Hurm, Patrik Knopf

Abstract:
In this talk I would like to present some results concerning a Navier-Stokes-Cahn-Hilliard model with singular potential describing immiscible, viscous two-phase flows with matched densities, which is referred to as the Model H, in three (and two) dimensional bounded domains. I will first concentrate on some new results of local-in-time strong well-posedness for the nonlocal version of the model H with singular potential. Namely, I will also discuss the validity of the instantaneous strict separation property of the concentration variable from pure phases, by adapting the recent result for the nonlocal Cahn-Hilliard equation in 3D by Poiatti (Anal. PDE, to appear). I will then present the nonlocal-to-local convergence of strong solutions to the model H. This means that the strong solutions to the nonlocal Model H converge to the strong solution to the local Model H as the weight function in the nonlocal interaction kernel approaches the delta distribution. To this aim, I will show some uniform bounds on the strong solutions to the nonlocal Model H, which are essential to prove the nonlocal-to-local convergence results. The novelty of this approach is that we are able to find precise convergence rates, in suitable norms, of the strong solutions to nonlocal model H to the strong solution to local model H.

Biological aggregations from spatial memory and nonlocal advection

Schedule: December 19 9:00-9:30 Capital Suite 9

Junping Shi
College of William & Mary
USA

Co-Author(s): Di Liu, Yurij Salmaniw, Jonathan Potts, Junping Shi and Hao Wang

Abstract:
Spatial memory is a key feature driving the movement of mobile organisms. A key tool for modelling movement in response to remembered space use is via an advection term in a partial differential equation (PDE). We use a reaction-diffusion-advection model to describe the movement of an animal species, with a non-local advection term driven by a cognitive map representing memory of past animal locations embedded in the environment. The global existence and boundedness of solutions are shown, and the existence of spatial patterns formed in the model are rigorously proved using spectral analysis and bifurcation methods.

Boundary-layer problem for the singular Keller-Segel model

Schedule: December 19 8:00-8:30 Capital Suite 9

Zhi-An Wang
The Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Jose Carrillo, Jingyu Li, Wen Yang

Abstract:
In this talk, we shall discuss the boundary layer problem of the singular Keller-Segel model with physical boundary conditions in any dimensions. First, we obtain the existence and uniqueness of boundary-layer solution to the steady-state problem and identify the boundary-layer profile and thickness near the boundary. Then we find the asymptotic expansion of boundary-layer profile in terms of the radius for the radially symmetric domain, which can assert how the boundary curvature affects the boundary-layer thickness. Finally, we establish the nonlinear stability of the unique boundary-layer steady state solution with exponential convergence rate for the radially symmetric domain.

Special Session 57 : Dynamics and Numerics of Stochastic Differential Equations

Introduction: This special session aims to showcase the most recent advances in the field of stochastic differential equations, encompassing both analytical and numerical aspects. The session will explore topics related to the theory and methodologies developed for studying the qualitative behavior of stochastic systems, as well as innovative numerical schemes designed for the simulation of these systems. The broader applications of stochastic systems in applied sciences and engineering will also be included, illustrating the diverse impact of these advancements in various domains.

On the random age structured model

Schedule: December 20 15:30-16:00 Capital Suite 2

Jiaqi Cheng
Northeast Normal University
Peoples Rep of China

Co-Author(s): Xiaoying Han

Abstract:
A random age-structured model with nonlinear birth is formulated. Its mathematical theories including wellposedness, cocycle property, and the asymptotic behaviors of the solution are developed. The emphasis is given to the asymptotic smoothness and the bounded dissipativeness of the cocycle, which implies the fractal dimension of the random attractor is finite.

Wasserstein Hamiltonian Flow and Its Structure Preserving Numerical Scheme

Schedule: December 20 14:30-15:00 Capital Suite 2

Jianbo Cui
Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Luca Dieci and Haomin Zhou

Abstract:
We study discretizations of Hamiltonian systems on the probability density manifold equipped with the L2-Wasserstein metric. For low dimensional problems, based on discrete optimal transport theory, several Wasserstein Hamiltonian flows (WHFs) on graph are derived. They can be viewed as spatial discretizations to the original systems. By regularizing the system using Fisher information, we propose a novel regularized symplectic scheme which could preserve several desirable longtime behaviors. Furthermore, we use the coupling idea and WHF to propose a supervised learning scheme for some high-dimensional problem.

A Smoluchowski-Kramers approximation to the variational wave equation

Schedule: December 20 14:00-14:30 Capital Suite 2

Billel Guelmame
ENS Lyon
France

Co-Author(s): Julien Vovelle

Abstract:
We study the variational wave equation subject to stochastic forcing, which arises in the modeling of liquid crystals. In this talk, we focus on the existence of local-in-time regular solutions, the occurrence of finite-time blow-up, and the existence of global martingale weak solutions. Additionally, we explore the small-mass limit, known as the Smoluchowski-Kramers approximation, proving that the solution converges to that of a stochastic quasilinear parabolic equation. This is a joint work with Julien Vovelle.

Can one hear the shape of high-dimensional landscape?

Schedule: December 20 8:00-8:30 Capital Suite 2

Shirou Wang
Jilin University
Peoples Rep of China

Co-Author(s): Yao Li, Molei Tao

Abstract:
Potential functions used in optimizations, dynamics applications, and machine learning etc. can be rather complicated in term of their structures and properties especially in very high dimensions. Due to lacking of knowledge on concrete forms of potential functions in real applications, even the determination of their basic structures and properties is a challenging problem in both mathematical analysis and numerical simulations. This talk presents a probabilistic approach to investigate the landscape of potential functions, including those in high dimensions, by using an appropriate coupling scheme to couple two copies of the overdamped Langevin dynamics of the potential functions. It can be theoretically shown that for potential functions with single or multiple wells, the coupling time distributions admit qualitatively distinct exponential tails in terms of noise magnitudes. In addition, a quantitative characterization of the non-convexity of a multi-well potential function can also be obtained via linear extrapolation. These theoretical findings thus suggest a promising approach to probe the shape of a potential landscape through the coupling time distributions at least numerically. Numerical examples of loss landscapes of neural networks with different sizes will be presented. This talk is mainly based on a recent joint work with Yao Li at UMASS and Molei Tao at Georgia Tech.

Convergence of the Backward Deep BSDE Method with Applications to Optimal Stopping Problems

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Schedule: December 20 8:30-9:00 Capital Suite 2

Zimu Zhu
Hong Kong University of Science and Technology(Guangzhou)
Peoples Rep of China

Co-Author(s): Chengfan Gao, Siping Gao, Ruimeng Hu

Abstract:
The optimal stopping problem is one of the core problems in financial markets, with broad applications such as pricing American and Bermudan options. The deep BSDE method [Han, Jentzen and E, PNAS, 115(34):8505-8510, 2018] has shown great power in solving high-dimensional forward-backward stochastic differential equations (FBSDEs), and inspired many applications. However, the method solves backward stochastic differential equations (BSDEs) in a forward manner, which can not be used for optimal stopping problems that in general require running BSDE backwardly. To overcome this difficulty, a recent paper [Wang, Chen, Sudjianto, Liu and Shen, arXiv:1807.06622, 2018] proposed the backward deep BSDE method to solve the optimal stopping problem. In this paper, we provide the rigorous theory for the backward deep BSDE method. Specifically, 1. We derive the {\it a posteriori} error estimation, i.e., the error of the numerical solution can be bounded by the training loss function; and; 2. We give an upper bound of the loss function, which can be sufficiently small subject to universal approximations. We give two numerical examples, which present consistent performance with the proved theory. This is a joint work with C.Gao, S.Gao and R.Hu.

Special Session 58 : Recent Advances in Numerical Methods for Partial Differential Equations

Introduction: This session will highlight innovative numerical methods and their applications in solving high-dimensional, nonlinear, and complex geometrical PDEs that arise in cutting-edge research. We will focus on topics that include, but not limited to, novel discretization methods such as FEM, FDM, spectral methods, machine learning and high-performance computing strategies.

Small cut cells in a fictitious domain approach for fluid structure interactions

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Schedule: December 20 8:00-8:30 Capital Suite 21 C

Daniele Boffi
King Abdullah University of Science and Technology
Saudi Arabia

Abstract:
In this talk I will present recent advances on the numerical analysis and implementation of a fictitious domain approach for the approximation of fluid structure interaction problems. As opposed to other unfitted discretizations, our analysis doesn`t require any particular treatment of small cells generated by elements cut by the interface between fluid and solid. Several numerical experiments confirm the stability of the method independently on the size of the cut cells.

Highly efficient and energy stable multi-step SAV approaches for phase field models

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Schedule: December 19 17:30-18:00 Capital Suite 21 C

Yanping Chen
Nanjing University of Posts and Telecommunications, CHINA
Peoples Rep of China

Abstract:
Recently, the scalar auxiliary variable (SAV) approach and its extended SAV-based approaches have been widely used to simulate a series of phase field models. However, many SAV-based schemes are known for the stability of a modified energy. In this paper, we construct a series of modified SAV approaches with unconditional energy dissipation law based on several improvements to the traditional SAV approach. Firstly, by introducing the three-step technique, we can reduce the number of constant coefficient linear equations that need to be solved at each time step, while retaining all of its other advantages. Secondly, the addition of energy-optimized technique and SAV/Lagrange multiplier technique can make the numerical schemes have the advantage of preserving the original energy dissipation. Thirdly, we use the first-order approximation of the energy balance equation in the GSAV approach, instead of discretizing the dynamic equation of the auxiliary variable, so that we can construct the high-order unconditional original energy stable numerical schemes. Finally, representative numerical examples show that the efficiency and accuracy of the proposed schemes are improved.

A Construction of C^r Conforming Finite Element Spaces in Any Dimension

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Schedule: December 19 15:15-15:45 Capital Suite 21 C

Jun Hu
Peking University
Peoples Rep of China

Abstract:
This talk proposes a construction of C^r conforming finite element spaces with arbitrary r in any dimension. It is shown that if $k \geq 2^d r + 1$ the space P_k of polynomials of degree $\leq k$ can be taken as the shape function space of C^r finite element spaces in d dimensions. This is the first work on constructing such C^r conforming finite elements in any dimension in a unified way.

Green Multigrid Network

Schedule: December 20 14:30-15:00 Capital Suite 21 C

Jiwei Jia
Jilin University
Peoples Rep of China

Co-Author(s): Jiwei Jia, Young Ju Lee, Ye Lin

Abstract:
We propose a framework of the Green Multigrid network (GreenMGNet), a type of operator learning algorithm for a class of asymptotically smooth Green functions. The new framework presents itself better accuracy and efficient computational complexity, thereby achieving a significant improvement. GreenMGNet is composed of two technical novelties. First, the Green function is modeled as a piecewise function to preserve its singular behavior in some part of the hyperplane. Such piecewise function is then approximated by a neural network with augmented output(AugNN), so that it can capture singularity accurately. Second, the asymptotic smoothness property of the Green function is used to leverage Multi-Level Multi-Integration(MLMI) algorithm for both training and inference stages. Several test cases of operator learning are presented to demonstrate the accuracy and effectivity of the proposed method. On average, GreenMGNet achieves 3.8% to 39.15% accuracy improvement. To match the accuracy level of GL, GreenMGNet requires only about 10% of the full grid data, resulting in a 55.9% and 92.5% reduction in training time and GPU memory cost for one-dimensional test problems, and a 37.7% and 62.5% reduction for two-dimensional test problems.

A perfectly matched layer method for scattering problem in cylindrical coordinates

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Schedule: December 19 18:00-18:30 Capital Suite 21 C

Xue Jiang
Beijing University of Technology
Peoples Rep of China

Abstract:
This talk is focused on the modelling of signal propagations in myelinated axons. The well-posedness of model is established upon Dirichlet boundary conditions at the two ends of the neural structure and the radiative condition in the radial direction of the structure. Using the perfectly matched layer (PML) method, we truncate the unbounded background medium and propose an approximate problem on the truncated domain. The well-posedness of the PML problem and the exponential convergence of the approximate solution to the exact solution are established. Numerical experiments are presented to demonstrate the theoretical results and the efficiency of our methods to simulate the signal propagation in axons.

A hybrid iterative method based on MIONet for PDEs: Theory and numerical examples

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Schedule: December 20 15:00-15:30 Capital Suite 21 C

Pengzhan Jin
Peking University
Peoples Rep of China

Abstract:
We propose a hybrid iterative method based on MIONet for PDEs, which combines the traditional numerical iterative solver and the recent powerful machine learning method of neural operator, and further systematically analyze its theoretical properties, including the convergence condition, the spectral behavior, as well as the convergence rate, in terms of the errors of the discretization and the model inference. We show the theoretical results for the frequently-used smoothers, i.e. Richardson (damped Jacobi) and Gauss-Seidel. We give an upper bound of the convergence rate of the hybrid method w.r.t. the model correction period, which indicates a minimum point to make the hybrid iteration converge fastest. Several numerical examples including the hybrid Richardson (Gauss-Seidel) iteration for the 1-d (2-d) Poisson equation are presented to verify our theoretical results, and also reflect an excellent acceleration effect. As a meshless acceleration method, it is provided with enormous potentials for practice applications.

Efficient quantum Gibbs samplers

Schedule: December 20 9:00-9:30 Capital Suite 21 C

Bowen Li
City University of Hong Kong
Hong Kong

Abstract:
Lindblad dynamics and other open-system dynamics provide a promising path towards efficient Gibbs sampling on quantum computers. In these proposals, the Lindbladian is obtained via an algorithmic construction akin to designing an artificial thermostat in classical Monte Carlo or molecular dynamics methods, rather than treated as an approximation to weakly coupled system-bath unitary dynamics. In this talk, we build upon the structural characterization of KMS detailed balanced Lindbladians by Fagnola and Umanita, and develop a family of efficient quantum Gibbs samplers using a finite set of jump operators (the number can be as few as one), akin to the classical Markov chain-based sampling algorithm. Compared to the existing works, our quantum Gibbs samplers have a comparable quantum simulation cost but with greater design flexibility and a much simpler implementation and error analysis. In addition, we will present an efficient preparation of low temperature Gibbs state for 2D toric code by an improved mixing time analysis.

DG method for fractional Laplace equations

Schedule: December 20 8:30-9:00 Capital Suite 21 C

Wenbo Li
The Academy of Mathematics and Systems Science of the Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Juan Pablo Borthagaray

Abstract:
In this talk we consider the integral fractional Laplace equation on bounded domains. We first review the basic theories including the regularity of solutions and convergence rates of standard conforming finite element method. Next, we introduce a ``DG`` formulation motivated by an integration by parts formula for fractional Laplacian and establish the well-posedness of this discretization. We also derive the convergence rates and justify its optimality by some numerical experiments. Some variants of the bilinear form and hanging nodes on the shape-regular mesh are also permitted in our theory. In the end, we apply this idea to the problem of fractional Laplacian with order higher than one.

An Energy-stable Numerical Approximation for the Willmore Flow

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Schedule: December 19 18:30-19:00 Capital Suite 21 C

Yifei Li
Tuebingen University
Peoples Rep of China

Co-Author(s): Weizhu Bao

Abstract:
The Willmore energy has widespread applications in differential geometry, cell membranes, optical lenses, materials science, among others. The Willmore flow, as the L^2 gradient flow dissipating the Willmore energy, serves as a fundamental tool for its analysis. Despite its importance, the development of energy-stable parametric methods for the Willmore flow remains open. In this talk, we present a novel energy-stable numerical approximation for the Willmore flow. We begin by introducing our method for planar curves, then demonstrating the underlying ideas -- the new transport equation and the time derivative of the mean curvature, that ensure energy stability. Finally, we discuss the extension of our approach to surfaces in 3D.

High accuracy algorithm and analysis for nonconforming element of Stokes equation

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Schedule: December 19 16:15-16:45 Capital Suite 21 C

Limin Ma
Wuhan University
Peoples Rep of China

Abstract:
For the Crouzeix-Raviart and enriched Crouzeix-Raviart elements of the Stokes problem, two pseudostress interpolations are designed and proved to admit a full one-order supercloseness with respect to the numerical velocity and the pressure, respectively. The design of these interpolations overcomes the difficulty caused by the lack of supercloseness of the canonical interpolations for the two nonconforming elements, and leads to an intrinsic and concise asymptotic analysis of numerical eigenvalues for the Stokes operator, which proves an optimal superconvergence of eigenvalues by the extrapolation algorithm. Meanwhile, an optimal superconvergence of postprocessed approximations for the Stokes equation is proved by use of this supercloseness. Finally, numerical experiments are tested to verify the theoretical results.

The condition for constructing a finite element from a superspline

Schedule: December 19 16:45-17:15 Capital Suite 21 C

Qingyu Wu
Peking University
Peoples Rep of China

Co-Author(s): Jun Hu, Ting Lin, Beihui Yuan

Abstract:
This talk addresses the sufficient and necessary conditions for constructing C^r conforming finite element spaces from a superspline spaces on general simplicial triangulations. We introduce the concept of extendability for the pre-element spaces, which encompasses both the superspline space and the finite element space. By examining the extendability condition for both types of spaces, we provide an answer to the conditions regarding the construction. A corollary of our results is that constructing C^r conforming elements in d dimensions should in general require an extra $C^{2^s r}$ continuity on s-codimensional simplices, and the polynomial degree is at least $(2^d r+1)$.

Weak Galerkin Finite Element Scheme and Its Applications

Schedule: December 19 15:45-16:15 Capital Suite 21 C

Ran Zhang
Jilin University
Peoples Rep of China

Abstract:
The weak Galerkin (WG) finite element method is a newly developed and efficient numerical technique for solving partial differential equations (PDEs). It was first introduced and analyzed for second order elliptic equations and further applied to several other model equations, such as the Brinkman equations, the eigenvalue problem of PDEs to demonstrate its power and efficiency as an emerging new numerical method. This talk introduces some progress on the WG scheme, which includes the applications on Brinkman problems, etc.

New error analysis of a class of fully discrete finite element methods for the dynamical inductionless MHD equations

Schedule: December 19 19:00-19:30 Capital Suite 21 C

Xiaodi Zhang
Zhengzhou University
Peoples Rep of China

Abstract:
In this talk, we present a new error analysis of a class of fully discrete finite element methods for the dynamical inductionless magnetohydrodynamic equations. The methods use the semi- implicit backward Euler scheme in time and use the standard inf-sup stable Mini/Taylor-Hood pairs to discretize the velocity and pressure, and the Raviart-Thomas for solving the current density in space. Due to the strong coupling of the system and the pollution of the lower-order Raviart-Thomas face approximation in analysis, the existing analysis is not optimal. In terms of a mixed Poisson projection and the corresponding estimates in negative norms, we establish new and optimal error estimates for all variables. Numerical experiments are performed to verify the theoretical analysis.

A new p-multigrid method for elliptic problems

Schedule: December 20 14:00-14:30 Capital Suite 21 C

Weying Zheng
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Nuo Lei and Donghang Zhang

Abstract:
In this talk, I will present a new p-multigrid method for solving second-order elliptic equations on structured meshes. Using Gauss-Seidel iterations for both pre- and post-smoothings, we prove the uniform convergence of W-cycle multigrid method with respect to both the mesh size h and the degree of polynomials p, provided that the number of smoothing steps is comparable to the degree of polynomials on each level. The p-multigrid method is robust to high-order polynomials and discontinuous coefficients with large jumps.

Special Session 59 : Backward Stochastic Volterra Integral Equations and Time Inconsistent Optimal Control Problems

Introduction: Backward stochastic Volterra integral equations (BSVIEs, for short) is a generalization of backward stochastic differential equations (BSDEs, for short). In contrast with BSDEs, one important advantage of BSVIEs is its tight connection with time inconsistent optimal control problems. Quite a few results have been developed on these two topics. However, there are still many relevant problems to be explored. The purpose of organizing this invited session is to have a forum for sharing ideas and results among the researchers in this area, and more importantly, attracting more interested researchers' attention. We believe that this invited session could lead to some interesting collaborations among scholars, and the research team of BSVIEs and time inconsistent optimal control problem could be substantially expanded.

Maximum principle for optimal control problems of stochastic Volterra equations with singular kernels

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Schedule: December 18 12:30-13:00 Capital Suite 12 B

Yushi Hamaguchi
Kyoto University
Japan

Abstract:
In this talk, we consider optimal control problems of stochastic Volterra equations (SVEs) with singular kernels and general (non-convex) control domain, and demonstrate a general maximum principle by means of the spike variation technique. We first show a Taylor type expansion of the controlled SVE with respect to the spike variation, where the convergence rates of the expansions are characterized by the singularity of the kernel. Next, assuming that the kernel is completely monotone, we convert the variational SVEs appearing in the expansion to their infinite-dimensional lifts. Then, we derive new kinds of first and second order adjoint equations in the infinite-dimensional framework and obtain a necessary condition for optimal controls. Furthermore, we discuss some relationships between the infinite dimensional adjoint equations and backward stochastic Volterra integral equations.

Asset Pricing with α-maxmim Expected Utility Model

Schedule: December 18 13:00-13:30 Capital Suite 12 B

Xuedong He
The Chinese University of Hong Kong
Hong Kong

Co-Author(s): Jiacheng Fan and Xuedong He and Ruocheng Wu

Abstract:
We study an asset pricing problem in which a representative agent trades a risky stock, a risk-free asset, and human capital to maximize her preference value of consumption represented by the α-maxmin expected utility model. This preference model is known to lead to time inconsistency, so we consider intra-personal equilibrium for the representative agent and define the market equilibrium to the set of asset prices under which the intra-personal equilibrium strategy clears the market. We prove that there exists a unique market equilibrium and the asset prices are determined by the solution to a second-order ordinary differential equation. Finally, we conduct comparative statics to study the effect of the agent`s ambiguity attitude on the asset prices. This is a joint work with Jiacheng Fan and Ruocheng Wu.

Dynamic Portfolio Choice with Illiquid Securities: An Infinite-Horizon Stochastic LQ Framework

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Schedule: December 18 13:30-14:00 Capital Suite 12 B

Ali Lazrak
UBC
Canada

Co-Author(s): Ali Lazrak, Hanxiao Wand and Jiongmin Yong

Abstract:
In this paper, we provide a stochastic linear-quadratic (LQ, for short) control approach to the portfolio choice model introduced by Garleanu and Pedersen (2016). We first solve the original model in Garleanu and Pedersen (2016) by the classical stochastic LQ control theory in infinite horizon.To capture the present bias, we then generalize the model to the case with non-constant discounting, which is an infinite-horizon time-inconsistent stochastic LQ optimal control problem with nonhomogeneous terms. With the dynamic game point of view, we rigorously develop an approach to finding the so-called equilibrium trading intensity, which is time-consistent and satisfies the local optimality. The solvability of the associated equilibrium algebra quasi-Riccati equations and infinite-horizon extended backward stochastic Volterra integral equations are established.

Solving Coupled Nonlinear Forward-backward Stochastic Differential Equations: An Optimization Perspective with Backward Measurability Loss

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Schedule: December 18 14:00-14:30 Capital Suite 12 B

Yuanhua Ni
Nankai University
Peoples Rep of China

Co-Author(s): Yutian Wang, Xun Li

Abstract:
This paper aims to extend the BML method proposed in [Probabilistic Framework of Howard`s Policy Iteration: BML Evaluation and Robust Convergence Analysis, IEEE TAC, 2024, vo.69, no.8, pp.5200-5215] to make it applicable to more general coupled nonlinear FBSDEs. We interpret BML from the fixed-point iteration perspective and show that optimizing BML is equivalent to minimizing the distance between two consecutive trial solutions in a fixed-point iteration. Thus, this paper provides a theoretical foundation for an optimization-based approach to solving FBSDEs. We also empirically evaluate the method through four numerical experiments.

Classical Differentiability of BSVIEs and Dynamic Capital Allocations

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Schedule: December 18 14:45-15:15 Capital Suite 12 B

Ludger Overbeck
Justus-Liebig-University/Institute of Mathematics
Germany

Co-Author(s): Eduard Kromer

Abstract:
Backward stochastic Volterra integral equations are used in Mathematical Finance and Risk Theory as a tool to define dynamic risk measures. We will adress the corresponding topic of Capital allocation, which requires some differentiablility of BSVIE. Capital allocations have been studied in conjunction with static risk measures in various papers. The dynamic case has been studied only in a discrete-time setting. We address the problem of allocating risk capital to subportfolios in a continuous-time dynamic context. For this purpose we introduce a classical differentiability result for backward stochastic Volterra integral equations and apply this result to derive continuous-time dynamic capital allocations. Moreover, we study a dynamic capital allocation principle that is based on backward stochastic differential equations and derive the dynamic gradient allocation for the dynamic entropic risk measure. As a consequence we finally provide a representation result for dynamic risk measures that is based on the full allocation property of the Aumann-Shapley allocation, which is also new in the static case.

On the Solvability of Second-order Backward Stochastic Volterra Integral Equations and Equilibrium HJB Equations

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Schedule: December 18 15:15-15:45 Capital Suite 12 B

Chi Seng Pun
Nanyang Technological University
Singapore

Co-Author(s): Qian Lei, Chi Seng Pun

Abstract:
This paper addresses the solvability of a broad class of nonlocal second-order backward stochastic differential equations featuring two temporal parameters or backward stochastic Volterra integral equations (2BSVIEs). These equations arise in the characterization of equilibrium strategies and corresponding value functions for time-inconsistent (TIC) stochastic control problems, where agents` present- or state-biased preferences violate Bellman`s principle of optimality. In such contexts, our formulation extends the scope of existing work by allowing both the drift and volatility of the underlying state process to be controllable, and considering objective functionals that depend on both the initial time and state. The comprehensive nature of our 2BSVIE framework requires moving away from a purely probabilistic approach for demonstrating solvability, directing us instead towards an analytical method grounded in partial differential equations (PDEs). Specifically, we employ a continuity method and Banach`s fixed-point arguments within custom-designed Banach spaces to establish the well-posedness and regularity of solutions for a class of PDEs with nonlocality in both time and space (nPDEs). Subsequently, we derive a Feynman--Kac-type formula using It\^{o}`s lemma to establish a relationship between the solutions of the 2BSVIEs and the nPDEs, thereby proving the solvability of the general 2BSVIEs. These solvability results significantly advance the understanding of long-standing open problems in equilibrium Hamilton-Jacobi-Bellman (HJB) equations and TIC controls. Finally, we present two globally solvable financial examples.

Optimal Controls for FBSDEs: Time-Inconsistency and Time-Consistent Solutions

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Schedule: December 18 15:45-16:15 Capital Suite 12 B

Hanxiao Wang
Shenzhen University
Peoples Rep of China

Co-Author(s): Jiongmin Yong, Chao Zhou

Abstract:
This talk is concerned with an optimal control problem for a forward-backward stochastic differential equation (FBSDE, for short) with a recursive cost functional determined by a backward stochastic Volterra integral equation (BSVIE, for short). It is found that such an optimal control problem is time-inconsistent in general, even if the cost functional is reduced to a classical Bolza type one as in Peng (AMO 1993), Lim-Zhou (SICON 2001), and Yong (SICON 2010). Therefore, instead of finding a global optimal control (which is time-inconsistent), we will look for a time-consistent and locally optimal equilibrium strategy, which can be constructed via the solution of an associated equilibrium Hamilton-Jacobi-Bellman (HJB, for short) equation. A verification theorem for the local optimality of the equilibrium strategy is proved by means of the generalized Feynman-Kac formula for BSVIEs and some stability estimates of the representation parabolic partial differential equations (PDEs, for short). Under certain conditions, it is proved that the equilibrium HJB equation, which is a nonlocal PDE, admits a unique classical solution. As applications, the linear-quadratic problems, a mean-variance model, a social planner problem with heterogeneous Epstein-Zin utilities, and a Stackelberg game are briefly mentioned. In particular, we will show an interesting phenomenon in the social planner problem. We remark that our framework can cover not only the optimal control problems for FBSDEs studied in Peng (AMO 1993), Lim-Zhou (SICON 2001), Yong (SICON 2010), and so on, but also the problems of the general discounting and some nonlinear appearance of conditional expectations for the terminal state, studied in Yong (MCRF 2012, ICM 2014) and Bjork-Khapko-Murgoci (FS 2017).

A general maximum principle for optimal control of stochastic differential delay systems

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Schedule: December 18 17:00-17:30 Capital Suite 12 B

Tianxiao wang
Sichuan University
Peoples Rep of China

Co-Author(s): Weijun Meng, Jingtao Shi, Jifeng Zhang

Abstract:
In this talk, we discuss the general maximum principle for a stochastic optimal control problem where the control domain is an arbitrary non-empty set and all the coefficients (especially the diffusion term and the terminal cost) contain the control and state delay. In order to overcome the difficulty of dealing with the cross term of state and its delay in the variational inequality, we propose a new method: transform a delayed variational equation into a Volterra integral equation without delay inspired by [Y. Hamaguchi, Appl. Math. Optim., 87 (2023), 42], and introduce novel first-order, second-order adjoint equations via the backward stochastic Volterra integral equation theory established in [T. Wang and J. Yong, SIAM J. Control Optim., 61 (2023), 3608-3634]. Finally we express these two kinds of adjoint equations in more compact anticipated backward stochastic differential equation types for several special yet typical control systems.

Extended mean-field control problems with Poissonian common noise: Stochastic maximum principle and Hamiltonian-Jacobi-Bellman equation

Schedule: December 18 17:30-18:00 Capital Suite 12 B

Xiaoli Wei
Harbin Insitute of Technology
Peoples Rep of China

Co-Author(s): Lijun Bo, Jingfei Wang, Xiang Yu

Abstract:
This paper studies mean-field control problems with state-control joint law dependence and Poissonian common noise. We develop the stochastic maximum principle (SMP) and establish its connection to the Hamiltonian-Jacobi-Bellman (HJB) equation on the Wasserstein space. The presence of the conditional joint law in the McKean-Vlasov dynamics and its discontinuity caused by the Poissonian common noise bring us new technical challenges. To develop the SMP when the control domain is not necessarily convex, we first consider a strong relaxed control formulation that allows us to perform the first-order variation. We also propose the technique of extension transformation to overcome the compatibility issues arising from the joint law in the relaxed control formulation. By further establishing the equivalence between the relaxed control formulation and the strict control formulation, we obtain the SMP for the original problem with strict controls. In the part to investigate the HJB equation, we formulate an auxiliary control problem subjecting to a controlled measure-valued dynamics with Poisson jumps, which allows us to derive the HJB equation of the original problem by a newly established equivalence result. We also show the connection between the SMP and the HJB equation and present an illustrative example of linear quadratic extended mean-field control with Poissonian common noise.

Almost strong equilibria for time-inconsistent stopping problems under finite horizon in continuous time

Schedule: December 18 18:00-18:30 Capital Suite 12 B

Zhou Zhou
The University of Sydney
Australia

Co-Author(s): Zhou Zhou

Abstract:
We consider time-inconsistent stopping problems for a continuous-time Markov chain under finite time horizon with non-exponential discounting. We provide an example indicating that strong equilibria may not exist in general. As a result, we propose a notion of equilibrium called almost strong equilibrium (ASE), which is a weak equilibrium and satisfies the condition of strong equilibria except at the boundary points of the associated stopping region. We provide an iteration procedure and show that this procedure leads to an ASE. Moreover, we prove that this ASE is the unique ASE among all regular stopping policies under finite horizon. In contrast, we show that strong equilibria (and thus ASE) exist and may not be unique for the infinite horizon case. Furthermore, we show that the limit of the finite-horizon ASE, as the time horizon goes to infinity, is a weak equilibrium for the infinite-horizon problem and may not be a strong equilibrium or ASE.

Special Session 60 : Nonlinear Evolution Equations and Related Topics

Introduction: This session will focus on the recent developments in the theory of Nonlinear Evolution Equations and Related Topics including the theory of abstract evolution equations in Banach spaces as well as the studies of several types of nonlinear partial differential equations (the existence, regularity, and asymptotic behavior of solutions).

Existence of distributional solutions to elliptic systems of p-Laplacian type for locally integrable forcing

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Schedule: December 17 19:00-19:30 Conference Hall B (B)

Goro Akagi
Tohoku University
Japan

Co-Author(s): Hiroki Miyakawa

Abstract:
This talk is concerned with existence and maximal regularity estimates for distributional solutions to degenerate/singular elliptic systems of p-Laplacian type with absorption and (prescribed) locally integrable forcing posed in unbounded Lipschitz domains. In particular, the forcing terms may not belong to the dual space of an energy space, e.g., $W^{1,p}_{\mathrm{loc}}$, which is necessary for the existence of weak (or energy) solutions of class $W^{1,p}_{\mathrm{loc}}$. The method of a proof relies on both local energy estimates and a relative truncation technique developed by Bul\`{i}\v{c}ek and Schwarzacher (Calc. Var. PDEs in 2016), where the bounded domain case is studied for (globally) integrable forcing.

Boundedness and stabilization in some degenerate parabolic-elliptic-elliptic attraction-repulsion chemotaxis system

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Schedule: December 17 13:00-13:30 Conference Hall B (B)

Yutaro Chiyo
Tokyo University of Science, Department of Mathematics
Japan

Co-Author(s): Yutaro Chiyo

Abstract:
This talk deals with a degenerate parabolic-elliptic-elliptic attraction-repulsion chemotaxis system. In the repulsion-dominant case, boundedness and stabilization in the nondegenerate version were obtained by C.-Yokota (2022) and C. (2022) by using the repulsion effect. However, in the degenerate case, there is no result obtained by extracting the effects of the attraction and repulsion. The purpose of this talk is to establish boundedness and stabilization in a degenerate system in the repulsion-dominant case.

A threshold type algorithm for fourth order geometric motions

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Schedule: December 17 16:15-16:45 Conference Hall B (B)

Katsuyuki Ishii
Kobe University
Japan

Abstract:
In this talk we would like to propose a threshold type algorithm for fourth order geometric motions, which are Willmore flows with lower order terms. This type of this algorithm was firstly proposed by Bence, Merriman and Osher to compute mean curvature flows. We use fourth order linear parabolic equations to construct our algorithm and show a consistency result if the initial surface is smooth. This is based on my joint work with Professores Y. Kohsaka, N. Miyake and K, Sakakibara

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Non-linear evolution equations with non-local coefficients and smoothing effect

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Schedule: December 17 14:00-14:30 Conference Hall B (B)

Akisato Kubo
Fujita Health University
Japan

Abstract:
We investigate the global existence in time and asymptotic profile of the solution of some nonlinear evolution equations with strong dissipation and the proliferation term:

$$w_{tt} = D\Delta w_t + \nabla \cdot (\alpha(w_t)e^{-w}\chi[w]) + \mu(1 - w_t)w_t, \text{ in } \Omega \times (0, T)$$

where D, μ are positive constants, $\alpha(\cdot)$ is an sufficiently smooth function, Ω is a bounded domain in R^n with smooth boundary $\partial\Omega$ and ν is the outer unit normal vector on $\partial\Omega$, $\chi[w] := \chi[w](x, t)$ is a non-local term. We will show the existence and asymptotic behaviour of solutions to the initial and zero-Neumann boundary value problem of the equation. We will apply our results to a model of mathematical biology, and we discuss the smoothing effect.

Non-autonomous singular perturbations of semilinear problems with dynamic boundary conditions

Schedule: December 17 17:30-18:00 Conference Hall B (B)

Jihoon Lee
Chonnam National University
Korea

Abstract:
In this talk we prove the continuity and the Gromov-Hausdorff stability of the solutions for a class of semilinear problems with dynamic boundary condition of pure reactive and reactive diffusive type. Our approach involves a non-autonomous singular perturbations of a reaction-diffusion equation with large diffusion in all domain and its boundary. This is joint work with P.T.P. Lopes and L. Pires. If you are interested in this topic, please refer to the papers on the following website:
http://jlee.jnu.ac.kr/Research.html

A chimera gradient flow approach to chemotaxis systems with indirect signal production

Schedule: December 17 13:30-14:00 Conference Hall B (B)

Yoshifumi Mimura
Nihon University
Japan

Abstract:
In this talk, we discuss the existence of time global solutions for chemotaxis systems involving indirect signal generation. In particular, the case involving a degenerate diffusion term is considered from a variational rather than a semigroup approach; for each of the three unknown functions, an approximate solution is constructed by applying the so-called minimizing movement scheme. Since this system of equations is not a gradient flow, the relative compactness of the approximate solutions is not guaranteed, but the presence of Lyapunov functions provides the conditions for the existence of time global solutions and their relative compactness.

Existence of time-fractional gradient flows for nonconvex energies in Hilbert spaces

Schedule: December 17 18:30-19:00 Conference Hall B (B)

Yoshihito Nakajima
Tohoku University
Japan

Co-Author(s): Goro Akagi

Abstract:
This talk is concerned with the solvability of time-fractional gradient flow equations for nonconvex energies in Hilbert spaces. Main results consist of local and global (in time) existence of (continuous) strong solutions to time-fractional evolution equations governed by the difference of two subdifferential operators in Hilbert spaces. In contrast with classical evolution equations (with standard time-derivatives), there arise several new difficulties such as lack of chain-rule identity and low regularity of solutions from the subdiffusive nature of the problem. To prove the main results, integral forms of chain-rule formulae for time-fractional derivatives, a Lipschitz perturbation theory for time-fractional gradient flows for convex energies and Gronwall-type lemmas for nonlinear Volterra integral inequalities are developed. These abstract results are also applied to the Cauchy-Dirichlet problem for some p-Laplace subdiffusion equations with blow-up terms.

Construction of distance functions for topology optimization

Schedule: December 17 14:45-15:15 Conference Hall B (B)

Tomoyuki Oka
Fukuoka Institute of Technology
Japan

Co-Author(s): Tomoyuki Oka

Abstract:
The topology optimization problem is a problem that determines the shape and topology of materials that minimize a given energy and attracts attention in industry. However, the obtained shapes are not always manufacturable. In this talk, we construct a distance function, which is one of the geometric features, by employing a solution of an elliptic equation.

Boundedness of solutions to a chemotaxis system with a Robin boundary condition

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Schedule: December 17 12:30-13:00 Conference Hall B (B)

Yuya Tanaka
Department of Mathematical Sciences, Kwansei Gakuin University
Japan

Co-Author(s): Silvia Frassu, Giuseppe Viglialoro

Abstract:
In studies of chemotaxis system, Neumann boundary conditions are usually assumed. In this talk we deal with a chemotaxis system under a Robin boundary condition and discuss global existence and boundedness of solutions. This is a joint work with Silvia Frassu and Giuseppe Viglialoro.

Optimal control problem of evolution equation governed by hypergraph Laplacian

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Schedule: December 17 15:15-15:45 Conference Hall B (B)

Shun Uchida
Oita University/Faculty of Science and Technology
Japan

Abstract:
In this talk, we consider some optimal control problem of an ODE governed by the hypergraph Laplacian, which is defined as a subdifferential of a convex function and then is a set-valued operator. In our previous works, we see that this ODE has some properties which resemble those of the PDEs with p-Laplacian. By using methods for a priori estimates, we can assure the existence of the optimal control for a suitable cost function. However, since the hypergraph Laplacian is a set-valued operator, it seems to be difficult to derive the necessary optimality condition for this problem. To cope with this difficulty, we introduce an approximation problem and assure the optimality condition for this. We also discuss the convergence of the condition to that for the original problem.

Stability of non-zero equilibrium states for the viscous conservation laws with delay effect

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Schedule: December 17 17:00-17:30 Conference Hall B (B)

Yoshihiro Ueda
Kobe University
Japan

Abstract:
In this talk, we consider the stability of the non-zero equilibrium state for the viscous conservation laws with a delay effect. The linear stability is analyzed by using the characteristic equation of the corresponding eigenvalue problem. If our equation does not have a delay effect, the characteristic equation is given by a polynomial equation. On the other hand, if our equation has a delay effect, the characteristic equation becomes a transcendental equation, and it is difficult to analyze it. In this situation, we apply the useful known result concerned with the characteristic equation for the ordinary delay differential equations and try to get the sharp stability condition for the viscous viscous conservation laws with delay.

Weighted Energy-Dissipation approach to semilinear gradient flows with state-dependent dissipation

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Schedule: December 17 18:00-18:30 Conference Hall B (B)

Riccardo Voso
University of Vienna
Austria

Co-Author(s): Goro Akagi, Ulisse Stefanelli

Abstract:
We investigate the Weighted Energy-Dissipation variational approach to semilinear gradient flows with state-dependent dissipation. A family of parameter-dependent functionals defined over entire trajectories is introduced and proved to admit global minimizers. These global minimizers correspond to solutions of elliptic-in-time regularizations of the limiting causal problem. By passing to the limit in the parameter we show that such global minimizers converge, up to subsequences, to a solution of the gradient flow.

Standing waves for the nonlinear Schr\odinger-Poisson system with a doping profile

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Schedule: December 17 15:45-16:15 Conference Hall B (B)

Tatsuya Watanabe
Kyoto Sangyo University
Japan

Co-Author(s): Mathieu Colin

Abstract:
In this talk, we consider the nonlinear Schr\odinger-Poisson system with a doping profile, which appears in the study of semi-conductor theory. We are interested in the existence of ground state solutions and their orbital stability. The presence of a doping profile causes several difficulties, such as the proof of the strict sub-additivity and the uniqueness of a maximum point of a fibering map.When the doping profile is a characteristic function supported on a bounded smooth domain, some geometric quantities related to the domain, such as the mean curvature, are responsible for the existence of ground state solutions.

Special Session 62 : Mathematical problems arising in recognizing the data value chain efficiency

Introduction: Data has the dual attributes of basic strategic resources and key production factors. Data efficiency is not only reflected in the various chains of data creation and data flow, but also strongly relevant to the data factor market. The design of data factor market is based on the effective use of data. Many problems in data value chain should be focused on. For instance, recognizing expected efficiency of data value chain in various fields; the integration degree of data value chain with various industrial chains; measuring efficiency for multi chains; new landscape of global data value chain; data ecological governance and data value chain efficiency improvement path, and so forth. There are some mathmatical problems arising in the study of data value chain efficiency. The input-output models are widely applied in this field. This session aims to provide a platfotm for discussing how to use more mathematical methods and techniques to solve problems arising in the study of data value chain efficiency.

The dark side of financial digitalization: Corporate digital finance and speculative financial investments

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Schedule: December 19 15:15-15:45 Conference Hall B (D)

Zhehao Huang
Guangzhou University
Peoples Rep of China

Abstract:
In this paper, we devote to exploring the effects of digital finance on the corporate financialization. We first built a two-stage portfolio model to analyze how the digital finance development impacts the financial investment of corporations with different financialization motives, which is followed by empirical examinations corresponding to the theoretical analysis, where the corporate digital finance index was constructed by text analysis in a keyword network describing the logical relationship among 138 keywords standing for corporate digital transformation and corporate finance. Two core results are achieved. First, digital finance development pushes the corporate financialization. Serial robustness tests and endogeneity test were also carried out to support this result. Second, digital finance development has heterogeneous effects on corporate financialization. It drives speculative financialization positively but has no significant impact on risk-hedging financialization, while speculative financial investments increase corporate uncertainty and affect core business development. Finally, some additional heterogeneity analysis with respect to managers` financial capability, ownership nature and industry characteristics are carried out to complete our paper. Some targeted policy recommendations are proposed in the conclusion.

Volatility spillover between carbon market and related markets in time-frequency domain based on BEKK-GARCH and complex network analysis

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Schedule: December 19 16:15-16:45 Conference Hall B (D)

Tinghui Li
Guangzhou University
Peoples Rep of China

Abstract:
With rising public attention to climate issues and sustainable development, the connection be-tween carbon market and its related markets has become closer. Based on BEKK-GARCH method and complex network theory, this study tries to explore the volatility spillover effects and net-work topology among China`s carbon market, non-renewable energy market, renewable energy market, high-tech market and climate policy uncertainty index from the perspective of time do-main and frequency domain. The findings include that, firstly, there are significant asymmetric volatility spillover effects among the above-mentioned markets. Secondly, the volatility spillover effects between the markets are time-varying, especially during crisis periods in which the volatility spillover effects are significantly higher than that during the stable period. Thirdly, with the increase of time, the closer the connection between the markets. In the long run, the closeness of the connection is directly proportional to the spillover effect. Finally, climate policy uncertainty is the main source of risk. For the full sample period, from the perspective of frequency domain, non-renewable energy market and carbon market are the main risk recipients. Based on the above research findings, the authors suggest stepping up efforts on market monitoring and intervention during crisis periods, strengthening cross-market risk management, paying attention to climate policy uncertainty, and attaching importance to time and frequency varying characteristics of volatility spillovers, so as to provide useful information for policy makers and investors.

Modelling the data generating mechanism of Chinese commodity market by identifying hidden information fow regimes

Schedule: December 19 15:45-16:15 Conference Hall B (D)

Zhenghui Li
Guangzhou University
Peoples Rep of China

Abstract:
The commodity market contains abundant information from macro economy. Measuring the macroeconomic information fows in the fuctuations of commodity priceindexes are conducive to monitoring the market and forecasting its growing trend.In this paper, a high-order hidden Markov chain (HOHMC)is used to measurehidden macroeconomic information fows in the (hinese commodity futures index.where the time frame is from June 25, 2004 to January 31, 2023. Some interest-ing empirical results are achieved for investors and regulators as follows. First, themacroeconomic hidden information fows can be categorized into high volatility regime and low volatility regime. During a high volatility regime, the Chinese Commodity Index exhibits increased volatility and frequent jumps in behavior. Inthe panic phase of this regime, the market is relatively efcient; during its bub.ble phase, it becomes relatively inefcient. Second, different commodity marketshave heterogeneous data generation mechanisms, with industrial, metal, and energymarkets being more sensitive to exogenous shocks compared to the less sensitiveagricultural market. Third, the macroeconomic hidden information fows that driveChinese commodity market data generation mechanism serve as an explicit leadingindicator for macroeconomic variables.

Does Corporate Greenwashing Affect Investors` Decisions?

Schedule: December 19 16:45-17:15 Conference Hall B (D)

Gaoke Liao
Guangzhou University
Peoples Rep of China

Abstract:
Greenwashing creates a misleadingly positive image for corporations while leading to the misguidance of investors` behaviors. Based on the sample of Chinese A-share listed companies for the period 2008-2021, this paper investigates the impact of corporate greenwashing on investors` decisions. The empirical results indicate that (i) greenwashing significantly improves short-term returns on corporate stocks, but reduces long-term returns; (ii) in the short term, investors are influenced by expressive manipulation rather than selective disclosure, but this impact is not sustainable, and both have an impact in the long term. These findings provide a new risk reminder for investors` behaviors and have practical significance for government to promote the green development of corporations.

Cryptocurrencies as Safe Havens for Geopolitical risk? A Quantile Analysis Approach

Schedule:

Bin Mo
Guangzhou University
Peoples Rep of China

Abstract:
In recent years, global geopolitical risk (GPR) events have had profound effects on economies and financial markets. This paper systematically ana- lyzes the hedging characteristics of traditional safe-haven assets (gold, USD, oil) compared to cryptocurrencies (Bitcoin, Ethereum, Litecoin) under different levels of GPR. Utilizing quantile regression and QQ plots, the study explores the dynamic nonlinear impacts of GPR on various assets and em- pirically analyzes the influence of key geopolitical events on asset markets. The findings reveal that cryptocurrencies have relatively weaker hedging functions in the context of geopolitical risks, while traditional safe-haven assets like gold, USD, and oil demonstrate more stable hedging character- istics during periods of uncertainty. Notably, the correlation between GPR and asset prices is more pronounced under extreme market conditions. This research offers new asset allocation recommendations for investors and en- hances the understanding of the hedging properties of cryptocurrencies.

Special Session 63 : Singular limit problems arising from nonlinear PDEs

Introduction: The main toipics of this special session include that the vanishing viscosity limit and low Mach number limit of Navier-Stokes equations and MHD equations, long wave limit in plasma, hydrodynamics limit in kinetic equation.

COUPLING AND PROPAGATION OF SINGULARITIES IN THE INITIAL LAYER FOR BOLTZMANN EQUATION

Schedule: December 20 8:30-9:00 Capital Suite 8

Hung-Wen Kuo
National Cheng Kung University
Taiwan

Co-Author(s): Tai-Ping Liu and Shih-Hsien Yu

Abstract:
In the study of the relationship between the Boltzmann equation in kinetic theory and fluid dynamics, it is essential to understand the singular layers. In the classical paper by Harold Grad, he identified three basic layers: boundary, shock, and initial layers. In this talk, I will present joint work with Tai-Ping Liu and Shih-Hsien Yu on the formation and propagation of singularities in the initial layer of the solutions to the Boltzmann equation in both the space-time (x, t) and microscopic velocity $\boldsymbol{\xi}$ domains. Singularities transport in the space-time (x, t) domain and interact with the nonlinear collision operator in the microscopic velocity $\boldsymbol{\xi}$ domain, creating rich singular coupling in the $(x, t, \boldsymbol{\xi})$ domain. Our work identifies the essential features of the collision operators using generalized Carleman-Hilbert coordinates, ensuring that the Green`s function approach is sufficient to reveal the explicit structure of the singularities in the initial layers.

Vanishing viscosity limits for the free boundary problem of compressible flows

Schedule: December 20 9:00-9:30 Capital Suite 8

Yu Mei
Northwestern Polytechnical University
Peoples Rep of China

Abstract:
In this talk, we present some results of vanishing viscosity limits for the free boundary problem of compressible isentropic flows. For the free boundary compressible Navier-Stokes equations of Newtonian fluids with or without surface tension, we established the uniform regularities of solutions in Sobolev conormal and Lipschitz spaces, and justified the vanishing viscosity and surface tension limits by a strong convergence argument. On the other hand, for the free boundary compressible viscoelastic equations of neo-Hookean fluids with or without surface tension, we obtained the uniform Sobolev regularities of solutions and proved the vanishing viscosity limits in Sobolev spaces, which indicates the stabilizing effect of elasticity.

3D hard sphere Boltzmann equation: explicit structure and the transition process from polynomial tail to Gaussian tail

Schedule: December 20 14:00-14:30 Capital Suite 8

Haitao Wang
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Yu-Chu Lin, Kung-Chien Wu

Abstract:
We study the Boltzmann equation with hard sphere in a near-equilibrium setting. The initial data is compactly supported in the space variable and has a polynomial tail in the microscopic velocity. We show that the solution can be decomposed into a particle-like part (polynomial tail) and a fluid-like part (Gaussian tail). The particle-like part decays exponentially in both space and time, while the fluid-like part dominates the long time behavior and exhibits rich wave motion. The nonlinear wave interactions in the fluid-like part are precisely characterized. Furthermore, the transition process from the polynomial to the Gaussian tail is quantitatively revealed.

GLOBAL SOLUTION OF 3-D KELLER-SEGAL MODEL WITH COUETTE FLOW IN WHOLE SPACE

Schedule: December 20 14:30-15:00 Capital Suite 8

Weike WANG
Shanghai Jiao Tong University
Peoples Rep of China

Abstract:
we introduce both parabolic-elliptic Keller-Segel model and parabolic-parabolic Keller-Segel model in the background of a Couette flow with spatial variables in R^3. It is proved that for both parabolic-elliptic and parabolic-parabolic cases, a Couette flow with a suffciently large amplitude prevents the blow-up of solutions. This result is totally different from either the classical Keller-Segel model or the case with a large shear flow and the periodic spatial variable x; for those two cases, the solution may blow up. Here, we apply Green`s function method to capture the suppression of blow-up and prove the global existence of the solutions.

Stability analysis of boundary layers and inviscid limits of MHD equations

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Schedule: December 20 15:00-15:30 Capital Suite 8

Feng Xie
Shanghai Jiao Tong University
Peoples Rep of China

Abstract:
In this talk, we will discuss the inviscid limit of solutions to initial boundary value problems of viscous hydrodynamics equations with high Reynolds numbers. Due to the mismatch of boundary conditions between the viscous hydrodynamics equations and the limit system (ideal hydrodynamics equations), the boundary layer correction functions usually are introduced as studying the process of inviscid limit of solutions. We will discuss both the stability of boundary layers and the justification of Prandtl boundary layer expansions. First, we will review the progress of analysis of boundary layer equations and inviscid limits; Then, we will introduce the results obtained in recent years in the study of inviscid limits and the stability analysis of boundary layers on MHD.

On the Sobolev stability threshold for 3D Navier-Stokes equations with rotation near the Couette flow

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Schedule: December 20 16:15-16:45 Capital Suite 8

Xiaojing Xu
Beijing Normal University
Peoples Rep of China

Co-Author(s): Wenting Huang, Ying Sun

Abstract:
In this talk, we introduce the dynamic stability of periodic, plane Couette flow in the three-dimensional Navier-Stokes equations with rotation at high Reynolds number $\mathbf{Re}$. Our aim is to determine the stability threshold index on $\mathbf{Re}$, we demonstrate that if initial data satisfies $\|u_{\mathrm{in}}\|_{H^{\sigma}}\frac{9}{2}$ and some $\delta = \delta(\sigma) > 0$ depending only on σ, then the solution to the 3D Navier-Stokes equations with rotation is global in time without transitioning away from Couette flow. In this sense, Coriolis force contributes as a factor enhancing fluid stability by improving its threshold from $\frac{3}{2}$ to 1. This is a jointed work with Wenting Huang, and Ying Sun.

The limit from Vlasov-Poisson system to KdV/ZK equations

Schedule: December 20 16:45-17:15 Capital Suite 8

Xiongfeng Yang
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Zhao Lixian

Abstract:
This talk presents the long wavelength approximation limit of the Vlasov-Poisson (VP) system in torus. We derive formally two-directional wave packets as the solutions of Korteweg-de Vries (KdV) equations from 1-D VP system, the two distinct wave packets as the solutions of Zakharov-Kuznetsov (ZK) equations from 3-D VP system with magnetic field, and the two-way waves as the solutions to the corresponding Kadomtsev-Petviashvili equations from 2-D VP system without magnetic field. A rigorous justification of this long-wave limit is established by the relative entropy method.

BV solutions to the Navier-Stokes equation

Schedule: December 20 17:15-17:45 Capital Suite 8

Xiongtao Zhang
Wuhan University
Peoples Rep of China

Co-Author(s): Haitao Wang and Shih-Hsien Yu

Abstract:
In this talk, I will introduce the well-posedness and the large time behaviors of the BV solutions to the compressible Navier-Stokes equation. The method is based on the Green`s function of the heat kernel and NS equations.

Special Session 64 : Blow-ups and dynamics of nonlinear parabolic equations

Introduction: Nonlinear parabolic equations, including many important geometric flows, fluid equations and those stemming from mathematical biology and physics, have attracted much attention in recent years. Of particular interest are their singularity formation, regularity and global dynamics. Their thorough investigations have led to tremendous amount of analytical techniques and profound results. This special session aims to gather leading expects in this field, and its focus will be on the blow-ups, global dynamics and asymptotics of parabolic PDEs.

Infinite time blow-up for the energy critical heat equation on bounded domains in low dimension

Schedule: December 19 16:45-17:15   Capital Suite 11 A

Giacomo Ageno
University of Cambridge
England

Co-Author(s): Manuel del Pino

Abstract:
A positive solution to the Dirichlet problem for the energy-critical heat equation typically decays exponentially fast or blows up in finite time. Threshold behaviors between these two scenarios exist, having been studied since the 1980s. In this talk, I will introduce the first examples of global, unbounded solutions without radial symmetry, precisely describing asymptotic and stability. The low dimension $\{3, 4\}$ plays a crucial role, making the heart of the problem nonlocal. In dimension 3 the analysis reveals a connection with the Brezis-Nirenberg number. This is joint work with Manuel del Pino.

Liouville theorems in the upper half-space and the fully nonlinear Loewner-Nirenberg problem

Schedule: December 19 19:00-19:30   Capital Suite 11 A

Jonah Duncan
University College London
England

Co-Author(s): Luc Nguyen

Abstract:
I will discuss recent work with Luc Nguyen concerning a class of fully nonlinear Yamabe-type equations of negative curvature type on the upper half-space. We show that whether the hyperbolic metric is the unique solution is completely determined by a single parameter associated with the equation; in the case of non-uniqueness, we classify all other solutions. I will also discuss implications of non-uniqueness on the validity of certain estimates for the fully nonlinear Loewner-Nirenberg problem on compact manifolds with boundary.

Smooth nonradial stationary 2d Euler flows with compact support

Schedule: December 19 18:00-18:30   Capital Suite 11 A

Antonio J. Fernandez
Universidad Autonoma de Madrid
Spain

Co-Author(s): Alberto Enciso (Instituto de Ciencias Matem\` aticas, Madrid (Spain)); David Ruiz (Universidad de Granada, Granada (Spain))

Abstract:
In this talk we will show how to construct nonradial classical solutions to the $2d$ incompressible Euler equations. More precisely, for any positive integer k, we will see how to construct compactly supported stationary Euler flows of class $C^k(\mathbb{R}^2)$ which are not locally radial.

Vortex dynamics for the Gross-Pitaevskii equation

Schedule: December 19 18:30-19:00 Capital Suite 11 A

Rowan Juneman
University of Bath
England

Co-Author(s): Manuel del Pino, Monica Musso

Abstract:
The Gross-Pitaevskii equation in the plane arises as a physical model for an idealized, two-dimensional superfluid. We construct solutions to this equation with multiple vortices of degree ± 1, corresponding to concentration points of the associated fluid vorticity. The vortex dynamics is described on any finite time interval, and at leading order is governed by the classical Helmholtz-Kirchhoff system. Compared to previous rigorous results of Bethuel-Jerrard-Smets and Jerrard-Spirn, we use a different method based on linearization around an approximate solution. This approach provides a very precise description of the solutions near the vortex set and information on lower order corrections to the vortex dynamics. Moreover, our analysis of the linearized problem is potentially of independent interest in the study of long-time dynamics. This is joint work with Manuel del Pino and Monica Musso.

Existence of solutions to a fractional semilinear heat equation in uniformly local weak Zygmund type spaces

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Schedule: December 19 15:45-16:15 Capital Suite 11 A

Tatsuki Kawakami
Ryukoku University
Japan

Co-Author(s): Norisuke Ioku, Ryo Takada, and Kazuhiro Ishige

Abstract:
The study of the solvability of the Cauchy problem for semilinear (fractional) heat equations is divided into the three cases with respect to the nonlinear exponent: $1

Infinite-time blowing-up solutions to small perturbations of the Yamabe flow

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Schedule: December 19 17:30-18:00 Capital Suite 11 A

Seunghyeok Kim
Hanyang University
Korea

Co-Author(s): Monica Musso

Abstract:
In this talk, we will examine a PDE aspect of the Yamabe flow as an energy-critical parabolic equation of the fast-diffusion type. It is well-known that under the validity of the positive mass theorem, the Yamabe flow on a smooth closed Riemannian manifold M exists for all time t and converges uniformly to a solution to the Yamabe problem on M as $t \to \infty$. We will observe that such results no longer hold if some arbitrarily small and smooth perturbation is imposed on it, by constructing solutions to the perturbed flow that blow up at multiple points on M in the infinite time. We are also concerned about the stability of the blow-up phenomena under a negativity condition on the Ricci curvature at blow-up points. This is joint work with Monica Musso (University of Bath, UK).

Liouville theorems and universal estimates for superlinear parabolic problems

Schedule: December 19 15:15-15:45 Capital Suite 11 A

Pavol Quittner
Comenius University, Bratislava
Slovak Rep

Co-Author(s): Pavol Quittner

Abstract:
It is known that Liouville-type theorems guarantee universal estimates of solutions to various superlinear elliptic and parabolic problems which are scale-invariant. We discuss several recent related results, particularly for parabolic problems without scale invariance. Part of these results is a joint work with Philippe Souplet.

Critical norm blow-up rates for the energy supercritical nonlinear heat equation

Schedule: December 19 16:15-16:45 Capital Suite 11 A

Jin Takahashi
Institute of Science Tokyo
Japan

Abstract:
We study the behavior of the scaling critical Lebesgue norm for blow-up solutions to a nonlinear heat equation (the Fujita equation). For the Sobolev supercritical nonlinearity, we show that the critical norm also blows up. Moreover, we give estimates of the blow-up rate for the critical norm. This talk is based on a joint work with Tobias Barker (University of Bath) and Hideyuki Miura (Institute of Science Tokyo).

Special Session 65 : Recent Progress in Free Boundary Problems in Fluid Flow and Fluid-Structure Interactions

Introduction:

Global Well-posedness of Viscous Water-Waves

Schedule: December 19 9:00-9:30 Capital Suite 12 B

Hantaek Bae
Ulsan National Institute of Science and Technology
Korea

Co-Author(s): Woojae Lee, Jaeyong Shin

Abstract:
In this talk, we discuss a nonlinear model of the viscous water-waves system proposed by Dias-Dychenko-Zakharov (DDZ). We first study the linear model of DDZ. We then derive a new approximated model of DDZ and show how to find a global-in time solution.

On a Nonlinear Acoustics - Structure Interaction Model

Schedule: December 19 8:00-8:30 Capital Suite 12 B

Barbara Kaltenbacher
University of Klagenfurt
Austria

Co-Author(s): Amjad Tuffaha

Abstract:
In this talk we consider a coupled system of nonlinear acoustic structure interactions. The model consists of the nonlinear Westervelt equation on a bounded domain with non homogeneous boundary conditions, coupled with a 4th order linear equation defined on a lower dimensional interface occupying part of the boundary of the domain, with transmission boundary conditions matching acoustic velocities and acoustic pressures. While the well-posedness of the Westervelt model has been well studied in the literature, we here present new work on the analysis of this coupled problem. We establish local-in-time and global in time well-posedness for small data. Another contribution of this work, is a novel variational weak formulation of the linearized system and a consideration of various boundary conditions. If time permits, we will also provide an outlook on a control-shape optimization problem for this coupled system.

On the dynamics of the interface between two incompressible fluids in a porous media

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Schedule: December 19 13:30-14:00 Capital Suite 12 B

Omar Lazar
New-York Abu Dhabi university
United Arab Emirates

Abstract:
Consider two incompressible fluids with different densities and same viscosity in a porous media. We shall consider surface tension effect (in addition to gravity) and show why the dynamic of the interface between these two immiscible fluids can be arbitrarily large Lipschitz.

Stability of the Stokes immersed boundary problem with bending and stretching energy

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Schedule: December 19 13:00-13:30 Capital Suite 12 B

Hui Li
New York University Abu Dhabi
United Arab Emirates

Abstract:
In this talk, we present stability results for an elastic string with bending and stretching energy immersed in a 2-D Stokes flow. We introduce the curve`s tangent angle function and the stretching function to describe the different deformations of the elastic string. These two functions are defined on the arc-length coordinate and the material coordinate respectively. Reformulating the problem into a parabolic system via the fundamental solution of the Stokes equation, we establish local well-posedness in Sobolev space under non-self-intersecting and well-stretched initial configurations. For initial configurations close to an evenly parametrized circle, we prove that the solution can be extended globally and the global solution will converge exponentially to the equilibrium state.

Variational theory of a incompressible heat conducting bi-fluid system involving an elastic interface.

Schedule: December 19 8:30-9:00 Capital Suite 12 B

Sourav Mitra
IIT Indore
India

Co-Author(s): Dr. Sourav Mitra, Dr. Sebastian Schwarzacher

Abstract:
In this talk I will present our recent result on the global existence of weak solutions of a fluid structure interaction problem involving two Newtonian incompressible heat conducting fluids separated by an elastic plate/ shell. The elastic plate involved allows heat transfer between the two fluids. We show the global existence of weak solution to our model until the Koiter energy degenerates or the structure undergoes a self intersection or touches the rigid boundary $\partial\Omega$. The two fluids involved are assumed to have different viscosities and they depend on the respective temperatures. The temperature dependence of the viscosities is modeled by the celebrated Vogel-Fulcher-Tammann equation. We use a variational strategy in order to construct weak solutions which involves regularization of the Koiter energy, adding artificial dissipation and discretization using two different time scales: velocity scale and the acceleration scale.

Special Session 66 : Advances in discrete-time dynamical systems with applications

Introduction: The topic of discrete-time dynamical systems has experienced a surge in interest and quick expansion in the last three decades. This session offers researchers a chance to meet, discuss ideas in a friendly environment and present their results on the latest developments in the subject. The session themes encompass topological dynamics, periodic solutions and forcing periodicity, stability, bifurcations, and the diverse applications of discrete systems in economics, mathematical biology, and ecology.

Optimal Control Approaches for Managing Infectious Diseases with Behavioral Dynamics

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Schedule: December 16 18:30-19:00 Capital Suite 6

Mo`tassem Al-arydah
Khalifa University
United Arab Emirates

Co-Author(s): Omar Forrest

Abstract:
This study develops a simplified SVIR (Susceptible, Vaccinated, Infected, Recovered) model to examine COVID-19 transmission, incorporating the nonlinear effects of population caution on infection rates. The model`s validity is confirmed by demonstrating the existence of positive bounded solutions. The basic reproduction number is calculated, and the local stability of both the disease-free equilibrium (DFE) and endemic equilibrium (EE) is assessed, revealing that the EE only exists when the basic reproduction number exceeds a critical threshold. Global stability for both equilibria is established using Lyapunov functions. Additionally, an optimal control strategy for vaccination is proposed, proving its existence and uniqueness, with simulations showing that the strategy effectively minimizes infection rates and associated costs. The impact of integrating public education into the model is also explored, emphasizing its critical role in enhancing vaccination coverage and reducing overall transmission.

Strong local asymptotic stability enhances global stability techniques

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Schedule: December 16 17:00-17:30 Capital Suite 6

Ziyad AlSharawi
American University of Sharjah and Universidad Politecnica de Cartagena
United Arab Emirates

Co-Author(s): Ziyad AlSharawi, Jose Canovas and Sadok Kallel

Abstract:
In this talk, we consider the scalar difference equation $x_{n+1} = F_0(x_n, \dots, x_{n-k+1})$ in which F_0 is sufficiently differentiable and has a fixed point $\bar{x}$. When $F_0(x_{n-1}, \dots, x_{n-k})$ replaces x_n, we obtain a new system with higher delay, namely

$$y_{n+1} = F_1(y_{n-1}, \dots, y_{n-k}) = F_0(F_0(y_{n-1}, \dots, y_{n-k}), y_{n-1}, \dots, y_{n-k+1}).$$

The authors define the expansion strategy as successively repeating the above process, i.e., repeating the process j-times gives the system

$$u_{n+1} = F_j(u_{n-j}, u_{n-j-1}, \dots, u_{n-j-k+1}).$$

The fixed point $\bar{x}$ of F_0 is a fixed point of F_j for all j. In this talk, we discuss the relationship between the local stability of F_0 and F_j at $\bar{x}$. In particular, $\bar{x}$ is locally asymptotically stable (LAS) under F_0, if and only if $\|\nabla F_j\|_1

Enveloping in difference equations of order greater than one

Schedule: December 16 17:30-18:00 Capital Suite 6

Jose S Canovas
Department of Applied Mathematics and Statistics, Technical University of Cartagena
Spain

Co-Author(s): Ziyad AlSharawi

Abstract:
In this talk, we consider the scalar difference equation $x_{n+1} = f(x_n, x_{n-1})$ in which f is sufficiently differentiable and has a fixed point x_0. We say that x_0 is strongly locally stable (SLAS for short) whenever the sum of the absolute values of $f_x(x_0, x_0)$ and $f_y(x_0, x_0)$ is smaller than 1. We show the advantages of the SLAS on developing the notion of dominance condition as introduced in [1] and the similar enveloping notion for one-dimensional difference equations given in [2]. We give some geometric results that make finding an enveloping one-dimensional map more practical, which makes proving global stability a manageable task. When the map f is of mixed monotonicity, we establish the connection between the enveloping and the embedding techniques. In particular, we prove that embedding is enough to give the existence of an enveloping function and provide ideas for finding enveloping functions. Some interesting questions will be posed. References. [1] H. A. El-Morshedy and V. Jimenez Lopez. Global attractors for difference equations dominated by one-dimensional maps. J. Difference Equ. Appl., 14(4):391-410, 2008 [2] Paul Cull. Enveloping implies global stability. In Difference equations and discrete dynamical systems, pages 71-85. World Sci. Publ., Hackensack, NJ, 2005. [3] Ziyad AlSharawi, Jose S. Canovas. Integrating the expansion strategy with the enveloping technique to establish stability 2024.

The simplest neural network does solve the simplest classification problem

Schedule: December 16 18:00-18:30 Capital Suite 6

Victor Jimenez Lopez
Universidad de Murcia
Spain

Co-Author(s): V\`{\i}ctor Jim\`{e}nez L\`{o}pez (coauthor: Jes\`{u}s Molina Rodr\`{\i}guez de Vera)

Abstract:
A single-layer neural network, usually referred to as a \emph{perceptron}, is the most elementary of all machine learning tools to deal with the \emph{classificacion problem}. Roughly speaking, if disjoint finite sets $A, B \subset \mathbb{R}^h$ are given, we look for a (computationally efficient) way to distinguish points $\mathbf{x} = (x_1, \ldots, x_h)$ from A and B. More precisely, we look for a \emph{weight vector} $\mathbf{w} = (w_1, \ldots, w_h)$ and a \emph{bias} b so that, when applying the \emph{sigmoid activation function} $\sigma(z) = 1/(1 + e^{-z})$ to the scalar product of $\overline{\mathbf{x}} = (1, \mathbf{x})$ and $\mathbf{u} = (b, \mathbf{w})$, the resultant function $Z(\mathbf{x}) = Z(\mathbf{x}, \mathbf{u}) = \sigma(\overline{\mathbf{x}} \cdot \mathbf{u})$ takes values close to 1 (respectively, to 0) when $\mathbf{x} \in A$ (respectively, $\mathbf{x} \in B$). To do this, and after rewriting $A \cup B = \{\mathbf{x}_k\}_{k=1}^m$, the natural way is to minimize the \emph{squared error function} $E(\mathbf{u}) = \sum_{k=1}^m (Z(\overline{\mathbf{x}_k}, \mathbf{u}) - y_k)^2$, where $y_k = 1 - \epsilon$ or $y_k = \epsilon$ according to, respectively, $\mathbf{x}_k \in A$ or $\mathbf{x}_k \in B$, and ϵ is a fixed small positive number (the natural choice $\epsilon = 0$ must be avoided for technical reasons; typically, $\epsilon = 0.1$ is used). Hopefully, the error function will have exactly one minimum $\mathbf{u}^* = (b^*, \mathbf{w}^*)$ having the prescribed properties. Moreover, it should be found by using the \emph{gradient descent algorithm} with a \emph{learning rate} $\alpha > 0$ sufficiently small. In dynamical systems terms, this means that $\mathbf{u}_{n+1} = \mathbf{f}(\mathbf{u}_n)$ given by $\mathbf{f}(\mathbf{u}) = \mathbf{u} - \alpha \nabla E(\mathbf{u})$ has $\mathbf{u}^*$ as a stable global attractor. While it is very well-known that this dream scenario needs not hold (thus the need to resort to multilayer networks), there are no examples in the literature, to the best of our knowledge, where global convergence of a perceptron, in the previous sense, has been rigorously proved. In the present work we succeed in doing so in the simplest of all cases: when $A = \{1\}, B = \{0\}$.

Special Session 67 : Fractional Differential Equations: Theory, Methods and Applications

Introduction: The aim of the session is to gather experts and researchers at their debut working on the theory, the analysis and the applications of time/space fractional differential equations.

Stability analysis of of Fractional Reaction Diffusion Systems

Schedule: December 17 9:00-9:30 Capital Suite 21 C

Sofwah Ahmad
Khalifa University
United Arab Emirates

Co-Author(s): Szymon Cygan and Grzegorz Karch

Abstract:
In the talk, results on the stability of solutions to general evolution equations with the Caputo fractional-in-time derivatives will be presented. Our results can be applied, for example, either to systems of fractional differential equations or to general reaction-diffusion systems on bounded domains with Neumann boundary conditions. In particular, we provide an extended analysis of the so-called linearization principle (i.e. when the linear stability/instability implies the non-linear stability/instability). These results have important biological implications including Turing instability criteria.

Applications of FDE to Real-World Problems

Schedule: December 17 8:00-8:30 Capital Suite 21 C

Ricardo Almeida
University of Aveiro
Portugal

Abstract:
This talk is devoted to the study of nonlinear fractional differential equations involving Caputo-type fractional derivatives with respect to another function. We establish existence and uniqueness results for these equations using some standard fixed point theorems. Furthermore, we present several applications of these results, specifically in optimal control theory, population growth models, and epidemiological models.

ON A NEW FORMULATION OF THE INVERSE PROBLEM OF DETERMINING THE ORDER OF FRACTIONAL DERIVATIVES IN PARTIAL DERIVATIVE EQUATIONS

Schedule: December 17 14:45-15:15 Capital Suite 21 C

Ravshan R. Ashurov
Institute of Mathematics, Academy of Scienses of Uzbekistan
Uzbekistan

Co-Author(s): Ravshan Ashurov

Abstract:
The inverse problem of determining the unknown order of a fractional derivative in differential equations has been actively studied by many specialists. A number of interesting results have been obtained that have a certain applied significance. By now, the authors have investigated various modifications of this inverse problem: determining the order of the derivative or, along with the unknown order, determining some other unknown parameter or function included in the initial-boundary value problem under consideration. Analyzing the known results, we can conclude that in all these works, firstly, only the subdiffusion equation was considered and, secondly, the elliptic part of these equations has a discrete spectrum, and the authors were able to prove only the uniqueness of the solution to the inverse problem under consideration. This report will give a brief overview of the most interesting works in this area, and will propose a new formulation and methods for solving these inverse problems. It will be proved that in the new formulation the solutions of inverse problems are not only unique, but also exist. In this case, not only the subdiffusion equations will be considered, and the elliptic parts of the equation can also have a continuous spectrum.

A fractional Laplacian and its extension problem

Schedule: December 17 9:30-10:00 Capital Suite 21 C

Salem Ben Said
United Arab Emirates University
United Arab Emirates

Abstract:
In this paper, we establish four equivalent characterizations of the fraction Laplacian operator $(-\|x\|\Delta_k)^{\sigmaup}$ with $0

On the solvability of some inverse problems for a high-order nonlocal parabolic equation with multiple involution

Schedule: December 17 17:30-18:00 Capital Suite 21 C

Meiirkhan Borikhanov
Khoja Akhmet Yassawi International Kazakh--Turkish University
Kazakhstan

Co-Author(s): Batirkhan Turmetov

Abstract:
This work investigated the solvability of a some inverse issues for a high-order parabolic equations nonlocal analogue. Non local equivalent of the biharmonic operator has been developed for this purpose. Transformations of the involution type were used in the definition of this operator. The eigenfunctions and eigenvalues of the Dirichlet type problem for a nonlocal biharmonic operator have been studied in a parallelepiped. For this particular problem, the eigenvalues and eigenfunctions were explicitly constructed, and the proof of the system`s completeness was presented. We examined two different kinds of inverse problems that involved solving the equation and its right-hand side. Using the Fourier variable separation approach or reducing it to an integral equation, the two problems` right hand terms that depended on the spatial and temporal variables were found. The theorems for the existence and uniqueness of the solution were proved.

Blowing-up Solution of a System of Fractional Differential Equations with Variable Order

Schedule: December 17 15:45-16:15 Capital Suite 21 C

Muhammad R Fadillah
Khalifa University
United Arab Emirates

Co-Author(s): Mokhtar Kirane

Abstract:
We investigated the necessary condition for the following nonlinear system of fractional differential equations to have a blowing-up solution in finite time

$$u'(t) + D_{0|t}^{\alpha(t)}(u(t) - u_0) = |v(t)|^q, t > 0, q > 1,$$

and

$$v'(t) + D_{0|t}^{\beta(t)}(v(t) - v_0) = |u(t)|^p, t > 0, p > 1$$

where $u(0) = u_0 > 0, v(0) = v_0 > 0, \alpha, \beta \in C^1[0, +\infty)$ such that $0 < \alpha_m \leq \alpha(t) \leq \alpha_M < 1$ and $0 < \beta_m \leq \beta(t) \leq \beta_M < 1$ and $D_{0|t}^{\rho(t)}$ is Riemann-Liouville derivative of order $\rho(t)$. Our method was to use a suitable test function in the weak functions.

Blow-up and lifespan estimate of the solution of the wave equation with critical damping

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Schedule: December 17 13:30-14:00 Capital Suite 21 C

Mohamed Ali Hamza
Imam Abdulrahman Bin Faisal University
Saudi Arabia

Abstract:
In this talk we discuss the wave equation in the critical damping case. In the first part, we study the influence of the damping term in the global dynamics of the solution in the case of time derivative nonlinearity, under the assumption of small initial data. The second part will be devoted for the same problem in the case whith combined nonlinearities.

Positivity properties of discrete time-fractional operators on uniform and nonuniform meshes

---

Schedule: December 17 17:00-17:30 Capital Suite 21 C

Samir Karaa
Sultan Qaboos University
Oman

Co-Author(s): Samir Karaa

Abstract:
The positive definiteness of discrete convolution kernels plays an important role in the stability analysis of time-stepping schemes for nonlocal models. Specifically, when these kernels are generated by convex sequences, their positivity can be verified by applying a classical result due to Zygmund. This talk has two main focuses. First, we improve Zygmund`s result and extend its validity to sequences that are almost convex. Next, we establish a more general inequality applicable to sequences that are nearly convex. Secondly, we consider convolution kernels on nonuniform grids and generalize the previous bounds. Our results are then applied to demonstrate the positivity properties of commonly used approximations for fractional integral and differential operators.

Optimality conditions for control problems involving generalized fractional derivatives

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Schedule: December 17 13:00-13:30 Capital Suite 21 C

Natalia Martins
University of Aveiro
Portugal

Co-Author(s): Fatima Cruz and Ricardo Almeida

Abstract:
In this talk, we extend fractional optimal control theory by proving a version of Pontryagin`s Maximum Principle and establishing a sufficient optimality condition for an optimal control problem. The dynamical system constraint in this problem is governed by a generalized form of a fractional derivative: the left-sided Caputo distributed-order fractional derivative with an arbitrary kernel. This approach provides a more versatile representation of dynamic processes, accommodating a broader range of memory effects and hereditary properties inherent in diverse physical, biological, and engineering systems.

Inverse boundary value problem with integral condition for a hyperbolic equation of fractional order

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Schedule: December 17 12:30-13:00 Capital Suite 21 C

Makhmud A. Sadybekov
Institute of Mathematics and Mathematical Modeling
Kazakhstan

Co-Author(s): Danabekova Moldir and Sairam Nurgul

Abstract:
In this report we consider initial-boundary value problems for a hyperbolic equation (with a fractional time Caputo derivative):

$$D_{0t}^{\alpha}u(x,t) - u_{xx}(x,t) + q(x)u(x,t) = f(x,t),\ 10.$$

In the case when the boundary conditions are strongly regular, the system of root vectors of this spectral problem forms a Riesz basis in $L_2(0,1)$. The Fourier method can be implemented to solve the original problem. However, when the boundary conditions are non strongly regular, the system of root vectors of the spectral problem may not form an unconditional basis, preventing the use of the Fourier method. These are the types of problems that will be presented in this report.

Inverse coefficient problems for fractional heat equations

Schedule: December 17 8:30-9:00 Capital Suite 21 C

Durvudkhan Suragan
Nazarbayev University
Kazakhstan

Co-Author(s): Gulaiym Oralsyn

Abstract:
In this talk, we discuss inverse problems related to determining the time-dependent coefficient and unknown source function of fractional heat equations. Our approach shows that having just one set of data at an observation point ensures the existence of a weak solution for the inverse problem. Furthermore, if there is an additional datum at the observation point, it leads to a specific formula for the time-dependent source coefficient. Moreover, we investigate inverse problems involving non-local data and recovering the space-dependent source function of the fractional heat equation. We also discuss extensions of these results to time and space fractional heat equations. The talk is based on our recent results.

Nonexistence of global solutions for an inhomogeneous semiliniar heat equation

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Schedule: December 17 18:00-18:30 Capital Suite 21 C

Nurdaulet Tobakhanov
Nazarbayev University
Kazakhstan

Co-Author(s): -

Abstract:
This report is devoted to the nonexistence of global weak solutions to the inhomogeneous semilinear heat equations with forcing terms on exterior domains. We investigate the critical behavior of solutions to the semilinear biharmonic heat equation ($|u|^p$ and $I_{0+}^{\gamma}(|u|^p)$) with forcing term $f(x)$. By employing a method of test function, we derive blow-up results for the critical case in the sense of Fujita.

On the solvability of some inverse problems for a high-order nonlocal parabolic equation with multiple involution

Schedule: December 17 17:00-17:30 Capital Suite 21 C

Batirkhan Turmetov
Khoja Akhmet Yassawi International Kazakh-Turkish University
Kazakhstan

Co-Author(s): Borikhanov M

Abstract:
This work investigated the solvability of a some inverse issues for a high-order parabolic equations nonlocal analogue. Non local equivalent of the biharmonic operator has been developed for this purpose. Transformations of the involution type were used in the definition of this operator. The eigenfunctions and eigenvalues of the Dirichlet type problem for a nonlocal biharmonic operator have been studied in a parallelepiped. For this particular problem, the eigenvalues and eigenfunctions were explicitly constructed, and the proof of the system`s completeness was presented. We examined two different kinds of inverse problems that involved solving the equation and its right-hand side. Using the Fourier variable separation approach or reducing it to an integral equation, the two problems` right hand terms that depended on the spatial and temporal variables were found. The theorems for the existence and uniqueness of the solution were proved.

Determination of the flux terms in a time fractional viscoelastic equation

Schedule: December 17 15:15-15:45 Capital Suite 21 C

Suleyman Ulusoy
American University of Ras Al Khaimah
United Arab Emirates

Co-Author(s): Mohamed BenSalah, Salih Tatar, Masahiro Yamamoto

Abstract:
We will introduce our results for the flux identification problem for a nonlinear time-fractional viscoelastic equation with a general source function based on the boundary measurements. We prove that the direct problem is well-posed, i.e., the solution exists, unique and depends continuously on the heat flux. Then the Frechet differentiability of the cost functional is proved. The Conjugate Gradient Algorithm, based on the gradient formula for the cost functional, is proposed for numerical solution of the inverse flux problem. The numerical examples, both with noise-free and noisy data, provide a clear demonstration of the applicability and accuracy of the proposed method. If time permits, we will discuss further directions and ongoing investigations.

Special Session 68 : Recent advances on interfaces dynamics modeling, simulation and applications

Introduction: The dynamics of interfaces, involving phenomena such as deformation and reactions, are pivotal in various fields, from biological processes like cell aggregation to industrial applications like water-proof materials. However, modeling and simulating interface dynamics pose challenges due to the evolution of multiphase-flow and multiphysics fields. Recent advancements leverage machine learning, particularly Neural networks, to efficiently tackle the complexities of nonlinear coupled systems. This symposium aims to unite researchers engaged in modeling, theory, and numerical approaches to interface problems. It provides a platform to exchange the latest advancements in the field and fosters opportunities for collaborative endeavors.

Coupled Capillary-Perivascular Flow and Mass Transport: Modeling and Computation

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Schedule: December 20 14:30-15:00 Capital Suite 21 B

Xuelian Bao
South China University of Technology
Peoples Rep of China

Abstract:
In this talk, we will present a coupled model for the Capillary-Perivascular Flow and Mass Transport of oxygen.

Numerical Studies for Multicomponent Vesicles

Schedule: December 20 16:45-17:15 Capital Suite 21 B

Zhenlin Guo
Beijing Computational Science Research Center
Peoples Rep of China

Co-Author(s): Shuqi Tang, John Lowengrub

Abstract:
In this presentation, we will introduce a thermodynamically consistent phase field model for multi-component vesicles in fluids. Our model encompasses dual two-phase fluid systems: one to depict the interaction dynamics between the vesicle and its ambient fluid, and the other to capture the dynamics of the multi-component on the vesicle membrane. These two systems are coupled within a diffuse domain framework, which provides a high-accuracy approach for solving partial differential equations on complex surfaces. We will illustrate a series of numerical examples showcasing classical scenarios encountered in multicomponent vesicles, including phase separation, tank treading, and phase treading. Additionally, we will validate the accuracy of our model by comparing these simulations with experimental observations.

Interfaced neural networks for solving (parametric) interface PDE problems

Schedule: December 20 9:00-9:30 Capital Suite 21 B

Benzhuo Lu
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Sidi Wu, Aiqing Zhu, Yifa Tang

Abstract:
Machine learning is used as an accessible meshless approach for solving PDEs. For interface problem, the computational domain can be decomposed into several subdomains, and the solution on each subdomain can be accordingly represented by one network. In this talk, we will present, 1) a Physics-Informed Neural Network, interfaced neural network (INN) to solve interface problems with discontinuous coefficients as well as irregular interfaces, 2) an interfaced operator network (IONet) to solve parametric elliptic interface PDEs, where different coefficients, source terms, and boundary conditions are considered as input features. The convergence of the INN will be discussed as well.

A phase field description of droplet dynamics with ion transport

Schedule: December 20 17:15-17:45 Capital Suite 21 B

Yuzhe Qin
Shanxi University
Peoples Rep of China

Co-Author(s): Hoaxing Huang, Zilong Song, Shixin Xu

Abstract:
We present a phase field model to describe the charged droplets suspended in a viscous fluid with ion transport across the membrane. Our model incorporates spatial variations in electric permittivity and diffusion constants, as well as interfacial capacitance. An ion pump is added to describe the ion active transport to maintain the ion difference between the inner and outer regions. We perform a detailed asymptotic analysis to demonstrate the convergence of the diffusive interface model to the sharp interface model as the interface thickness approaches zero. A series of numerical experiments are conducted to validate the asymptotic analysis and demonstrate the model`s effectiveness. Our numerical results show the pump with phase field method is effective in maintaining the ion difference across the interface. Besides, the motions of multiple droplets have been investigated in the numerical tests. The numerical solutions confirm our model is a reasonable model and easy to develop a series of models to consider the interface problems.

Convergent finite element approximations of surface evolution with relaxed minimal deformation

Schedule: December 20 15:30-16:00 Capital Suite 21 B

Rong Tang
The Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Guangwei Gao, Buyang Li

Abstract:
The finite element approximation of surface evolution under an external velocity field is studied. An artificial tangential motion is designed by using harmonic map heat flow from the initial surface onto the evolving surface. This makes the evolving surface have minimal deformation (up to certain relaxation) from the initial surface and therefore improves the mesh quality upon discretization. By exploiting and utilizing an intrinsic cancellation structure in this formulation and the role played by the relaxation term, convergence of the proposed method in approximating surface evolution in the three-dimensional space is proved for finite elements of degree $k \geq 4$. One advantage of the proposed method is that it allows us to prove convergence of numerical approximations by using the normal vector of the computed surface in the numerical scheme, instead of evolution equations of normal vector (as in the literature). Another advantage of the proposed method is that it leads to better mesh quality in some typical examples, and therefore prevents mesh distortion and breakdown of computation. Numerical examples are presented to illustrate the convergence of the proposed method and its advantages in improving the mesh quality of the computed surfaces.

An efficient unconditional energy stable scheme for multiphase flow simulations

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Schedule: December 20 8:00-8:30 Capital Suite 21 B

Xiaoping Wang
The Chinese University of Hong Kong (Shenzhen) and the Shenzhen International Center for Industrial and Applied Mathematics
Peoples Rep of China

Abstract:
We design an efficient and unconditionally energy stable method for simulating the dynamics of the multi-phase flow based on the the Cahn-Hilliard-Navier-Stokes phase field model with variable density and viscosity. An improved SAV type scheme is developed. We introduce some nonlocal auxiliary variables and associated ordinary differential equations to decouple the nonlinear terms. The resulting scheme is completely decoupled and unconditionally energy stable. The accuracy and stability of the algorithm are verified by numerical simulation.

The Onsager variational principle and physics preserving numerical schemes

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Schedule: December 20 14:00-14:30 Capital Suite 21 B

Xianmin XU
Chinese Academy of Sciences
Peoples Rep of China

Abstract:
The Onsager variational principle is a fundamental law for irreversible processes in non-equilibrium statistical physics. It has been used to model many complicated phenomena in soft matter. By using the Onsager principle, one can formulate partial differential equation for diverse gradient flow systems. In this talk, we will show it also acts as a natural framework for constructing energy-stable time discretization schemes. It provides a robust basis for developing numerical schemes that uphold crucial physical properties. Within this framework, several widely used schemes emerge naturally, showing its versatility and applicability.

A Cartesian grid method for nonhomogeneous elliptic interface problems on unbounded domains

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Schedule: December 20 8:30-9:00 Capital Suite 21 B

Wenjun Ying
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Wenjun Ying

Abstract:
We will present a Cartesian grid based fast and accurate method for indirectly evaluating boundary and volume integrals in a boundary-volume integral approach for nonhomogeneous elliptic interface problems on unbounded domains. The indirect calculation is done by solving equivalent but simple interface problems. We accelerate the computation by introducing an intermediate, transitional circle or sphere and taking advantages of super-convergent numerical quadrature or series expansion on circles/spheres. We first map the boundary or volume integral on the irregular boundary or domain to the intermediate circle/sphere; then evaluate the boundary integral on the intermediate circle/sphere to get boundary conditions for the simple interface problem. We will also show numerical results of examples in both two and three space dimensions.

Simulation of wetting/dewetting process on a permeable and inextensible elastic sheet

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Schedule: December 20 15:00-15:30 Capital Suite 21 B

Zhen Zhang
Southern University of Science and Technology
Peoples Rep of China

Co-Author(s): Weidong Shi, Weiqing Ren, Xiaoping Wang, Zhen Zhang

Abstract:
In this work, we derive a two-dimension continuum model for wetting/dewetting on a thin, permeable and inextensible elastic sheet in a thermodynamically consistent framework. The derived model satisfies an energy dissipation law. We present an Eulerian weak formulation for the former and an arbitrary Langrangian-Eulerian weak formulation for the latter. The two weak formulations are discretized by finite element method on the moving mesh. Numerical experiments show the convergence and effectiveness of the numerical method.

Thermodynamically consistent hydrodynamic phase-field computational modeling for fluid-structure interaction with moving contact lines

Schedule: December 20 16:15-16:45 Capital Suite 21 B

Jia Zhao
Binghamton University
USA

Abstract:
In this talk, I will present a novel computational modeling approach for investigating fluid structure interactions with moving contact lines. By applying the generalized Onsager principle, we develop a coupled hydrodynamics and phase-field system in a thermodynamically consistent manner. The resulting partial differential equation (PDE) model consists of the Navier Stokes equations and a nonlinear Allen Cahn type equation, with volume conservation enforced through an additional penalty term. We propose a fully discrete, structure preserving numerical scheme that combines several techniques to solve this coupled PDE system effectively and accurately. Finally, various numerical simulations will be shown to verify the model`s capabilities and demonstrate the scheme`s effectiveness, accuracy, and stability.

Special Session 69 : New developments in symplectic dynamics

Introduction: This special session aims to gather experts on symplectic dynamics in a leisurely ambiance to actively present recent advances, exchange stimulating ideas, explore novel research directions, and more importantly, initiate collaborations closely. Symplectic dynamics has been studied ever since the birth of modern symplectic geometry in the early 1980s, well-known for many surprising rigidity phenomena in Hamiltonian dynamics. Besides, past decades have seen a significant improvement in our understanding of symplectic dynamics, especially at the crossroads of various fast-developing subjects including the Reeb dynamics in contact geometry, C^0-symplectic geometry, closed geodesics in Finsler geometry, and diffeomorphism groups in low dimension. Moreover, with the advent of strong machinery such as barcode theory, symplectic field theory, index theory, and feral curves theory, applied to explore more sophisticated dynamical properties, symplectic dynamics has become one of the most active research areas in symplectic and contact geometry. If the schedule permits, we will end this session with an open discussion.

On the minimal number of closed geodesics on positively-curved spheres

Schedule: December 19 8:30-9:00 Conference Hall B (A)

Huagui Duan
Nankai University
Peoples Rep of China

Abstract:
In this talk, we will introduce the problem about the optimal number of closed geodesics on spheres. Recently it has been proved that for every Finsler metric on certain positively-curved spheres of dimension n, there exist at least n prime closed geodesics, which solved a conjecture of Katok and Anosov for such spheres when n is even, which is a joint work with Dong Xie.

Symplectic packing stability

Schedule: December 19 14:00-14:30 Conference Hall B (A)

Oliver Edtmair
ETH Zurich
Austria

Abstract:
Biran proved that the full volume of a rational closed symplectic 4-manifold can be symplectically packed by any sufficiently large number of equally sized balls, a phenomenon known as packing stability. In my talk, I will explain how to extend this result to arbitrary compact symplectic 4-manifolds with smooth boundary. This is in contrast to a recent result of Cristofaro-Gardiner and Hind concerning the failure of packing stability in the case of non-smooth boundary. I will also explain how packing stability relates to the subleading asymptotics in the Weyl laws for ECH and PFH spectral invariants and to the simplicity/non-simplicity of groups of Hamiltonian diffeomorphisms/homeomorphisms.

Degenerate Arnol`d conjectures, Hamiltonian periodic orbits and Lagrangian intersections

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Schedule: December 19 17:30-18:00 Conference Hall B (A)

Wenmin Gong
Beijing Normal University
Peoples Rep of China

Abstract:
Symplectic geometry has some wide open problems concerning Hamiltonian periodic orbits and Lagrangian submanifolds. Among them, Arnold`s conjectures are of central importance. In this talk, I will survey some important solved and unsolved problems about the degenerate homological Arnold conjecture.

The shape invariant of toric domains

Schedule: December 19 14:30-15:00 Conference Hall B (A)

Richard Hind
University of Notre Dame
USA

Abstract:
We define a shape invariant, a sort of set valued symplectic capacity, for domains in $\mathbb{R}^4$. The shape of a domain X captures the Hamiltonian isotopy classes, in $\mathbb{R}^4$, of embedded Lagrangian tori in X. Then we describe computations for a class of toric X, showing that the moment image and the shape coincide in certain regions. Hence we have rigidity for many symplectic embedding problems. This reports on joint work with Ely Kerman and Jun Zhang.

Rabinowitz Floer homology for prequantization bundles

Schedule: December 19 15:45-16:15 Conference Hall B (A)

Jungsoo Kang
Seoul National University
Korea

Abstract:
Prequantization bundles are circle bundles over integral symplectic manifolds and come with canonical contact structures. In this talk, I will explain the construction of a Floer Gysin exact sequence for prequantization bundles using Rabinowitz Floer homology. Some applications will also be discussed. This is a joint work with Joonghyun Bae and Sungho Kim.

Lagrangian link quasimorphisms and the non-simplicity of Hameomorphism group of surfaces

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Schedule: December 19 15:15-15:45 Conference Hall B (A)

Cheuk Yu Mak
University of Sheffield
England

Co-Author(s): Daniel Cristofaro-Gardiner, Vincent Humiliere, Sobhan Seyfaddini, Ivan Smith and Ibrahim Trifa

Abstract:
In this talk, we will explain the construction of a sequence of homogeneous quasi-morphisms of the area-preserving homeomorphism group of the sphere using Lagrangian Floer theory for links. This sequence of quasi-morphisms has asymptotically vanishing defects, so it is asymptotically a homomorphism. It enables us to show that the Hameomorphism group is not the smallest normal subgroup of the area-preserving homeomorphism group. If time permits, we will explain how to generalize it to all positive genus surfaces even though we no longer have quasi-morphisms. The case of the sphere is joint work with Daniel Cristofaro-Gardiner, Vincent Humiliere, Sobhan Seyfaddini, and Ivan Smith. The case of positive genus surfaces is joint work with Ibrahim Trifa.

Barcode entropy of Lagrangian submanifolds

Schedule: December 19 16:15-16:45 Conference Hall B (A)

Matthias Meiwes
Tel Aviv University
Israel

Abstract:
Recently, some fruitful approaches were found to express complexity of Hamiltonian or Reeb dynamics in terms of Floer theory or contact homology. One goes back to Alves and Pirnapasov, where the growth of essential homotopy classes of orbits in a complement of a link of periodic orbits in 3-dimensional flows is studied, another is due to Cineli, Ginzburg, and Gurel, through the study of barcode entropy. In my talk, I will explain some recent results on estimates of the barcode entropy of Hamiltonian diffeomorphisms relative to pairs of Lagrangian submanifolds, and discuss connections to other properties of the dynamics. Some of the results reveal moreover some interesting connections between the two approaches to complexity mentioned above.

Symplectic Dynamics and the Spatial Isosceles Three-Body Problem

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Schedule: December 19 16:45-17:15 Conference Hall B (A)

Pedro A Salomao
SUSTech
Peoples Rep of China

Co-Author(s): Xijun Hu (Shandong University), Lei Liu (Shandong University), Ywei Ou (Shandong University), Guowei Yu (Nankai University)

Abstract:
In this talk, I will discuss tools from Symplectic Dynamics that can be used to answer some questions in the spatial isosceles three-body problem. The main results are related to periodic orbits, global surfaces of section, and, more generally, transverse foliations. We focus on the dynamics of energy surfaces and explain how those objects change as the energy increases.

Symplectic classification of compact almost-toric systems of dimension four

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Schedule: December 19 18:00-18:30 Conference Hall B (A)

Xiudi Tang
Beijing Institute of Technology
Peoples Rep of China

Abstract:
Almost-toric systems are important in mirror symmetry. We give a classification of 4-dimensional compact almost-toric systems up to fiber-preserving symplecctomorphisms. This generalizes the classification by Pelayo--V\~u Ng\d{o}c on simple semitoric systems and that by the speaker together with Pelayo and Palmer on semitoric systems, both in dimension four. The extra difficulty for almost-toric systems is the lack of a global circle action. The polygon invariant is replaced by an almost-toric closed disk, and we give appropriate notions of focus-focus label and twisting indices in the almost-toric case.

Dynamics of composite symplectic Dehn twists

Schedule: December 19 13:00-13:30 Conference Hall B (A)

Jinxin Xue
Tsinghua University
Peoples Rep of China

Co-Author(s): Wenmin Gong, Zhijing Wang

Abstract:
We show that composite symplectic Dehn twists have certain form of nonuniform hyperbolicity: it has positive topological entropy as well as two families of local stable and unstable Lagrangian manifolds, which are analogous to signatures of pseudo Anosov mapping classes. Moreover, we show that the rank of the Floer cohomology group of these compositions grows exponentially under iterations, which partially answers a question of Smith concerning the classification of symplectic mapping class group in higher dimensions. Finally, we propose a conjecture on the positive metric entropy of our model and point out its relationship with the standard map.

Givental`s non-linear Maslov index via Floer cones

Schedule: December 19 8:00-8:30 Conference Hall B (A)

Jun ZHANG
University of Science and Technology of China
Peoples Rep of China

Co-Author(s): Dylan Cant, Eric Kilgore, Igor Uljarevi\`{c}

Abstract:
In this talk, we will present how to apply a recently developed Floer theory on a fillable contact manifold, called the contact Hamiltonian Floer homology, to generate a homological machinery that replaces the classical Givental non-linear Maslov indices. As a key step, we will emphasize the role of the homological mapping cone from this Floer theory (called a Floer cone) and its fundamental role in reflecting local data of periodic orbits. As an application, the multiplicity of translated points, serving as a natural generalization of fixed points in contact Hamiltonian dynamics, will be deduced. This talk is based on joint work with Dylan Cant, Eric Kilgore, and Igor Uljarevic.

Symplectic camel herd

Schedule: December 19 13:30-14:00 Conference Hall B (A)

Zhengyi Zhou
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Weiwei Wu

Abstract:
I will explain the analog of the symplectic camel theorem with a coisotropic needle, i.e. non-triviality of certain higher loops of ball embeddings into an exotic symplectic R^{2n}. Joint work with Weiwei Wu.

Special Session 71 : Pure and Applied Analysis, Local and Nonlocal

Introduction: Local and nonlocal analysis has developed into a huge field within pure and applied mathematics. The goal of this section is to bring together experts and junior participants from pure and applied aspects of PDE in the realm of local and nonlocal analysis.

Harmonic functions are Lipschitz continuous

Schedule: December 18 15:45-16:15 Capital Suite 11 A

Karthik Adimurthi
TIFR-CAM
India

Co-Author(s): Karthik Adimurthi

Abstract:
In this talk, we discuss some old ideas from DeGiorgi-Nash-Moser theory and Piccinini-Spagnolo. Subsequently, we propose a possible strategy to extend the result of Piccinini-Spagnolo to higher dimensions and prove this idea for harmonic functions.

A global Calderon-Zygmund theory for nonlocal elliptic equations

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Schedule: December 18 18:00-18:30 Capital Suite 11 A

Sun-Sig Byun
Seoul National University
Korea

Co-Author(s): Sun-Sig Byun

Abstract:
In this talk a global Calderon-Zygmund theory is discussed, focusing particularly on a nonlocal elliptic equation with discontinuous coefficients on a bounded domain.

Pasting embeddings of pieces

Schedule: December 18 17:30-18:00 Capital Suite 11 A

Florin Catrina
St. John`s University
USA

Co-Author(s): S. Ostrovska, M. Ostrovskii

Abstract:
One of the local-global themes in the theory of metric embeddings is: suppose that all bounded subsets of an unbounded metric space A admit bilipschitz embeddings into a Banach space X with uniformly bounded distortions. Does the whole metric space A admit a bilipschitz embedding into X? In some cases, we answer this question positively by using smooth transitions between the parts` embeddings; the construction is based on logarithmic spirals.

Asymptotic behaviour of three fractional spaces

Schedule: December 18 14:00-14:30 Capital Suite 11 A

Ahmed Dughayshim
University of Pittsburgh
USA

Abstract:
We obtain asymptotically sharp identification of fractional Sobolev spaces $W^s_{p,q}$, extension spaces $E^s_{p,q}$, and Triebel-Lizorkin spaces $\dot{F}^s_{p,q}$. In particular we obtain for $W^s_{p,q}$ and $E^s_{p,q}$ a stability theory a la Bourgain-Brezis-Mironescu as $s \to 1$, answering a question raised by Brazke--Schikorra--Yung. Part of the results are new even for $p = q$.

Fundamental theorem of submanifold theory and isometric immersions with supercritical low regularity

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Schedule: December 18 16:15-16:45 Capital Suite 11 A

Siran Li
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Xiangxiang Su

Abstract:
A fundamental result in global analysis and nonlinear elasticity asserts that given a solution $\mathfrak{S}$ to the Gauss--Codazzi--Ricci equations over a simply-connected closed manifold $(\mathcal{M}^n, g)$, one may find an isometric immersion ι of $(\mathcal{M}^n, g)$ into the Euclidean space $\mathbb{R}^{n+k}$ whose extrinsic geometry coincides with $\mathfrak{S}$. Here the dimension n and the codimension k are arbitrary. Abundant literature has been devoted to relaxing the regularity assumptions on $\mathfrak{S}$ and ι. The best result up to date is $\mathfrak{S} \in L^p$ and $\iota \in W^{2,p}$ for $p > n \geq 3$ or $p = n = 2$. In this paper, we extend the above result to $\iota \in \mathcal{X}$ whose topology is strictly weaker than $W^{2,n}$ for $n \geq 3$. Indeed, $\mathcal{X}$ is the weak Morrey space $L^{p,n-p}_{2,w}$ with arbitrary $p \in]2, n]$. This appears to be first supercritical result in the literature on the existence of isometric immersions with low regularity, given the solubility of the Gauss--Codazzi--Ricci equations. Our proof essentially utilises the theory of Uhlenbeck gauges --- in particular, Rivi\`{e}re--Struwe`s work on harmonic maps in arbitrary dimensions and codimensions --- and compensated compactness.

Variational Analysis of a Parametrized Family of Transmission Problems Coupling Nonlocal and Fractional Models

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Schedule: December 18 17:00-17:30 Capital Suite 11 A

Tadele Mengesha
The University of Tennessee, Knoxville
USA

Abstract:
I will present a recent work on the analysis of a parameterized family of energies associated with transmission problems that effectively couple two distinct models across an interface. Specifically, we examine the coupling between a model based on the regional fractional Laplacian and another model employing a nonlocal operator with a position-dependent interaction kernel. Both operators are inherently nonlocal and act on functions defined within their respective domains. The coupling occurs via a transmission condition across a hypersurface interface. The heterogeneous interaction kernel of the nonlocal operator leads to an energy space endowed with a well-defined trace operator. This, combined with well-established trace results of fractional Sobolev spaces, facilitates the imposition of a transmission condition across an interface. The family of problems will be parametrized by two key parameters that measure nonlocality and differentiability. For each pair of parameters, we demonstrate existence of a solution to the resulting variational problems. Furthermore, we investigate the limiting behavior of these solutions as a function of the parameters.

Partial regularity in nonlocal systems

Schedule: December 18 14:45-15:15 Capital Suite 11 A

Simon Nowak
Bielefeld University
Germany

Co-Author(s): Cristiana De Filippis, Giuseppe Mingione

Abstract:
The theory of partial regularity for elliptic systems replaces the classical De Giorgi-Nash-Moser theory for scalar equations, asserting that solutions are regular outside of an in general non-empty negligible closed subset called the singular set. The local theory was initiated by Giusti \& Miranda and Morrey, in turn relying on De Giorgi`s seminal ideas in the context of minimal surfaces. I will present several extensions of the classical local partial regularity theory to nonlinear integro-differential systems along with some general tools for proving ε-regularity theorems in nonlocal settings. This is joint work with Cristiana De Filippis and Giuseppe Mingione (Parma).

A weighted Schauder estimate for an irregular oblique derivative problem

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Schedule: December 18 12:30-13:00 Capital Suite 11 A

Michiaki Onodera
Tokyo Institute of Technology
Japan

Co-Author(s): Toru Kan, Rolando Magnanini

Abstract:
I will talk about an elliptic regularity estimate for an oblique derivative boundary value problem, in which the directional derivative of solution along a vector field on the boundary is prescribed. It is known that the classical Schauder estimate is no longer valid if the vector field is tangential at a submanifold of the boundary. Our new Schauder-type estimate, in contrast to previously known subelliptic estimates, does not lose the derivatives, but it takes into account the regularity deficit as a weight in the estimate. In fact, this estimate is shown to be appropriate for an application to Backus` problem in geodesy. This talk is based on joint work with Toru Kan (Osaka Metropolitan University) and Rolando Magnanini (University of Florence).

Nonlocal boundary-value problems with local boundary conditions

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Schedule: December 18 13:00-13:30 Capital Suite 11 A

James Scott
Columbia University
USA

Co-Author(s): Qiang Du

Abstract:
We state and analyze nonlocal problems with classically-defined, local boundary conditions. The model takes its horizon parameter to be spatially dependent, vanishing near the boundary of the domain. We establish a Green`s identity for the nonlocal operator that recovers the classical boundary integral, which permits the use of variational techniques. Using this, we show the existence of weak solutions, as well as their variational convergence to classical counterparts as the horizon uniformly converges to zero. In certain circumstances, global regularity of solutions can be established, resulting in improved modes and rates of variational convergence. We also show that Galerkin discretization schemes for the nonlocal problems converge unconditionally with respect to the nonlocal parameter, i.e. that the schemes are asymptotically compatible.

Nonlocal Sublinear Elliptic Problems with Measure Coefficients and Data

Schedule: December 18 15:15-15:45 Capital Suite 11 A

Adisak Seesanea
Sirindhorn International Institute of Technology, Thammasat University
Thailand

Abstract:
We study elliptic equations of the form $(-\Delta)^{\frac{\alpha}{2}} u = f(x,u)$ in $\mathbb{R}^n$, where $(-\Delta)^{\frac{\alpha}{2}}$ denotes the fractional Laplacian in $\mathbb{R}^n$ for $0 < \alpha < n$ and $n \geq 2$. The nonlinearity $f(x,u) = \sum_{i=1}^{M} \sigma_i u^{q_i} + \omega$ includes sublinear growth terms, with $0 < q_i < 1$, the coefficients σ_i and the data ω are Radon measures on $\mathbb{R}^n$. We will present results on the existence, uniqueness, and pointwise estimates for some classes of solutions to these problems. This talk is based on joint work with Kentaro Hirata, Aye Chan May, Toe Toe Shwe, and Igor E. Verbitsky.

Improved moduli of continuity for degenerate phase transitions

Schedule: December 18 13:30-14:00 Capital Suite 11 A

José Miguel Urbano
King Abdullah University of Science and Technology (KAUST)
Saudi Arabia

Co-Author(s): Ugo Gianazza and Naian Liao

Abstract:
We substantially improve in two scenarios the current state-of-the-art modulus of continuity for weak solutions to the N-dimensional, two-phase Stefan problem featuring a $p-$degenerate diffusion: for $p = N \geq 3$, we sharpen it to

$$\boldsymbol{\omega}(r) \approx \exp(-c|\ln r|^{\frac{1}{N}});$$

for $p > \max\{2, N\}$, we derive an unexpected H\older modulus.

Special Session 72 : Nonlinear elliptic PDEs

Introduction: This group will focus on nonlinear equations and systems involving the weighted p-Laplacian operator, the fractional Laplacian and more general elliptic operators. It will highlight new developments on the existence and qualitative properties of solutions, such as symmetry, monotonicity, uniqueness, and regularity. The group will also discuss broad applications of these equations to various branches of Sciences, such as Physics, Chemistry, Biology, Probability, and Finance.

Positive Solutions to Singular Second Order BVPs on Time Scales

Schedule: December 18 12:30-13:00 Capital Suite 12 A

Shalmali Bandyopadhyay
The University of Tennessee at Martin
USA

Co-Author(s): Curtis Kunkel

Abstract:
We study singular second order BVPs with nonlinear boundary conditions on general time scales. We prove existence of a positive solution using sub and super solution methos, fixed point theory and perturbation methods used in approximating regular problems.

Normalized solutions of Sobolev critical Schrodinger equations in bounded domains

Schedule: December 18 14:45-15:15 Capital Suite 12 A

Xiaojun Chang
Northeast Normal University
Peoples Rep of China

Abstract:
In this talk, we will discuss the existence of normalized solutions for Sobolev critical Schr\odinger equations within general bounded domains. While recent studies have extensively explored normalized solutions in whole spaces, less is known about their existence in bounded domains. By integrating a recent abstract minimax principle, which incorporates Morse index information for constrained functionals, with novel blow-up analyses, we will demonstrate the existence of normalized solutions of the mountain pass type.

The Br\`ezis-Nirenberg problem for mixed local-nonlocal quasilinear operators

Schedule: December 19 8:00-8:30 Capital Suite 12 A

Alessio Fiscella
Universidade Estadual de Campinas
Brazil

Co-Author(s): Jo\~ao Vitor da Silva and Victor A. Blanco Viloria

Abstract:
In this talk, we present existence and multiplicity results, in the spirit of the celebrated paper by Br\`ezis and Nirenberg https://doi.org/10.1002/cpa.3160360405, for a perturbed critical problem driven by the sum of local classical p-Laplacian plus the nonlocal fractional p-Laplacian. More precisely, we face our problem in the case of superlinear perturbations. For this, we first retrace the historical path and we make comparisons with the local classical situation and with the nonlocal fractional situation. We conclude the talk presenting some interesting open questions. The results discussed in this talk are freshly published in https://doi.org/10.1016/j.jde.2024.07.028

Monotonicity trick in nonsmooth critical point theory and its application

Schedule: December 18 13:00-13:30 Capital Suite 12 A

Norihisa Ikoma
Keio University
Japan

Co-Author(s): Jaeyoung Byeon, Andrea Malchiodi, Luciano Mari

Abstract:
A motonicity trick due to Struwe and Jeanjean is a powerful tool for functionals of class C^1 when it is hard to check the Palais-Smale condition. However, some functionals corresponding to equations appearing in physics or geometry are not of class C^1. Szulkin extended the mountain pass and symmetric mountain pass theorem due to Ambrosetti and Rabinowitz into nonsmooth functionals. The aim of this talk is to provide an extension and an application of the monotonicity trick for nonsmooth functionals in a setting which is close to Szulkin`s setting. In particular, we consider Born-Infeld type equations and prove the existence of infinitely many solutions. This talk is based on joint work with Jaeyoung Byeon, Andrea Malchiodi and Luciano Mari.

Some recent results on nonlinear PDEs on lattice graphs

Schedule: December 18 15:15-15:45 Capital Suite 12 A

Chao Ji
East China University of Science and Technology
Peoples Rep of China

Abstract:
In this talk, we will introduce some recent results on nonlinear PDEs on lattice graphs. Specifically, we will explore the existence and multiplicity of solutions for the logarithmic Schrodinger equation on lattice graphs, and introduce the double phase problems on lattice graphs. We will also provide some differences between problems on graphs and continuous problems.

Critical planar Schrodinger-Poisson equations: existence, multiplicity and concentration

Schedule: December 19 9:00-9:30 Capital Suite 12 A

Yiqing Li
Shandong University of science and technology
Peoples Rep of China

Co-Author(s): Vicentiu D. Radulescu, Binlin Zhang

Abstract:
In this talk, we will consider the study of the 2-D Schr\{o}dinger-Poisson equation with critical exponential growth. By variational methods, we first prove the existence of ground state solutions for this Schr\{o}dinger-Poisson system with the periodic potential. Then we obtain that there exists a positive ground state solution of the Schr\{o}dinger-Poisson system concentrating at a global minimum of potential function in the semi-classical limit under some suitable conditions. Meanwhile, the exponential decay of this ground state solution is detected. Finally, we establish the multiplicity of positive solutions by using the Ljusternik-Schnirelmann theory.

Variational methods for scaled problems with applications to the Schrodinger-Poisson-Slater equation

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Schedule: December 18 13:30-14:00 Capital Suite 12 A

Kanishka Perera
Florida Institute of Technology
USA

Co-Author(s): Carlo Mercuri

Abstract:
We develop novel variational methods for solving scaled equations that do not have the mountain pass geometry, classical linking geometry based on linear subspaces, or $\mathbb{Z}_2$ symmetry, and therefore cannot be solved using classical variational arguments. Our contributions here include critical group estimates, nonlinear saddle point and linking geometries based on scaling, a scaling-based notion of local linking, and scaling-based multiplicity results for symmetric functionals. We develop these methods in an abstract setting involving scaled operators and scaled eigenvalue problems. Applications to subcritical and critical Schrodinger-Poisson-Slater equations are given.

One-dimensional boundary blow up problem with a nonlocal term

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Schedule: December 18 15:45-16:15 Capital Suite 12 A

Futoshi Takahashi
Osaka Metropolitan University
Japan

Co-Author(s): Taketo Inaba

Abstract:
In this talk, we study a nonlocal boundary blow up problem on an interval and obtain the precise asymptotic formula for solutions when the bifurcation parameter in the problem is large. This talk is based on a joint work with Taketo Inaba (Fujitsu Ltd.).

Structures and evolution of bifurcation diagrams of a p-Laplacian generalized logistic problem with constant yield harvesting

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Schedule: December 18 14:00-14:30 Capital Suite 12 A

Shin-Hwa Wang
National Tsing Hua University, TAIWAN
Taiwan

Co-Author(s): Kuo-Chih Hung and Jhih-Jyun Zeng

Abstract:
We study evolutionary bifurcation diagrams for a p-Laplacian generalized logistic problem where $p > 1$ and $\mu > 0$ is the harvesting parameter. We mainly prove that, for fixed $\mu > 0$, on the $(\lambda, \|u\|_\infty)$-plane, the bifurcation diagram always consists of a $\subset$-shaped curve and then we study the structures and evolution of bifurcation diagrams for varying $\mu > 0$. We give two interesting applications. It is a joint work with Kuo-Chih Hung and Jhih-Jyun Zeng.

Multi-bump solutions for the critical Choquard equation

Schedule: December 19 8:30-9:00 Capital Suite 12 A

Jiankang Xia
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Xu Zhang

Abstract:
In this talk, I will present our recent results in constructing multi-bump solutions for the critical Choquard equation. These solutions are obtained by combining the variational gluing method with a penalization technique. In contrast to the local Yamabe equation, we find that for all dimensions $N \geq 3$, there are infinitely many ℓ-bump ($\ell \geq 2$) positive solutions with polynomial decay. This occurs when the potential function displays periodicity in one variable and features a global maximum with a rapid decay rate in the vicinity of that maximum point. This talk is based on the joint work with Professor Xu Zhang from Central South University, China.

Towards Finding Multiple KKT Points: Part 1-Computing an Inequality/Equality Constrained Local Minimum Point

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Schedule: December 18 16:15-16:45 Capital Suite 12 A

Jianxin Zhou
Texas A&M University, College Station, TX, USA
USA

Co-Author(s): Suhan Zhong and Jianxin Zhou

Abstract:
The well-known Karush-Kuhn-Tucker (KKT) Theorem provides a set of necessary conditions for a local minimum point subject to finitely many inequality/equality constraints. This long term research project is to develop computational theory and methods for finding multiple KKT points in an infinite-dimensional space setting. In Part 1, an equivalent condition is established for a KKT point, from which a numerical method can be devised to compute a KKT point as a constrained local minimum point. This method is mathematically validated. Numerical examples will be presented to illustrate the algorithm. By an implementation strategy, a convergence result is established. It turns out that this equivalent condition opens a door for people to design numerical methods for computing multiple KKT points or solutions to some differential inclusion problems.

Special Session 73 : Nonlinear elliptic and parabolic equations and related functional inequalities

Introduction: This Special Session will be focused on recent advances in the analysis of qualitative properties of solutions to nonlinear elliptic and parabolic equations. Key topics include existence, non-existence, uniqueness, non-uniqueness and multiplicity of solutions, as well as asymptotic behavior, blow-up, singularity formation and bubbling phenomena. Special attention will be given to the use of critical and limiting inequalities as a fundamental tool to refine the understanding of nonlinear equations. Indeed, the analysis of these equations within the Calculus of Variations is profoundly related to the development of sharp inequalities describing subtle relations between functional spaces. We hope to encourage vital discussions between researchers from Real Analysis and PDEs, fostering collaborations and connections.

New solutions for the Lane-Emden problem in planar domains

Schedule: December 17 13:30-14:00 Capital Suite 1

Luca Battaglia
Universita degli Studi Roma Tre
Italy

Co-Author(s): Isabella Ianni, Angela Pistoia

Abstract:
We consider the Lane-Emden problem on a smooth bounded planar domain. We find nodal concentrating solutions, for large values of p, where both the positive and negative part blow up, the latter with a non-radial profile. Up to our knowledge, this is the first result concerning concentration with such a pattern for planar elliptic problems.

Nonlinearities and singularities

Schedule: December 16 17:00-17:30 Capital Suite 1

Marta Calanchi
Universit\`a degli Studi di Milano
Italy

Abstract:
We discuss some applications of singularity theory to nonlinear differential equations. In particular, we consider an elliptic equation with a nonlinearity which interacts with the k-th eigenvalue, and show that only fold and cusp singularities occur.

Fine bounds for best constants in subcritical Sobolev`s embeddings and applications

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Schedule: December 16 15:45-16:15 Capital Suite 1

Daniele Cassani
University of Insubria & RISM
Italy

Abstract:
We establish upper and lower estimates for the optimal embedding constants related to the classical Sobolev embeddings. In particular we derive fine bounds for best constants of the fractional subcritical Sobolev embeddings

$$W_0^{s,p}(\Omega) \hookrightarrow L^q(\Omega),$$

where $N \geq 1$, $0

Recent developments in the study of nonrelativistic limit of nonlinear Dirac equations

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Schedule: December 16 18:00-18:30 Capital Suite 1

Qi Guo
Renmin University of China
Peoples Rep of China

Co-Author(s): Pan Chen, Xiaojing Dong, Yanheng Ding, Huayang Wang, Yuanyang Yu

Abstract:
This talk presents a summary of recent findings on nonrelativistic limit of nonlinear Dirac equations. The discussion is divided into two main parts. Firstly, we discuss the ground states of nonlinear Dirac equations without constraints, focusing on the nonrelativistic limit of these ground states and the convergence behavior in cases with different potentials. Secondly, we delve into the nonrelativistic limit of normalized solutions of nonlinear Dirac equations. Specifically, we demonstrate that the first two components of the normalized ground states converge to the normalized ground states of the corresponding nonlinear Schr\odinger equations and the last two components converges to trivial states. This talk aims to provide an overview of the pertinent findings in this domain.

Relationship between maximizers of maximization problems and ground state solutions of semilinear elliptic equations

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Schedule: December 16 17:30-18:00   Capital Suite 1

Masato Hashizume
Osaka University
Japan

Co-Author(s): Masato Hashizume

Abstract:
We consider maximization problems in $\mathbb{R}^2$ with the Sobolev norm constraints and with the Dirichlet norm constraints. Typical maximization problems are the Sobolev inequalities and the Trudinger-Moser inequalities, and the existence and non-existence of maximizers for these variational problems have been studied so far. In this talk we focus on properties of maximizers for the maximization problems. We show that maximizers of the maximization problems are ground state solutions of corresponding elliptic equations. Moreover, we also discuss other connections between maximizers of maximization problems and ground state solutions of corresponding elliptic equations.

Existence of solutions to a semilinear heat equation in uniformly local weak Zygmund type spaces

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Schedule: December 16 15:15-15:45   Capital Suite 1

Norisuke Ioku
Tohoku University
Japan

Co-Author(s): Kazuhiro Ishige, Tatsuki Kawakami

Abstract:
We consider an optimal sufficient condition for the existence of solutions to the critical semilinear heat equation by introducing uniformly local weak Zygmund type spaces. Differences between standard (weak) Zygmund spaces and the space introduced here will be explained by focusing several properties for the heat semigroup in these spaces.

On the asymptotic behavior of noncompact orbits for dynamical systems

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Schedule: December 16 14:00-14:30   Capital Suite 1

Michinori Ishiwata
Osaka university
Japan

Abstract:
In this talk, we are concerning the asymptotic behavior of noncompact orbits for dynamical systems. First we introduce a semilinear parabolic problem defined onentire spatial domain as a typical example and give a typical behavior which comes from the noncompactness of the spatial domain. The possibility to develop a general dynamical system theory allowing the noncompactness of the orbit (i.e., a generalization of the LaSalle principle) will be also discussed. The method is based on the profile decomposition.

N-Euclidean Logarithmic Moser-Trudinger-Onofri inequality and some geometrical variants

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Schedule: December 17 9:00-9:30 Capital Suite 1

Gabriele Mancini
University of Bari Aldo Moro
Italy

Co-Author(s): Natalino Borgia, Silvia Cingolani

Abstract:
In this talk, I will provide a brief overview of the history of Onofri`s inequality for the unit sphere, highlighting its connection with Trudinger-Moser type inequalities on Euclidean bounded domains. I will focus on an $N$-dimensional Euclidean version of Onofri`s inequality, proved by del Pino and Dolbeault, for smooth compactly supported functions in $\mathbb{R}^N$, with $N \geq 2$. I will prove that this inequality can be extended to a suitable weighted Sobolev space and, although there is no clear connection with standard Sobolev spaces on $\mathbb{S}^N$ via stereographic projection, I will show that it is equivalent to the logarithmic Moser-Trudinger inequality with sharp constant, obtained by Carleson and Chang for balls in $\mathbb{R}^N$. These results are part of a joint work with N. Borgia and S. Cingolani.

Uniqueness and minimality in Euler`s elastica problem

Schedule: December 17 13:00-13:30 Capital Suite 1

Tatsuya Miura
Kyoto Univeristy
Japan

Co-Author(s): Tatsuya Miura

Abstract:
Euler`s elastica problem is the oldest variational model for elastic rods and serves as a classic example of higher-order geometric variational problems. In this talk, I will discuss recent advancements concerning the issues of uniqueness and minimality in the elastica problem.

Concentration and oscillation analysis of semilinear elliptic equations with exponential growth in a disc

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Schedule: December 16 16:15-16:45 Capital Suite 1

Daisuke Naimen
Muroran Institute of Technology
Japan

Abstract:
We study blow-up positive solutions of semilinear elliptic equations with supercritical exponential growth. We detect infinite sequences of bubbles by a scaling technique. Then, we observe that the infinite sequences of bubbles cause infinite oscillations, around singular solutions, of blow-up solutions. Thanks to this, we finally arrive at a proof of infinite oscillations of bifurcation diagrams which yield the existence of infinitely many solutions.

Concentrations in Bernoulli`s free boundary problem

Schedule: December 17 8:30-9:00 Capital Suite 1

Michiaki Onodera
Tokyo Institute of Technology
Japan

Abstract:
Bernoulli`s free boundary problem is an overdetermined boundary value problem in which one seeks an annular domain such that the capacitary potential satisfies an extra boundary condition. I will talk about recent progress on a conjecture of Flucher and Rumpf that asserts the existence of a family of free boundaries concentrating at non-degenerate local minima of the Robin function.

Proof of the Brezis-Gallouet inequality via heat semigroup

Schedule: December 16 13:00-13:30 Capital Suite 1

Tohru Ozawa
Waseda University
Japan

Co-Author(s): Yi Huang, Chenmin Sun, Taiki Takeuchi

Abstract:
Proof of the Brezis-Gallouet inequality is given by means of the heat semigroup in two space dimensions. This talk is based on my recent joint-work with Yi Huang (Nanjing Normal University), Chenmin Sun (Universit\`{e} Paris-Est Cr\`{e}teil), and Taiki Takeuchi (Kyushu University).

Overdetermined problems in cylinders and related questions

Schedule: December 16 13:30-14:00 Capital Suite 1

Filomena Pacella
University of Roma Sapienza
Italy

Co-Author(s): Danilo Gregorin Afonso, Paolo Caldiroli, Alessandro Iacopetti, David Ruiz, Pieralberto Sicbaldi

Abstract:
We consider overdetermined semilinear elliptic problems in bounded domains contained in an unbounded cylinder in $\mathbb{R}^{\mathbb{N}}$. The variational formulation of these problems naturally leads to study the stationary points (under a volume constraint) of a corresponding energy functional. In particular, domains which are local minima of the energy are of special interest. We will present several results which show that the domains with the simplest geometry (namely bounded cylinders) are not always the best candidates to minimize the energy. This, in turn, suggests the existence of nontrivial domains for which the overdetermined problem admits a solution which can be obtained by globally minimizing the energy or by a bifurcation analysis.

: Global existence of solutions of a class of system of reaction-diffusion equations on evolving domains.

Schedule: December 17 14:00-14:30 Capital Suite 1

Jyotshana Prajapat
University of Mumbai
India

Co-Author(s): Vandana Sharma

Abstract:
In this talk, I will discuss the existence and global existence of solutions of system of reaction diffusion equation where the components diffuse inside an evolving domain and react on the surface through mass transport type boundary conditions. Furthermore, we also report progress on the case where some components react and diffuse on the boundary of the region in addition to the components reacting and diffusing in the interior of an evolving domain. Interactions for different boundary conditions will be explored.

Critical cases of Boundary Hardy and applcation to Moser-Trudinger inequality

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Schedule: December 16 18:30-19:00 Capital Suite 1

Prosenjit Roy
Indian Institute of Technology, Kanpur
India

Co-Author(s): Adimurthi, Purbita Jana, Vivek Sahu

Abstract:
Boundary Hardy inequality states that if ~$1 < p < \infty$ and Ω is a bounded Lipschitz domain in $\mathbb{R}^d$, then

$$\int_\Omega \frac{|u(x)|^p}{\delta_\Omega^p(x)} dx \le C \int_\Omega |\nabla u(x)|^p dx, \forall\, u \in C_c^\infty(\Omega),$$

where ~$\delta\Omega(x)$ is the distance function from $\partial\Omega$. B. Dyda generalised the above inequality to the fractional setting, which says, for $sp > 1$ and $s \in (0,1)$

$$\int_\Omega \frac{|u(x)|^p}{\delta_\Omega^{sp}(x)} dx \le C \int_\Omega \int_\Omega \frac{|u(x)-u(y)|^p}{|x-y|^{d+sp}} dxdy,\ \forall\, u \in C_c^\infty(\Omega).$$

The first and the second inequality is not true for $p = 1$ and $sp = 1$ respectively. In this talk, I will present the appropriate inequalities for the critical cases: $p = 1$ for the first and $sp = 1$ for the second inequality. I will also discuss the case when the weight function (δ_Ω) in the first inequality is replaced by distance function from a $k-$ dimensional sub manifold of Ω and some related applications to Moser-Trudinger inequality.

Deficit estimates for an entropic form of Gagliardo-Nirenberg inequalities related to nonlinear diffusion equations and their application

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Schedule: December 17 9:30-10:00 Capital Suite 1

Takeshi Suguro
Kumamoto University
Japan

Abstract:
We consider functional inequalities concerning the p-Laplace equation. In this talk, we introduce an entropic form of the Gagliardo--Nirenberg inequalities based on the Tsallis entropy, a one-parameter extension of the Boltzmann--Shannon entropy. We obtain deficit estimates for the inequality and consider their application to the uncertainty relation inequality.

Bifurcation into spectral gaps for Schr\odinger equations: from local to non local case

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Schedule: December 17 12:30-13:00 Capital Suite 1

Cristina Tarsi
Universit\`a degli Studi di Milano
Italy

Abstract:
In this talk we consider a Schr\odinger-Choquard equation of the type

$$-\Delta u + V(x)u = (I_\alpha * |u|^p)|u|^{p-2}u + \lambda u \quad x \in \mathbb{R}^N$$

where V is a periodic and non costant potential, I_α denotes the Riesz potential and $N \geq 3$. In this case, the spectrum of the self-adjoint operator $-\Delta + V$ in $L^2(\mathbb{R}^N)$ is purely continuous and may contain gaps. An interesting physical and mathematical issue is establishing the existence of branches of solutions converging towards the trivial solution as λ approaches some {\emph{bifurcation point}} of the spectrum. An intriguing situation is the so called {\emph{gap-bifurcation}}, occurring at boundary points of the spectral gaps: we review the main known results and open problems in the local case (in presence of a local perturbation $f(u)$) and we address the non local case.

Some nonlinear heat equations with exponential non-linearity and with singular data in two dimensions

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Schedule: December 17 8:00-8:30 Capital Suite 1

Elide Terraneo
University of Milano
Italy

Co-Author(s): Y. Fujishima, N. Ioku , and B. Ruf

Abstract:
In this talk we deal with a class of nonlinear heat equations in two dimensions. Recently, for some specific nonlinearities with exponential growth of Trudinger-Moser type, Ioku et al and Ibrahim et al establish the existence of a singular stationary solution. Then, they prove that the Cauchy problem, with this singular solution as initial data, admits, at least, two different solutions. Here we consider similar nonuniqueness phenomena for a wider class of nonlinearities in two dimensions.

Recent progress in the study of concentrated helical vortices of 3d incompressible Euler equations

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Schedule: December 16 19:00-19:30 Capital Suite 1

Jie Wan
Beijing Institute of Technology
Peoples Rep of China

Co-Author(s): Daomin Cao, Rui Li, Guolin Qin

Abstract:
In this talk, we first introduce recent progress of the existence of concentrated helical vortices of 3d incompressible Euler equations when the orthogonality condition holds. Then, in case that the orthogonality condition fails, we prove the existence of concentrated helical vortices of 3d incompressible Euler equations in infinite cylinders. As parameter $\varepsilon \to 0$, the vorticity concentrates near a helix evolved by the vortex filament equations.

Special Session 74 : Recent Advances in Local and Non-local Elliptic PDEs

Introduction: In recent years, there have been a lot of advancements in the theory of both local and non-local elliptic partial differential equations. This session provides a platform for researchers to share their latest contributions and related open problems. Mainly, this session will focus on functional inequalities in Sobolev spaces and qualitative properties of solutions of local and non-local PDEs.

Multiplicity of solutions for mixed local-nonlocal elliptic equations with singular nonlinearity

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Schedule: December 17 14:00-14:30 Capital Suite 12 A

Kaushik Bal
Indian Institute of Technology, Kanpur
India

Co-Author(s): Stuti Das

Abstract:
We prove multiplicity of solutions for the mixed local-nonlocal elliptic equation of the form $-\Delta_p u + (-\Delta)^s_p u = \frac{\lambda}{u^\gamma} + u^r \text{ in } \Omega,\ u > 0 \text{ in } \Omega,\ u = 0 \text{ in } \mathbb{R}^n \setminus \Omega;$ where $(-\Delta)^s_p u(x) = c_{n,s}\,\mathrm{P.V.}\int_{\mathbb{R}^n} \frac{|u(x)-u(y)|^{p-2}(u(x)-u(y))}{|x-y|^{n+sp}}\,dy.$ Under the assumptions that Ω is a smooth bounded domain in $\mathbb{R}^n$, 1

Hodge decomposition in variable exponent spaces with applications to regularity theory

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Schedule: December 17 8:30-9:00 Capital Suite 12 A

Anna Balci
Charles University, Bielefeld University
Germany

Abstract:
In this talk, we explore the Hodge Laplacian in variable exponent spaces with differential forms on smooth manifolds. We present several results, including the Hodge decomposition in variable exponent spaces and a priori estimates. As an application, we derive Calderon-Zygmund estimates for variable exponent problems involving differential forms and discuss numerical approximations for nonlinear models with differential forms, which have applications in superconductivity. This presentation is based on several works with Swarnendu Sil, Michail Surnachev, and Alex Kaltenbach.

An interpolation approach to L^∞ a priori estimates for elliptic problems with nonlinearity on the boundary

Schedule: December 17 14:45-15:15 Capital Suite 12 A

Maya Chhetri
The University of North Carolina at Greensboro
USA

Co-Author(s): N. Mavinga and R. Pardo

Abstract:
In this talk, we present an explicit $L^\infty(\Omega)$ estimate for weak solutions to subcritical elliptic problems with nonlinearity on the boundary, expressed in terms of powers of their $H^1(\Omega)$ norm. Our approach relies on the already available regularity results, established using Moser's iteration technique, elliptic regularity and Gagliardo�Nirenberg interpolation inequality. We illustrate our result with an application to subcritical problems satisfying Ambrosetti-Rabinowitz condition.

Sharp bounds for higher Steklov-Dirichlet Eigenvalue

Schedule: December 17 19:00-19:30 Capital Suite 12 A

Anisa M H Chorwadwala
IISER Pune
India

Abstract:
We consider a mixed Steklov-Dirichlet eigenvalue problem on smooth bounded domains in Riemannian manifolds. Under certain symmetry assumptions on multi-connected domains in a Euclidean space with a spherical hole, we obtain isoperimetric inequalities for k-th Steklov- Dirichlet eigenvalues for k between 2 and n +1 We extend Theorem 3.1 of GPPS from Euclidean domains to domains in space forms, that is, we obtain sharp lower and upper bounds of the first Steklov-Dirichlet eigenvalue on bounded star-shaped domains in the unit n-sphere and in the hyperbolic space. GPPS Nunzia Gavitone, Gloria Paoli, Gianpaolo Piscitelli, and Rossano Sannipoli. An isoperimetric inequality for the first steklov�dirichlet laplacian eigenvalue of convex sets with a spherical hole. Pacific Journal of Mathematics, 320 (2) 241-- 259, 2023.

Rate of Convergence of Approximations to Nonlocal HJB Equations

Schedule: December 17 18:30-19:00 Capital Suite 12 A

Indranil Chowdhury
Indian Institute of Technology, Kanpur
India

Co-Author(s): Espen R. Jakobsen

Abstract:
We discuss monotone approximation schemes of fractional and nonlocal Hamilton-Jacobi-Bellman (HJB) equations. It is well-known in analysis that convergence rates depend on the regularity of solutions, and here we consider cases with varying solution regularity: Strongly degenerate problems with Lipschitz solutions, and weakly non-degenerate problems where the solutions have bounded fractional derivatives. We study the error estimates with convergence rates that capture precisely both the fractional order of the schemes and the fractional regularity of the solutions.

ANISOTROPIC p-LAPLACE EQUATIONS ON LONG CYLINDRICAL DOMAIN

Schedule: December 17 18:00-18:30 Capital Suite 12 A

Purbita Jana
Madras School of Economics
India

Abstract:
The main aim of this talk is to study the Poisson type problem for anisotropic p-Laplace type equation on long cylindrical domains. The rate of convergence is shown to be expo- nential, thereby improving earlier known results for similar type of operators. Poincare inequality for pseudo p-Laplace operator on an infinite strip-like domain is also studied and the best constant, like many other situations in literature for other operators, is shown to be the same with the best Poincare constant of an analogous problem set on a lower dimension.

Semilinear elliptic boundary value problems on the exterior of a ball in R^n, n $geq 2$

Schedule: December 17 15:45-16:15 Capital Suite 12 A

Lakshmi Sankar Kalappattil
Indian Institute of Technology Palakkad
India

Co-Author(s): Anumol Joseph

Abstract:
We consider problems of the form, $\{ -\Delta u \quad = \lambda K(x) f(u) \text{ in } B_1^c,\ u(x) \quad = 0 \text{ on } \partial B_1,$ where $B_1^c = \{x \in \mathbb{R}^n : |x| > 1\}, n \geq 2,$ λ is a positive parameter, and $K : B_1^c \to \mathbb{R}^+$, $f : (0, \infty) \to \mathbb{R}$ belong to classes of continuous functions with K satisfying certain decay assumptions. For various classes of reaction terms and non radial weight functions, we will discuss the existence of positive solutions to such problems.

Optimal harvesting for a logistic model with grazing

Schedule: December 17 9:30-10:00 Capital Suite 12 A

Mohan Kumar Mallick
VNIT Nagpur
India

Co-Author(s): Mohan Mallick, Ardra A, and Sarath Sasi

Abstract:
We consider semi-linear elliptic equations of the following form:
$\begin{cases} -\Delta u = \lambda[u - \frac{u^2}{K} - c\frac{u^2}{1+u^2} - h(x)u] =: \lambda f_h(u) \quad \text{in } \Omega, \frac{\partial u}{\partial \eta} + qu = 0 \quad \text{on } \partial\Omega, \end{cases}$ where,
$h \in U = \{h \in L^2(\Omega) : 0 \leq h(x) \leq H\}$. We prove the existence and uniqueness of the positive solution for large λ. Further, we establish the existence of an optimal control $h \in U$ that maximizes the functional $J(h) = \int_\Omega h(x)u_h(x)\, \mathrm{d}x - \int_\Omega (B_1 + B_2 h(x))h(x)\, \mathrm{d}x$ over U, where u_h is the unique positive solution of the above problem associated with h, $B_1 > 0$ is the cost per unit effort when the level of effort is low and $B_2 > 0$ represents the rate at which the cost rises as more labor is employed. Finally, we provide a unique optimality system.

High energy solutions for non-compact variational problems

Schedule: December 17 17:30-18:00 Capital Suite 12 A

Saikat Mazumdar
Indian Institute of Technology Bombay
India

Abstract:
In this talk, we will revisit the topological method of Coron to obtain solutions of a critical exponent polyharmonic equation. A key step is to show that in the absence of minimizers, a small perturbation of the first energy level can be embedded into the domain.

Nonlinear nonlocal potential theory at the gradient level

Schedule: December 17 9:00-9:30 Capital Suite 12 A

Simon Nowak
Bielefeld University
Germany

Co-Author(s): Lars Diening, Kyeongbae Kim, Ho-Sik Lee

Abstract:
I will present pointwise gradient potential estimates for a class of nonlinear nonlocal equations related to quadratic nonlocal energy functionals. These pointwise estimates imply that the first-order regularity properties of such general nonlinear nonlocal equations coincide with the sharp ones of the fractional Laplacian. The talk is based on joint work with Lars Diening (Bielefeld), Kyeongbae Kim (Seoul) and Ho-Sik Lee (Bielefeld).

Asymptotic Estimates for (p, q) Laplace Problems with Singular and Indefinite Sign Non-linearity and some applications

Schedule: December 17 17:00-17:30 Capital Suite 12 A

Dhanya Rajendran
IISER Thiruvananthapuram
India

Abstract:
We will focus on the asymptotic behavior of the solutions to the boundary value problem

$$-\Delta_p u - \Delta_q u = \lambda g(x) \text{ in } \Omega$$

and

$$u = 0 \text{ on } \partial\Omega$$

as λ approaches b ∞ where Ω in a smooth bounded domain in $\mathbb{R}^N$ and $g : \Omega \to \mathbb{R}$ is indefinite in sign and possibly singular near the boundary of Ω. These estimates find application in establishing the existence of a positive solution to a related problem

$$-\Delta_p u - \Delta_q u = \lambda f(u) \text{ in } \Omega$$

with zero boundary conditions. Here we consider the non-linearity $f : (0, \infty) \to \mathbb{R}$ to be p-sublinear at infinity. Moreover, when f takes a specific form, we obtain a positive solution that also serves as a local minimizer for the associated energy functional.

Degenerate Schr{\o}dinger-Kirchhoff (p, N)-Laplacian problem with singular Trudinger-Moser nonlinearity in $\mathbb{R}^N$

Schedule: December 17 16:15-16:45 Capital Suite 12 A

Abhishek Sarkar
Indian Institute of Technology Jodhpur
India

Co-Author(s): Deepak Kumar Mahanta, Tuhina Mukherjee

Abstract:
In this talk, we will discuss the existence of nontrivial nonnegative solutions for a (p, N)-Laplacian Schr{\o}dinger-Kirchhoff problem in $\mathbb{R}^N$ with singular exponential nonlinearity. The main features of the work are the (p, N) growth of the elliptic operators, the double lack of compactness, and the fact that the Kirchhoff function is of degenerate type. To establish the existence results, we use the mountain pass theorem, the Ekeland variational principle, the singular Trudinger-Moser inequality, and a completely new Br\`ezis-Lieb type lemma for singular exponential nonlinearity.

Uniqueness of positive solutions for a class of nonlinear elliptic equations with Robin boundary conditions

Schedule: December 17 13:00-13:30 Capital Suite 12 A

Ratnasingham Shivaji
University of North Carolina at Greensboro
USA

Co-Author(s): D.D. Hai & X.Wang

Abstract:
We prove uniqueness of positive solutions to the BVP $\left\{ -\Delta u = \lambda f(u) \setminus \text{in } \Omega,\ \frac{\partial u}{\partial n} + bu = 0 \setminus \text{on } \partial\Omega, \right.$ when the parameter λ is large independent of $b \in (0, \infty)$. Here Ω is a bounded domain in $\mathbb{R}^n$ with smooth boundary $\partial\Omega,\ f : [0, \infty) \to [0, \infty)$ is continuous, sublinear at ∞, and satisfies a concavity-like condition for u large.

On logarithmic p-Laplacian

Schedule: December 17 15:15-15:45 Capital Suite 12 A

Firoj Sk
University of Oldenburg
Germany

Co-Author(s): B. Dyda and S. Jarohs

Abstract:
We study the logarithmic p-Laplacian L_{Δ_p}, which arises as formal derivative of the fractional p-Laplacian $(-\Delta_p)^s$ at $s = 0$. We present a variational framework to study the Dirichlet problems involving the L_{Δ_p} in bounded domains and use it to characterize the asymptotics of principal Dirichlet eigenvalues and eigenfunctions of $(-\Delta_p)^s$ as $s \to 0$. As a byproduct, we then derive a Faber-Krahn type inequality for the principal Dirichlet eigenvalue of L_{Δ_p}. In addition, we discuss a boundary Hardy-type inequality for the spaces associated with the weak formulation of the logarithmic p-Laplacian. This talk is based on joint work with B. Dyda(Wroclaw) and S. Jarohs(Frankfurt).

Shape optimization problem for Steklov Dirichlet eigenvalues

Schedule: December 17 13:30-14:00 Capital Suite 12 A

Sheela Verma
Indian Institute of Technology (BHU) Varanasi
India

Co-Author(s): Sagar Basak, Anisa Chorwadwala

Abstract:
Let Ω be a bounded smooth domain in R^n with two disjoint boundary components C_1 and C_2. The mixed Steklov Dirichlet problem is to find harmonic function u in Ω such that $u = 0$ on C_1 and outer normal derivative of u is directly proportional to u along C_2. This problem models the stationary heat distribution in Ω with the conditions that the temperature along C_1 is kept to zero and that the heat flux through C_2 is proportional to the temperature. In this talk, I will first discuss about behaviour of the first Steklov Dirichlet eigenvalue on doubly connected domains and then provide some isoperimetric bounds for higher Steklov Dirichlet eigenvalues. I will also talk about similar bounds for eigenvalues of higher Steklov Neumann eigenvalues.

Special Session 75 : Stochastic Evolution Systems Across Scales: Theory and Applications

Introduction: The objective of this special section is to assemble experts who will present their recent discoveries on the behavior and characteristics of stochastic evolution systems across diverse scales. Specifically, it highlights Stochastic (Partial) Differential Equations and their applications from small to large scales. Participants in this session are expected to exchange novel ideas, discuss unresolved issues, investigate new topics and subjects, and foster new partnerships and connections.

L^2-Wasserstein ergodicity of modified Euler schemes for SDEs with high diffusivity and applications

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Schedule: December 17 17:00-17:30 Capital Suite 13

Jianhai Bao
Tianjin University
Peoples Rep of China

Abstract:
In this talk, we are concerned with a modified Euler scheme for the SDE under consideration, where the drift is of super-linear growth and dissipative merely outside a closed ball. By adopting the synchronous coupling, along with the construction of an equivalent metric, the L^2-Wasserstein ergodicity of the modified Euler scheme is addressed provided that the diffusivity is large enough. In particular, as a by-product, the L^2-Wasserstein ergodicity of the projected Euler scheme and the tamed Euler algorithm is treated under much more explicit conditions imposed on drifts. The theory derived on the L^2-Wasserstein ergodicity has numerous applications on various aspects. In addition to applications on Poincar\`{e} inequalities, concentration inequalities for empirical averages, and bounds concerning KL-divergence, in this paper we present another two potential applications. One concerns the L^2-Wasserstein error bound between the exact invariant probability measure and the numerical counterpart corresponding to the projected Euler scheme and the tamed Euler recursion, respectively. It is worthy to emphasize that the associated convergence rate is improved greatly in contrast to the existing literature. Another is devoted to the strong law of large numbers of additive functionals related to the modified Euler algorithm, where the observable functions involved are allowed to be of polynomial growth.

Well-posedness of stochastic Degasperis-Procesi equation

Schedule: December 17 15:45-16:15 Capital Suite 13

Nikolai V Chemetov
University of Sao Paulo
Brazil

Co-Author(s): Fernanda Cipriano

Abstract:
Well-posedness of stochastic Degasperis-Procesi equation \bigskip Nikolai V. Chemetov (DCM - FFCLRP, University of Sao Paulo, Brazil) \bigskip This talk is concerned with the existence of a solution to the stochastic Degasperis-Procesi equation on R with an infinite dimensional multiplicative noise and integrable initial data. Writing the equation as a system composed of a stochastic nonlinear conservation law and an elliptic equation [1], we are able to develop a method based on the conjugation of kinetic theory [2] with stochastic compactness arguments. More precisely, we apply the stochastic Jakubowski-Skorokhod representation theorem to show the existence of a weak kinetic martingale solution [3]. We also demonstrate the uniqueness result [4]. This is a joint work with Fernanda Cipriano (Universidade Nova de Lisboa, Portugal). \medskip Bibliography: 1. L.K. Arruda, N.V. Chemetov, F. Cipriano, Solvability of the Stochastic Degasperis-Procesi Equation. J. Dynamics and Differential Equations, 35(1) (2023), 523-542. 2. N.V. Chemetov, W Neves, The generalized Buckley--Leverett system: solvability. Archive for Rational Mechanics and Analysis, 208 (1) (2013), 1-24. 3. N.V. Chemetov, F. Cipriano, Weak solution for stochastic Degasperis-Procesi equation. J. Differential Equations, Vol. 382 (15) (2024), 1-49. 4. N.V. Chemetov, F. Cipriano, The uniqueness result for the weak solution for stochastic Degasperis-Procesi equation. To be submitted.

Invariant measures for a class of stochastic third grade fluid equations in 2D and 3D bounded domains

Schedule: December 17 17:30-18:00 Capital Suite 13

Fernanda F. Cipriano
NOVA University of Lisbon
Portugal

Co-Author(s): Yassine Tahraoui, Fernanda Cipriano

Abstract:
This work aims to investigate the well-posedness and the existence of ergodic invariant measures for a class of third grade fluid equations in bounded domain of $\mathbb{R}^d, d = 2, 3$, in the presence of a multiplicative noise. First, we show the existence of a martingale solution by coupling a stochastic compactness and monotonicity arguments. Then, we prove a stabilty result, which gives the pathwise uniqueness of the solution and therefore the existence of strong probabilistic solution. Secondly, we use the stability result to show that the associated semigroup is Feller and by using Krylov-Bogoliubov Theorem we get the existence of an invariant probability measure. Finally, we show that all the invariant measures are concentrated on a compact subspace of L^2, which leads to the existence of an ergodic invariant measure.

The Camassa-Holm equation with transport noise

Schedule: December 17 13:00-13:30 Capital Suite 13

Helge Holden
Norwegian University of Science and Technology
Norway

Abstract:
We will discuss recent work regarding the Camassa--Holm equation with transport noise, more precisely, the equation $u_t + uu_x + P_x + \sigma u_x \circ dW = 0$ and $P - P_{xx} = u^2 + u_x^2/2$. In particular, we will show existence of a weak, global, dissipative solution of the Cauchy initial-value problem on the torus. This is joint work with L. Galimberti (King`s College), K.H. Karlsen (Oslo), and P.H.C. Pang (NTNU/Oslo).

Compactness of Solutions to Stochastic Kinetic Equations

Schedule: December 17 14:45-15:15 Capital Suite 13

Kenneth H. Karlsen
Department of Mathematics, University of Oslo
Norway

Abstract:
We consider stochastically forced kinetic equations in heterogenous environments and stochastic conservation laws with spatially irregular flux. We present new results on the strong compactness of the velocity averages of solutions under general integrability conditions. The talk draws upon papers authored with M. Erceg, M. Kunzinger, and D. Mitrovic.

Restricted path characteristic function determines the law of stochastic processes

Schedule: December 17 18:00-18:30 Capital Suite 13

Siran Li
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Zijiu Lyu; Hao Ni; Jiajie Tao

Abstract:
A central question in rough path theory is characterising the law of stochastic processes. It is established in [I. Chevyrev $\&$ T. Lyons, Characteristic functions of measures on geometric rough paths, \textit{Ann. Probab.} \textbf{44} (2016), 4049--4082] that the path characteristic function (PCF), \emph{i.e.}, the expectation of the unitary development of the path, uniquely determines the law of the unparametrised path. We show that PCF restricted to certain subspaces of sparse matrices is sufficient to achieve this goal. The key to our arguments is an explicit algorithm --- as opposed to the nonconstructive approach in [I. Chevyrev $\&$ T. Lyons, \emph{op. cit.}] --- for determining a generic element X of the tensor algebra $\bigoplus_{n=0}^{\infty}\left(\mathbb{R}^d\right)^{\otimes n}$ from its moment generating function. Our only assumption is that X has a nonzero radius of convergence, which relaxes the condition of having an infinite radius of convergence in the literature. As applications of the above theoretical findings, we propose the restricted path characteristic function distance (RPCFD), a novel distance function for probability measures on the path space that offers enormous advantages for dimension reduction. Its effectiveness is validated via hypothesis testing on fractional Brownian motions, thus demonstrating the potential of RPCFD in generative modeling for synthetic time series generation.

On the Lagrange multiplier method to the Euler and Navier-Stokes equations

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Schedule: December 17 14:00-14:30 Capital Suite 13

Xiangdong Li
AMSS, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Guoping Liu

Abstract:
In this talk, we use the Lagrange multiplier method to derive the incompressible Euler and Navier-Stokes equations on a compact Riemannian manifold M, in which the pressure is given by a variant of the Lagrange multiplier for the incompressible condition $\mathrm{div}\ u=0$. Moreover, we give a new derivation of the incompressible Navier-Stokes equation on a compact Riemannian manifold M via the Bellman dynamic programming principle on the infinite dimensional group of diffeomorphisms $G=\mathrm{Diff}(M)$. In particular, in the inviscid case, we give a new derivation of the incompressible Euler equation on a compact Riemannian manifold M. Our method provides an explicit construction of a solution to the incompressible Euler and Navier-Stokes equations via the value function and the Lagrange multiplier of a deterministic or stochastic optimal control problem on $G=\mathrm{Diff}(M)$. Joint work with Guoping Liu (HUST, Wuhan).

Fluctuations of SHE

Schedule: December 17 13:30-14:00 Capital Suite 13

Xue-Mei Li
EPFL
Switzerland

Abstract:
We explore the stochastic heat equation (HE) with space time Gaussian noise exhibiting long-range spatial dependence. These equations produce solutions that admit a stationary field. Our focus is on the fluctuation problem associated with diffusively scaled solutions from their average. We demonstrate that the fluctuations of the appropriately scaled solutions from their mean converge weakly to the solution of a stochastic heat equation with additive noise, where the spatial correlation function is governed by the Riesz potential. This is joint work with L. Gerolla and M. Hairer

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2D Smagorinsky-Type Large Eddy Models as Limits of Stochastic PDEs

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Schedule: December 17 16:15-16:45 Capital Suite 13

Dejun Luo
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Abstract:
We prove that a version of Smagorinsky large eddy model for a 2D fluid in vorticity form is the scaling limit of suitable stochastic models for large scales, where the influence of small turbulent eddies is modeled by a transport-type noise. This talk is based on a joint work with F. Flandoli and E. Luongo.

Stochastic extrinsic derivative flows on the space of absolutely continuous measures

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Schedule: December 17 18:30-19:00 Capital Suite 13

Simon Wittmann
The Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Panpan Ren, Feng-Yu Wang

Abstract:
Right Markov processes, whose state space consists of absolutely continuous measures (resp.~probabilities) w.r.t.~a fixed measure λ on a Polish space M, are the central objects in this talk.These stand in one-to-one correspondence with quasi-regular Dirichlet forms. Our first result states the quasi-regularity for a broad class of Dirichlet forms, whose diffusion part is of extrinsic derivative type and which have a non-local (killing and jumping) part. A natural way to construct closed forms of this class is to take as reference measure the push-forward of a Gaussian on $L^2(M, \lambda)$ under $f \mapsto f^2\lambda$, resp.~$f \mapsto (f^2/\lambda(f^2))\lambda$. Hence, we obtain Gaussian-type Sobolev spaces on absolutely continuous measures and associated Ornstein-Uhlenbeck processes. In case $M = \mathbb{R}^d$ the entropy functional is identified as a member of such a Sobolev space and we construct its stochastic extrinsic derivative flow driven by the Ornstein-Uhlenbeck process.

On the empty balls of super-Brownian motion and branching random walk

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Schedule: December 17 15:15-15:45 Capital Suite 13

Jie Xiong
Southern University of Science and Technology
Peoples Rep of China

Co-Author(s): Shuxiong Zhang

Abstract:
In this talk, I will explore various limiting behavior of the radius of the largest ball around the origin which is not occupied by a super-Brownian motion and that not by a branching random walk according to the spatial dimension as time tends to infinity.

Metastability of Random Dynamical Systems

Schedule: December 17 12:30-13:00 Capital Suite 13

Tusheng Zhang
University of Science and Technology of China
Peoples Rep of China

Abstract:
In this talk, we first present a criterion on uniform large deviation principles (ULDP) of stochastic differential equations under Lyapunov conditions on the coefficients. In the second part, using the ULDP criterion we preclude the concentration of limiting measures of invariant measures of stochastic dynamical systems on repellers and acyclic saddle chains. Of particular interest, we determine the limiting measures of the invariant measures of the famous stochastic van der Pol equation and van der Pol Duffing equation whose noises are naturally degenerate.

Special Session 76 : Recent Developments in Nonlinear and Nonlocal Evolution Equations

Introduction: This special session will focus on the recent developments in the mathematical theory of nonlinear and nonlocal evolution equations, including but not limited to physical systems arising from chemotaxis, magnetohydrodynamics (MHD), Newtonian and non-Newtonian fluids. The primary objective of this session is to gather leading researchers to foster insightful discussions on the cutting-edge progressions, as well as significant real-world applications within the domain.

The relativistic quantum Boltzmann equation near equilibrium

Schedule: December 18 14:00-14:30 Conference Hall B (D)

Gi-Chan Bae
Seoul National University / Research institute of Mathematics
Korea

Co-Author(s): Jin Woo Jang, Seok-Bae Yun

Abstract:
The relativistic quantum Boltzmann equation (or the relativistic Uehling-Uhlenbeck equation) describes the dynamics of single-species fast-moving quantum particles. With the recent development of the relativistic quantum mechanics, the relativistic quantum Boltzmann equation has been widely used in physics and engineering such as in the quantum collision experiments and the simulations of electrons in graphene. In spite of such importance, there has been no mathematical theory on the existence of solutions for the relativistic quantum Boltzmann equation to the best of authors` knowledge. In this talk, we consider the global existence of a unique classical solution to the relativistic Boltzmann equation for both bosons and fermions when the initial distribution is nearby a global equilibrium. This is joint work with J. W. Jang and S. B. Yun.

Dynamics and Convergence Arising from Some Phase Field Models

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Schedule: December 18 13:00-13:30 Conference Hall B (D)

Yuan Chen
Chinese University of Hong Kong
Peoples Rep of China

Abstract:
We consider the mass-preserving L^2 -gradient flow of the weak or strong scaling of the functionalized Cahn-Hilliard equation and justify its sharp interface limit. With a suitable mass condition, the accumulated material forms a bilayer interface with width ε, which balances with the bulk phase. In the weak scaling case, we rigorously demonstrate that for well-prepared initial data, as the interface width ε tends to zero, the bilayer interface converges to an area-preserving Willmore flow. This result holds for any dimension n .

On the dynamics of surface waves for a fluid with odd viscosity

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Schedule: December 18 14:45-15:15 Conference Hall B (D)

Rafael Granero Belinchon
Universidad de Cantabria
Spain

Co-Author(s): Diego Alonso-Oran, Claudia Garcia, Alejandro Ortega

Abstract:
In this talk we will review some recent results on the dynamics of a free boundary problem arising in a non-newtonian viscous flow with the so called odd viscosity. This viscosity is also known as Hall viscosity and appears in a number of applications such as quantum Hall fluids or chiral active fluids. Besides the odd viscosity effects, the models that we will present capture both gravity and capillary forces up to quadratic interactions and take the form of nonlinear and nonlocal wave equations. We will present some well-posedness result and also study the existence of m-fold symmetric traveling waves.

Singularity formation and global weak solutions to the Serre-Green-Naghdi equations with surface tension

Schedule: December 18 15:15-15:45 Conference Hall B (D)

Billel Guelmame
ENS Lyon
France

Abstract:
In this talk, we explore the Serre-Green-Naghdi equations, which describe shallow-water waves while considering the influence of surface tension. These equations are locally (in time) well-posed. We identify a class of smooth initial data, leading to the development of singularities in finite time for the corresponding strong solutions. Additionally, we demonstrate the existence of global weak solutions for small-energy initial data.

Traveling waves for monostable reaction-diffusion-convection equations with discontinuous density-dependent coefficients

Schedule: December 18 17:30-18:00 Conference Hall B (D)

SOYEUN JUNG
Kongju National University
Korea

Co-Author(s): Pavel Dr\`{a}bek, Eunkyung Ko, Michaela Zahradn\`{i}kov\`{a}

Abstract:
In this talk we consider wave propagation in a class of scalar reaction-diffusion-convection equations with p-Laplacian-type diffusion and monostable reaction. We introduce a new concept of a non-smooth traveling wave profile, which allows us to treat discontinuous diffusion with possible degenerations and singularities at 0 and 1, as well as only piecewise continuous convective velocity. Our approach is based on comparison arguments for an equivalent non-Lipschitz first-order ODE. We formulate sufficient conditions for the existence and non-existence of these generalized solutions and discuss how the convective velocity affects the minimal wave speed compared to the problem without convection.

Some results on a repulsive chemotaxis-consumption model

Schedule: December 18 18:00-18:30 Conference Hall B (D)

Dongkwang Kim
Ulsan National Institute of Science and Technology, Department of Mathematical Sciences
Korea

Co-Author(s): Jaewook Ahn, Kyungkeun Kang

Abstract:
In this talk, we will discuss results concerning the solvability of a chemotaxis model, which describes the movement of organisms in response to chemical substances. Focusing on the repulsive chemotaxis-consumption system, we examine the criteria under which solutions remain bounded over time and the conditions leading to blow-up in higher dimensions. Specifically, we show that the system admits globally bounded solutions when the diffusion of the organisms is enhanced, or when the diffusion is weakened but the boundary data for the signal substance is sufficiently small. On the other hand, we prove that if the diffusion is further weakened and the boundary data for the signal is sufficiently large, the system exhibits blow-up behavior.

Blowup solutions to the complex Ginzburg-Landau equation

Schedule: December 18 12:30-13:00 Conference Hall B (D)

Van Tien Nguyen
National Taiwan University
Taiwan

Co-Author(s): Jiajie Chen, Thomas Y. Hou, Yixuan Wang

Abstract:
We develop a so-called generalized dynamical rescaling method to study singularity formation in the complex Ginzburg-Landau equation (CGL). This innovative technique enables us to capture all relevant symmetries of the problem, allowing us to directly demonstrate a full stability of constructed blowup solutions. One of the advantages of our approach is its ability to circumvent spectral decomposition, which is often complex for problems involving non-self- adjoint operators. Additionally, the (CGL) system lacks a variational structure, making standard energy-type methods difficult to apply. By employing the amplitude-phase representation, we establish a robust analysis framework that enforces vanishing conditions through a carefully chosen normalization and utilizes weighted energy estimates.

Liouville-type theorems for the stationary ideal magnetohydrodynamics equations in multi-dimensional cases

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Schedule: December 18 15:45-16:15 Conference Hall B (D)

Anthony Suen
The Education University of Hong Kong
Hong Kong

Co-Author(s): Lv Cai, Ning-An Lai, Manwai Yuen

Abstract:
We establish Liouville-type theorems for the stationary ideal compressible magnetohydrodynamics system in $\mathbb{R}^n$ with $n \in \{1,2,3\}$. We address various cases when the finite energy condition is in force and the stationary density function ρ satisfies $\lim_{|x|\to\infty} \rho(x) = \rho_\infty \geq 0$. Our proof relies heavily on the good structure of the nonlinear magnetic force term and the usage of well-chosen smooth cut-off test functions.

Mean Field Games, FBSDEs and Associated Master Equations

Schedule: December 18 17:00-17:30 Conference Hall B (D)

Ho Man Tai
Dublin City University
Ireland

Co-Author(s): Alain Bensoussan, Ho Man Tai, Tak Kwong Wong, and Sheung Chi Phillip Yam

Abstract:
In this talk, I introduce the global-in-time well-posedness for a broad class of mean field game problems, which is beyond the special linear-quadratic setting, as long as the mean field effect is not too large. Through the stochastic maximum principle, we adopt the forward backward stochastic differential equation (FBSDE) approach to investigate the unique existence of the corresponding equilibrium strategies. Further analysis on the Jacobian flow of the FBSDE will be discussed so as to establish the classical well-posedness of the master equation on R^d.

3D hard sphere Boltzmann equation: explicit structure and the transition process from polynomial tail to Gaussian tail

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Schedule: December 18 13:30-14:00 Conference Hall B (D)

Haitao Wang
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Yu-Chu Lin, Kung-Chien Wu

Abstract:
We study the Boltzmann equation with hard sphere in a near-equilibrium setting. The initial data is compactly supported in the space variable and has a polynomial tail in the microscopic velocity. We show that the solution can be decomposed into a particle-like part (polynomial tail) and a fluid-like part (Gaussian tail). The particle-like part decays exponentially in both space and time, while the fluid-like part dominates the long time behavior and exhibits rich wave motion. The nonlinear wave interactions in the fluid-like part are precisely characterized. Furthermore, the transition process from the polynomial to the Gaussian tail is quantitatively revealed.

Special Session 77 : Recent developments in variational problems and geometric analysis

Introduction: This session will focus on some recent developments in nonlinear PDEs related to variational problems and geometric analysis. Questions like existence, uniqueness, multiplicity, qualitative properties of solutions, functional inequalities in Sobolev spaces will be central topics of discussion.This session provides a platform for researchers to share their latest contributions and related open problems.

Concentration phenomena for nonlinear fractional relativistic Schrodinger equations

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Schedule: December 18 15:15-15:45 Conference Hall B (B)

Vincenzo Ambrosio
Universita' Politecnica delle Marche
Italy

Abstract:
In this talk, we consider the following class of fractional relativistic Schr\odinger equations: $\{ (-\varepsilon^2\Delta+m^2)^s u+V(x)u=f(u)+\gamma u^{2^*_s-1} \text{ in } \mathbb{R}^N,\ u\in H^s(\mathbb{R}^N), \quad u>0 \text{ in } \mathbb{R}^N,$ where $\varepsilon>0$ is a small parameter, $s\in(0,1)$, $m>0$, $N>2s$, $\gamma\in\{0,1\}$, and $2^*_s=\frac{2N}{N-2s}$ is the fractional critical exponent. Here, the pseudo-differential operator $(-\varepsilon^2\Delta+m^2)^s$ is simply defined in Fourier variables by the symbol $(\varepsilon^2|\xi|^2+m^2)^s$, $V:\mathbb{R}^N\to\mathbb{R}$ is a continuous potential satisfying a local condition, and $f:\mathbb{R}\to\mathbb{R}$ is a superlinear continuous nonlinearity with subcritical growth at infinity. Utilizing the extension method and penalization techniques, we first show that there exists a family of positive solutions $u_\varepsilon\in H^s(\mathbb{R}^N)$, with exponential decay, that concentrate around a local minimum of V as $\varepsilon\to 0$. Finally, we combine the generalized Nehari manifold method with the Ljusternik-Schnirelman theory to relate the number of positive solutions to the topology of the set where the potential V attains its minimum value.

Some new results on elliptic equations involving Logarithmic Laplacian

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Schedule: December 18 9:00-9:30 Conference Hall B (B)

Rakesh Arora
Indian Institute of Technology (IIT-BHU)
India

Co-Author(s): Jacques Giacomoni and Arshi Vaishnavi

Abstract:
This talk presents new existence, non-existence and uniqueness results for the following problem

$$L_\Delta u = f(x,u) \text{ in } \Omega, \quad u = 0 \text{ in } \mathbb{R}^N \setminus \Omega$$

where L_Δ is the Logarithmic Laplace operator and f satisfies sub-critical, critical and super-critical nonlinearities growth conditions. Such type of problems are connected to the model problems in population dynamics, optimal control, approximation of fractional harmonic maps, and fractional image denoising.

EXISTENCE AND NONEXISTENCE OF SOLUTIONS FOR QUASILINEAR EQUATIONS WITH WEIGHTS

Schedule: December 18 9:30-10:00 Conference Hall B (B)

Roberta Filippucci
University of Perugia
Italy

Co-Author(s): Laura Baldelli, Valentina Brizi, Yadong Zheng

Abstract:
In this talk, we present some recent results on existence and nonexistence of positive radial solutions for a Dirichlet problem both in the case of the p-Laplacian operator and of the mean curvature operator with weights in a ball with a suitable radius. Because of the presence of different weights, possibly singular or degenerate, the problem is delicate and requires an accurate qualitative analysis of the solutions, as well as the use of Liouville type results based on an appropriate Pohozaev type identity.

(p,q)-fractional problems involving a sandwich type perturbation and a critical Sobolev nonlinearity

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Schedule: December 18 8:30-9:00 Conference Hall B (B)

Alessio Fiscella
Universidade Estadual de Campinas
Brazil

Co-Author(s): Mousomi Bhakta and Shilpa Gupta

Abstract:
In this talk, we deal with elliptic problems set on a general open domain Omega, driven by a (p,q)-fractional operator, involving a critical Sobolev nonlinearity and a nonlinear perturbation of sandwich type. More precisely, the subcritical term is intrinsically linked to the double (p,q)-growth of the main operator. Under different settings of involved parameters, we prove existence and multiplicity results for our problems. For this, we combine topological tools and variational methods. Our results, contained in https://arxiv.org/abs/2409.13986, generalize in several directions the theorems proved in https://doi.org/10.1007/s00526-020-01867-6 and in https://doi.org/10.1016/j.aml.2020.106646

One-dimensional half-harmonic maps into the circle

Schedule: December 18 14:00-14:30 Conference Hall B (B)

Ali Hyder
TIFR-CAM Bangalore
India

Co-Author(s): L. Martinazzi

Abstract:

Given a function g in the homogeneous fractional Sobolev space $\dot{H}^{1/2,2}(R, S^1)$ from the real line into the unit circle, by the direct minimization method, one can construct a half-harmonic map u from the real line into the unit circle such that $u = g$ outside $(-1, 1)$. In this talk we will show the existence of another half-harmonic maps with the same boundary condition g by minimizing the fractional Dirichlet energy in a different homotopy class. We will also show that in general it is not possible to minimize the energy in every homotopy class.

Ground state solutions for a (p, q)--Choquard equation with a general nonlinearity

Schedule: December 18 16:15-16:45 Conference Hall B (B)

Teresa Isernia
Universita` Politecnica delle Marche
Italy

Co-Author(s): Vincenzo Ambrosio

Abstract:
In this talk, we will consider the following (p, q)-Choquard equation
$-\Delta_p u - \Delta_q u + |u|^{p-2}u + |u|^{q-2}u = (I_\alpha * F(u))\, f(u) \quad \text{in } \mathbb{R}^N$, where $2 \leq p < q < N$, Δ_s is the s--Laplacian operator with $s \in \{p, q\}$, I_α is the Riesz potential of order $\alpha \in ((N-2q)^+, N)$, $F \in C^1(\mathbb{R}, \mathbb{R})$ is a general nonlinearity of Berestycki--Lions type, and $F' = f$. By means of variational methods, we analyze the existence of ground state solutions, along with the regularity, symmetry, and decay properties of these solutions. Δ_s is the s-Laplacian operator with $s \in \{p, q\}$, I_α is the Riesz potential of order $\alpha \in ((N-2q)^+, N)$, $F \in C^1(\mathbb{R}, \mathbb{R})$ is a general nonlinearity of Berestycki--Lions type, and $F' = f$. By means of variational methods, we analyze the existence of ground state solutions, along with the regularity, symmetry, and decay properties of these solutions.

Quantitative stability of the Poincar\`{e}-Sobolev inequality on the hyperbolic space

Schedule: December 18 13:30-14:00 Conference Hall B (B)

Debabrata Karmakar
TIFR Centre for Applicable Mathematics
India

Co-Author(s): Mousomi Bhakta, Debdip Ganguly, Debabrata Karmakar, and Saikat Mazumdar

Abstract:

The classical Sobolev inequality in $\mathbb{R}^n$ states that the $L^{\frac{2n}{n-2}}$-norm of smooth compactly supported functions can be controlled, up to an optimal constant S, by the L^2-norm of their gradient. The explicit value of S is known, and the cases where equality holds have been obtained and classified as {\it Aubin-Talenti bubbles.} The question of quantitative stability and its applications has garnered significant interest in recent times. In this presentation, we will explain the question of the stability of the optimizers and their counterparts within the framework of the hyperbolic space.

Symmetry of Sobolev Extremals in the Hyperbolic space

Schedule: December 18 12:30-13:00 Conference Hall B (B)

Sandeep kunnath
TIFR Centre for Applicable Mathematics
India

Abstract:
Extremals of the Sobolev inequality in the Hyperbolic space satisfies a p-Laplace type equation. In this talk we investigate the radial symmetry of extremals of Sobolev inequality in the hyperbolic space or more generally the positive finite energy solutions of the corresponding Euler Lagrange equation. We prove using the moving plane method that the Solutions are radially symmetric with respect to a point in the hyperbolic space. The crucial ingredient in the proof is the sharp asymptotic estimates on the solution and its gradient at infinity, which depends crucially on a classification result for eigenfunctions of the p-Laplace equation in the hyperbolic space with a desired pole at infinity. This is a joint work with Ramya Datta.

Higher order semilinear equations on hyperbolic spaces

Schedule: December 18 13:00-13:30 Conference Hall B (B)

Jungang Li
University of Science and Technology of China
Peoples Rep of China

Abstract:
In this talk we will introduce some recent progress on higher order semilinear equations on hyperbolic spaces. Our results consists of the existence and symmetry of solutions to Br\`ezis-Nirenberg equations and Shr\odinger equations. Due to the complexity of hyperbolic spaces, classical variational methods such as the blow-up analysis and the mini-max theory have to be modified. Moreover, we will highlight the relation of this modification with the study of sharp Sobolev type inequalities on hyperbolic spaces. Part of these results are joint works with G. Lu. Q. Yang and Z. Wang.

Higher dimensional concentration for singularly perturbed coupled elliptic systems.

Schedule: December 18 14:45-15:15 Conference Hall B (B)

BHAKTI BHUSAN MANNA
IIT HYDERABAD
India

Co-Author(s): Alok Kumar Sahoo

Abstract:
In this talk, we shall discuss the existence of positive solutions and their concentration profile for the following problem: $-\varepsilon^2\Delta u + c(x)u = b(x)|v|^{q-1}v, \text{ and } -\varepsilon^2\Delta v + c(x)v = a(x)|u|^{p-1}u \quad \text{in } \Omega$, with Neumann boundary data on $\partial\Omega$. The domain is bounded, and the coefficients are considered smooth, positive and bounded. We shall first discuss the existence of positive solutions using some direct method of calculus of variations. Then, we explain the concentration profile of the solutions as the perturbation parameter converges to zero. Our emphasis will be on the dependence of the concentration profile on the coefficients. We conclude by applying the result for different kinds of higher dimensional concentrations for some coupled elliptic systems.

Compactness of conformal metrics with constant Q-curvature of higher order.

Schedule: December 18 15:45-16:15 Conference Hall B (B)

Saikat Mazumdar
Indian Institute of Technology Bombay
India

Co-Author(s): Bruno Premoselli

Abstract:
In this talk, we will consider the question of compactness for the higher-order Yamabe equation. This amounts to studying compactness (in C^2k) of nonnegative solutions of a $2k$-th order critical exponent elliptic equation, involving the GJMS operator, on a closed Riemannian manifold of dimension $\geq 2k+1$. Here k is a positive integer. We will assume positivity conditions on the GJMS operator and establish uniform bounds on the (geometric) solutions under appropriate geometric assumptions. This is a joint project with Bruno Premoselli (ULB Brussels).

An abstract multiplicity result with applications to critical growth elliptic problems

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Schedule: December 18 8:00-8:30 Conference Hall B (B)

Kanishka Perera
Florida Institute of Technology
USA

Abstract:
We present an abstract multiplicity theorem that can be used to obtain multiple nontrivial solutions of critical growth p-Laplacian type problems. We show that the problems considered here have arbitrarily many solutions for all sufficiently large values of a certain parameter $\lambda > 0$. In particular, the number of solutions goes to infinity as $\lambda \to \infty$. Moreover, we give an explicit lower bound on λ in order to have a given number of solutions.

Special Session 78 : Special Session on Mathematics of Data Science and Applications

Introduction: Over the last twenty years, data science, machine learning, and deep learning in particular, have begun transforming the global economy and modern life. While much attention is focused on empirical data mining success, there have been considerable mathematical structures and a growing body of mathematical theories about how the structures relate to observable properties of real-world systems. Discovering such structures may lead to important mathematical insights and implications for practitioners. This special session aims at interactions among approximation theory, deep neural networks, harmonic analysis, machine learning, numerical analysis, and statistics to foster further research in the fast-developing area of data science.

Enhanced Efficient Heterogeneous Graph Neural Networks

Schedule: December 18 9:30-10:00 Capital Suite 6

JIA CAI
Guangdong University of Finance and Economics
Peoples Rep of China

Co-Author(s): Ranhui Yan

Abstract:
Heterogeneous Graph Neural Networks (HGNNs) have shown powerful performance on heterogeneous graph learning by aggregating information from different types of nodes and edges. However, existing heterogeneous graph related models may confront with three major challenges: (1) Predefined meta-paths are required to capture the semantic relations between nodes from different types. (2) Existing models have to stack too many layers to learn long-range dependencies. (3) Performance degradation and semantic confusion may happen with the growth of the network depth. In this talk, we introduce two models to deal with the above-mentioned challenges. Specifically, we develop an end-to-end Dense connected Heterogeneous Graph Convolutional Network to learn node representations (Dense-HGCN). Dense-HGCN computes the attention weights between different nodes and incorporates the information of previous layers into each layer`s aggregation process via a specific fuse function. Moreover, Dense-HGCN leverages multi-scale information for node classification or other downstream tasks. Furthermore, we develop a Virtual Nodes based Heterogeneous Graph Convolutional Network (VN-HGCN). Virtual nodes are auxiliary nodes that are connected to all the nodes of a certain type in the graph, thus enabling efficient aggregation of long-range information across different types of nodes and edges.

Exploring the Optimal Choice for Generative Processes in Diffusion Models

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Schedule: December 17 8:30-9:00 Capital Suite 6

Yu Cao
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Jingrun Chen, Yixin Luo, and Xiang Zhou

Abstract:
The diffusion model has shown remarkable success in computer vision, but it remains unclear whether the ODE-based probability flow or the SDE-based diffusion model is more superior and under what circumstances. Comparing the two is challenging due to dependencies on data distributions, score training, and other numerical issues. In this talk, we will discuss a mathematical approach for this problem by considering two limiting scenarios: the zero diffusion (ODE) case and the large diffusion case. We will demonstrate that the time distribution of the score training error will determine the optimal dynamics in terms of minimizing the sampling error in the continuous-time setting. Numerical validation of this phenomenon is provided using various benchmark distributions, as well as realistic datasets.

Critical transitions in brain: modelling and control

Schedule: December 18 14:45-15:15 Capital Suite 6

Ting Gao
Huazhong University of Science and Technology
Peoples Rep of China

Abstract:
With the development of machine learning techniques, data-driven approaches are becoming increasingly important in real-world modeling with stochastic dynamical systems. However, in the field of neural science problems, these approaches are still in their early stages. We first review some neural inverse problems to deepen the understanding of neural dynamics in complex brain systems. Then we propose some applications to model tipping phenomena and optimal control in brain diseases. The methods include large deviation theory, optimal control, and Schrodinger bridge.

Pairwise learning problems with regularization networks and Nystrom subsampling approach

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Schedule: December 17 9:00-9:30 Capital Suite 6

Ting Hu
Xi`an Jiaotong University
Peoples Rep of China

Co-Author(s): Wang Cheng

Abstract:
Pairwise learning usually refers to the learning problem that works with pairs of training samples, such as ranking, similarity and metric learning, and AUC maximization. To overcome the challenge of pairwise learning in the large scale computation, this paper introduces Nystrom sampling approach to the coefficient-based regularized pairwise algorithm in the context of kernel networks. Our theorems establish that the obtained Nystrom estimator achieves the minimax error over all estimators using the whole data provided that the subsampling level is not too small. We derive the function relation between the subsampling level and regularization parameter that guarantees computation cost reduction and asymptotic behaviors` optimality simultaneously.The Nystrom coefficient-based pairwise learning method does not require the kernel to be symmetric or positive semi-definite, which provides more flexibility and adaptivity in the learning process. We apply the method to the bipartite ranking problem,which improves the state-of-the-art theoretical results in previous works.

An energy-stable machine-learning model of non-Newtonian hydrodynamics with molecular fidelity

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Schedule: December 18 15:15-15:45 Capital Suite 6

Huan Lei
Michigan State University
USA

Co-Author(s): Huan Lei

Abstract:
We introduce a machine-learning-based approach for constructing a continuum non-Newtonian fluid dynamics model directly from a micro-scale description. To faithfully retain molecular fidelity, we establish a micro-macro correspondence via a set of encoders for the micro-scale polymer configurations and their macro-scale counterparts, a set of nonlinear conformation tensors. The dynamics of these conformation tensors can be derived from a generalized extendable energy functional structure, and be learned from the micro-scale model with clear physical interpretation. The final model, named the deep non-Newtonian model (DeePN^2), takes the form of conventional non-Newtonian fluid dynamics models and ensures energy stability. Numerical results demonstrate the accuracy and robustness of DeePN^2.

Stochastic Gradient Methods: Bias, Stability and Generalization

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Schedule: December 18 8:00-8:30 Capital Suite 6

Yunwen Lei
The University of Hong Kong
Peoples Rep of China

Co-Author(s): Shuang Zeng

Abstract:
Recent developments of stochastic optimization often suggest biased gradient estimators to improve either the robustness, communication efficiency or computational speed. Representative biased stochastic gradient methods (BSGMs) include Zeroth-order stochastic gradient descent (SGD), Clipped-SGD and SGD with delayed gradients. The practical success of BSGMs motivates a lot of convergence analysis to explain their impressive training behaviour. As a comparison, there is far less work on their generalization analysis, which is a central topic in modern machine learning. In this paper, we present the first framework to study the stability and generalization of BSGMs for convex and smooth problems. We apply our general result to develop the first stability bound for Zeroth-order SGD with reasonable step size sequences, and the first stability bound for Clipped-SGD. While our stability analysis is developed for general BSGMs, the resulting stability bounds for both Zeroth-order SGD and Clipped-SGD match those of SGD under appropriate smoothing/clipping parameters. Furthermore, our stability analysis incorporates the training errors into the stability bounds and therefore can benefit from low noise conditions.

Learning, approximation and control

Schedule: December 18 15:45-16:15 Capital Suite 6

Qianxiao Li
National University of Singapore
Singapore

Abstract:
In this talk, we discuss some interesting problems and recent results on the interface of deep learning, approximation theory and control theory. Through a dynamical system viewpoint of deep residual architectures, the study of model complexity in deep learning can be formulated as approximation or interpolation problems that can be studied using control theory, but with a mean-field twist. In a similar vein, training deep architectures can be formulated as optimal control problems in the mean-field sense. We provide some basic mathematical results on these new control problems that so arise, and discuss some applications in improving efficiency, robustness and adaptability of deep learning models.

Beyond Unconstrained Features: Neural Collapse for Shallow Neural Networks with General Data

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Schedule: December 18 8:30-9:00 Capital Suite 6

Shuyang Ling
NYU Shanghai
Peoples Rep of China

Co-Author(s): Wanli Hong

Abstract:
Neural collapse is a phenomenon that occurs at the terminal phase of training of DNNs. The features of the data in the same class collapse to their respective sample means and the sample means exhibit an ETF. In the past few years, there have been a surge of works that focus on explaining why the $\mathcal{NC}$ occurs and how affects generalization. Since the DNNs is notoriously difficult to analyze, most works mainly focus on the unconstrained feature model (UFM). While the UFM explains the $\mathcal{NC}$ to some extent, it fails to provide a complete picture of how the network architecture and the dataset affect $\mathcal{NC}$. In this work, we focus on shallow ReLU neural network and try to understand how the width, depth, data dimension, and statistical property of the training dataset influence the neural collapse. We provide a complete characterization on when the $\mathcal{NC}$ occurs for two or three layer neural works. This sufficient condition depends on the data dimension, sample size, and the signal-to-noise ratio in the data instead of the width. For three-layer neural networks, we show that the $\mathcal{NC}$ occurs as long as the second-layer is sufficiently wide. Moreover, we show that even if the $\mathcal{NC}$ occurs, the generalization can still be bad provided that the SNR in the data is sufficiently lower. Our results significantly extend the state-of-the-art theoretical analysis of $\mathcal{NC}$ under UFM to shallow nonlinear feature models, and characterize the emergence of $\mathcal{NC}$ via data properties and network architecture.

A Generative Model-Based Variational Method for Wasserstein Gradient Flow

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Schedule: December 18 17:00-17:30 Capital Suite 6

Chengyu LIU
City University of Hong Kong
Hong Kong

Abstract:
In this work, we present a new generative model-based variational framework that utilizes Normalizing Flows (NFs) to solve Wasserstein Gradient Flows (WGFs), going beyond traditional chain-of-state methods by directly parameterizing the paths using the forward process of NFs as a representation of WGFs. Our approach enhances the capture of the Wasserstein Gradient Structure by incorporating an minimum action cost regularization term during the training of NFs. Additionally, we introduce an innovative adaptive sampling strategy that iteratively generates efficient stochastic collocation points, reflecting the evolving density estimates. This framework naturally incorporates the continuity equation within the network architecture, enabling the efficient estimation of high-dimensional density functions essential for free energy computations and improving the approximation of population dynamics. By integrating seamlessly with stochastic gradient descent techniques prevalent in deep learning, our method demonstrates robust performance on several illustrative problems, showcasing its potential in efficiently modeling the evolution of probability distributions in complex systems.

Error Analysis of Shallow Neural Network on Korobov Space

Schedule: December 18 12:30-13:00 Capital Suite 6

Yuqing Liu
City University of Hong Kong
Hong Kong

Abstract:
In this talk, an innovative approach and the result of the approximability of shallow neural networks on Korobov spaces will be presented. Then, the generalization analysis of shallow neural networks for classification on Korobov Space will be discussed. The talk is organized as follows. In the beginning, a dimensional independent rate of approximating functions from the Korobov space by ReLU shallow neural networks will be established. Following the first main result, a generalization error will be emphasized. A specific example will be given to justify the novelty and sufficiency of the main results. In addition, with the approximation error we get, we study the learning rates of the excess misclassification error according to the convex η-norm loss function $\phi(v) = (1-v)_+^{\eta}, \eta \geq 1$. The error under Tsybakov noise conditions is also discussed.

The Theory of Parameter Condensation in Neural Networks

Schedule: December 18 9:00-9:30 Capital Suite 6

Tao Luo
Shanghai Jiao Tong University
Peoples Rep of China

Abstract:
In this talk, we will first introduce the phenomenon of parameter condensation in neural networks, which refers to the tendency of certain parameters to converge towards the same values during training. Then, for certain types of networks, we prove that condensation occurs in the early stages of training. We further analyze which hyperparameters and training strategies influence parameter condensation. In some cases, we even provide a phase diagram that delineates whether parameter condensation occurs. We will also briefly discuss the relationship between parameter condensation and generalization ability. Finally, towards the end of the training, we study the set of global minima and present a detailed analysis of its geometric structure and convergence properties.

Approximation Rates for Shallow ReLUk Neural Networks on Sobolev Spaces via the Radon Transform

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Schedule: December 18 13:00-13:30 Capital Suite 6

Tong Mao
King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): J.W. Siegel, J. Xu

Abstract:
We consider the problem of how efficiently shallow neural networks with the ReLU^k activation function can approximate functions from Sobolev spaces $W^s(L_p(\Omega))$ with error measured in the $L_q(\Omega)$-norm. Utilizing the Radon transform and recent results from discrepancy theory, we provide a simple proof of nearly optimal approximation rates in a variety of cases, including when $q \leq p, p \geq 2$, and $s \leq k + (d+1)/2$. The rates we derive are optimal up to logarithmic factors, and significantly generalize existing results. An interesting consequence is that the adaptivity of shallow ReLU^k neural networks enables them to obtain optimal approximation rates for smoothness up to order $s = k + (d+1)/2$, even though they represent piecewise polynomials of fixed degree k.

Solving for the Mean Escape Time with Operator Learning and Deep Neural Networks

Schedule: December 18 13:30-14:00 Capital Suite 6

Nathanael Tepakbong
City University of Hong Kong
Hong Kong

Abstract:
Estimating the average amount of time needed for a stochastic particle to reach the boundary of a bounded domain Ω is a classical problem with applications in numerous fields. As there are no explicit solutions for this Mean Escape Time (MET) outside of the simplest domain geometries, practicioners have to rely on Monte Carlo simulations, series expansion ansatz, or grid-based methods which generally scale poorly with problem size and lack strong theoretical guarantees. By considering the MET as the solution of a PDE induced by the stochastic dynamics of the particle, we propose to learn the solution operator of the PDE by applying dimension reduction tools and Deep Learning. Leveraging results from the approximation theory of Deep Neural Networks, we provide a rigorous theoretical analysis of the sample complexity associated with the MET problem in our framework for different families of stochastic dynamics and domain geometries.

Towards generative diffusion models in infinite dimension

Schedule: December 17 9:30-10:00 Capital Suite 6

Zhongjian Wang
Nanyang Technological University
Singapore

Abstract:
We provide an estimate of Wasserstein distance between data distribution and generation of score-based generative models in the infinite dimensional function space. The bound only assumes the ϵ-accurate approximation of score and Gaussian type tail behavior of the data distribution. The key in the analysis is the Lipchitz bound of the score which relates to the Hessian estimate of a viscous Hamilton Jacobian equation (vHJ). The later is shown by utilizing a kernel estimate that is independent of dimension. Our complexity bound scales linearly with the trace of a covariance operator relates to the data distribution.

Approximation from Noisy and Blurring Data

Schedule: December 17 8:00-8:30 Capital Suite 6

Jianbin Yang
Hohai University, China
Peoples Rep of China

Abstract:
Approximation of functions from observed data is often needed. This has been widely studied in the literature when data is exact and the underlying function is smooth. However, the observed data is often contaminated with noise and the underlying function may be nonsmooth. To properly handle noisy and blurring data, any effective approximation scheme must contain a noise removal component. To well approximate nonsmooth functions, one needs to have a sparse approximation in, for example, the wavelet domain. This talk presents theoretical analysis and applications of such noise removal schemes through the lens of function approximation. For a given sample size, approximation from uniform grid data and scattered data is investigated.

The role of structures in neural networks

Schedule: December 18 14:00-14:30 Capital Suite 6

Ding-Xuan Zhou
dingxuan.zhou@sydney.edu.au
Australia

Abstract:
The classical approximation theory developed 35 years ago is for fully-connected neural networks. This theory does not apply to neural networks with structures arising from applications of deep learning in speech recognition, computer vision, natural language processing, and many other domains. The structures and related network architectures raise some essential differences between the classical fully-connected neural networks and structured ones used in deep learning. This talk describes some approximation and generalization properties of structured neural networks such as deep convolutional neural networks.

StringNET: Neural Network based Variational Method for Transition Pathways

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Schedule: December 18 16:15-16:45 Capital Suite 6

Xiang ZHOU
City University of Hong Kong
Hong Kong

Co-Author(s): Jiayue Han, Shuting Gu and Xiang Zhou

Abstract:
Rare transition events in meta-stable systems under noisy fluctuations are crucial for many non-equilibrium physical and chemical processes. The primary contributions to reactive flux are predominantly near the transition pathways that connect two meta-stable states. This work examines the temperature-dependent maximum flux path, the minimum energy path, and the minimum action path at zero temperature. We propose the StringNET method for training these paths using variational formulations and deep learning techniques. Unlike traditional chain-of-state methods, StringNET directly parametrizes the paths through neural network functions, utilizing the arc-length parameter as the main input. The tasks of gradient descent and re-parametrization in the string method are unified into a single framework using loss functions to train deep neural networks. More importantly, the loss function for the maximum flux path is interpreted as a softmax approximation to the numerically challenging minimax problem of the minimum energy path. To compute the minimum energy path efficiently and robustly, we developed a pre-training strategy that includes the maximum flux path loss in the early training stage, accelerating the computation. We demonstrate the superior performance of this method through various analytical and chemical examples, as well as the two- and four-dimensional Ginzburg-Landau functional energy.

Special Session 79 : Delayed Reaction-Diffusion Equations and Applications

Introduction: This special session aims to bring together researchers interested in the mathematical modeling and analysis of reaction-diffusion equations with time delays. The session will provide a platform for sharing recent progresses on analyzing the dynamics and applications of these equations in fields such as ecology, epidemiology, population dynamics and related areas. Topics of interest include the study of the qualitative and quantitative analysis on dynamics for delayed reaction-diffusion equations, as well as their practical implications in understanding and predicting complicated phenomena in natural systems.

Bogdanov-Takens bifurcation and multi-peak spatiotemporal staggered periodic patterns in a nonlocal Holling-Tanner predator-prey model

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Schedule: December 16 18:30-19:00 Capital Suite 12 B

Xun Cao
Harbin Institute of Technology
Peoples Rep of China

Abstract:
In this talk, we will discuss spatiotemporal dynamics of a reaction-diffusion Holling-Tanner predator-prey model with nonlocal prey competition involving purely spatial heat kernel. Firstly, the first bifurcation curve is mathematically described, that is a piecewise smooth parameter curve of dividing the stability and instability of the coexistence equilibrium. The concepts of Turing/Hopf instability are extended to the higher codimension bifurcation instability, because the non-smooth points of the first bifurcation curve can be Bogdanov-Takens/Turing-Hopf/Hopf-Hopf instability point. Then, utilizing normal form method, spatiotemporal dynamics near Z_2 symmetric Bogdanov-Takens singularity are theoretically and numerically studied, including the stable coexistence of a pair of steady states with the shape of $\cos(\frac{2x}{l})$ and a spatiotemporal staggered periodic solution with the shape of $\cos(\omega t)\cos(\frac{2x}{l})$. It is found that the larger the spatial size of a habitat is, the more complex the distributions of a species can be, while too narrow or wide range of nonlocal interactions inhibit the formations of complex spatiotemporal patterns.

Steady-state bifurcation and spike pattern in the Klausmeier-Gray-Scott model with non-diffusive plants

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Schedule: December 16 15:15-15:45 Capital Suite 12 B

Weihua Jiang
Harbin Institute of Technology
Peoples Rep of China

Abstract:
We studied the Klausmeier-Gray-Scott model with non-diffusive plants, which is a coupled ODE-PDE system. We first established the critical conditions for instability of the constant steady state in general coupled ODE-PDE activator-inhibitor systems. In addition, the local structure of the nonconstant steady state and the condition to determine the local bifurcation direction were obtained. Secondly, for the model with non-diffusive plants, the Turing bifurcation was subcritical and the nonconstant steady-state bifurcation solutions were unstable. Finally, we investigated the spatial pattern of the model with slowly diffusive plants to understand the formation of the spike pattern of the model with non-diffusive plants.

Global dynamics and asymptotic spreading of a diffusive age-structured model in spatially periodic media

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Schedule: December 16 16:15-16:45 Capital Suite 12 B

Hao Kang
Tianjin University
Peoples Rep of China

Co-Author(s): Hao Kang and Shuang Liu

Abstract:
The paper is concerned with the persistence and spatial propagation of populations with age structure in spatially periodic media. We first provide a complete characterization of the global dynamics for the problem via investigating the existence, uniqueness and global stability of the nontrivial equilibrium. This leads to a necessary and sufficient condition for populations to survive, in term of the principal eigenvalue of the associated linearized problem with periodic condition. We next establish the spatial propagation dynamics for the problem and derive the formula for the asymptotic speed of spreading. The result suggests that the propagating fronts of populations are uniform for all age groups with a common spreading speed. Our approach is to develop the theory of generalized principal eigenvalues and the homogenization method via overcoming some new challenges arising from the nonlocal age boundary condition.

Accelerating propagation in the periodic Fisher-KPP equation with nonlocal dispersal

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Schedule:

NA LI
Harbin institute of Technology
Peoples Rep of China

Abstract:
This talk is devoted to the problem how the tail of the nonlocal dispersal kernel influences the propagation speed of the Fisher-KPP equation in time periodic environment. When the nonlocal dispersal kernel is exponentially bounded, applying the monotone dynamical system theory, we prove that the solution level set is asymptotically linear in time. When the nonlocal dispersal kernel is exponentially unbounded, the solution level set propagates with an infinite asymptotic speed. Further, based on a heaviness characterization for the kernel tail, we establish the fine estimates of the fundamental solution and then determine sharp bounds for the solution level set by constructing subtle upper and lower solutions. The bounds are expressed in terms of the decay of the nonlocal dispersal kernel.

Lattice-based stochastic models motivate non-linear diffusion descriptions of memory-based dispersal

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Schedule: December 16 18:00-18:30 Capital Suite 12 B

Yifei Li
Harbin Institute of Technology
Peoples Rep of China

Co-Author(s): Matthew J Simpson, Chuncheng Wang

Abstract:
The role of memory and cognition in the movement of individuals (e.g. animals) within a population, is thought to play an important role in population dispersal. In response, there has been increasing interest in incorporating spatial memory effects into classical partial differential equation (PDE) models of animal dispersal. However, the specific detail of the transport terms, such as diffusion and advection terms, that ought to be incorporated into PDE models to accurately reflect the memory effect remains unclear. To bridge this gap, we propose a straightforward lattice-based model where the movement of individuals depends on both on crowding effects and the historic distribution within the simulation. The advantage of working with the individual-based model is that it is straightforward to propose and implement memory effects within the simulation in a way that is more intuitive than proposing extensions of classical PDE models. Through deriving the continuum limit description of our stochastic model we obtain a novel nonlinear diffusion equation which encompasses memory-based diffusion terms. In this talk I will show the relationship between memory-based diffusion and the individual-based movement mechanisms that depend upon memory effects.

A reaction-diffusion model with spatially inhomogeneous delays

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Schedule: December 16 17:30-18:00 Capital Suite 12 B

Yijun Lou
The Hong Kong Polytechnic University
Hong Kong

Abstract:
Motivated by population growth in a heterogeneous environment, this talk presents a reaction-diffusion model with spatially dependent parameters. In particular, a term for spatially uneven maturation durations is included in the model, which puts the current investigation among the very few studies on reaction-diffusion systems with spatially dependent delays. Rigorous analysis is performed, including the well-posedness of the model, the basic reproduction ratio formulation and long-term behavior of solutions. Under mild assumptions on model parameters, extinction of the species is predicted when the basic reproduction ratio is less than one. When the birth rate is an increasing function and the basic reproduction ratio is greater than one, uniqueness and global attractivity of a positive equilibrium can be established with the help of a novel functional phase space. Permanence of the species is shown when the birth function is in a unimodal form and the basic reproduction ratio is greater than one. The synthesized approach proposed here is applicable to broader contexts of studies on the impact of spatial heterogeneity on population dynamics, in particular, when the delayed feedbacks are involved and the response time is spatially varying.

Dynamics of reaction diffusion equations with memory-based diffusions

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Schedule: December 16 17:00-17:30 Capital Suite 12 B

Chuncheng Wang
Harbin Institute of Technology
Peoples Rep of China

Co-Author(s): Chuncheng Wang

Abstract:
In this talk, a class of reaction diffusion equations with memory-based diffusions is considered.The principle of linearized stability and the theory of normal form is established. In addition, the global boundedness of solutions is also proved. These are joint works with Junping Shi, Hao Wang, Yanhui Fan and Xuanyu Liu.

Spatial dynamics for time-periodic partially degenerate reaction-diffusion systems

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Schedule: December 16 15:45-16:15 Capital Suite 12 B

Shi-Liang Wu
Xidian University
Peoples Rep of China

Abstract:
Partially degenerate reaction-diffusion systems (i.e., reaction-diffusion systems with some but not all diffusion coefficients being zeros) arises from may particular fields, such as biology and epidemiology. In this talk, we introduce some results on spatial dynamics for time-periodic partially degenerate reaction-diffusion systems.

Special Session 80 : Nonlinear dynamics of particle systems and fluids

Introduction: Nonlinear systems are found in many areas like physics, biology, engineering, economics, and social sciences. They show us how complex nature can be. In this session, we plan to explore the complex behaviors of particles and fluid flow that are controlled by nonlinear events. We hope this meeting will lead to new research ideas and help us find new ways to solve the complex problems of nonlinear dynamics in particles and fluids.

High Reynolds number limit of 2D Boltzmann equation

Schedule: December 18 9:00-9:30 Conference Hall B (C)

Gi-Chan Bae
Seoul National University / Research institute of Mathematics
Korea

Co-Author(s): Chanwoo Kim

Abstract:
We prove the hydrodynamic limit of the 2D Boltzmann equation to the incompressible Euler equation in a periodic box. This is joint work with Chanwoo Kim.

Mathematical Analysis of Some Models of Active Matter

Schedule: December 18 8:00-8:30 Conference Hall B (C)

Hantaek Bae
Ulsan National Institute of Science and Technology
Korea

Co-Author(s): Young-Pil Choi, Kyungkeun Kang, Woojae Lee

Abstract:
Active matter theories have made remarkable progress in understanding the dynamics of suspension of active polar particles such as fish school, locust swarm, and bird flock. The large scale behavior of active matter systems can be described by continuum models which describe the evolution of slow variables such as the number density and the velocity field. In this talk, we introduce some some recents results on these continuum models.

Interaction of Rigid Ball and Incompressible Fluid

Schedule: December 18 13:00-13:30 Conference Hall B (C)

Hyeong-Ohk Bae
Ajou University
Korea

Co-Author(s): Bum Ja Jin

Abstract:
We talk the large time behavior of the solutions of the Stokes fluid-solid system. We compute the asymptotic expansion of the solution for L^q integrable initial data U_0. We show that the asymptotic profile of the solution is a linear combinations of the Stokes fundamental solution for the data with extra condition $|x|U_0 \in L^1$. We also show that L^1 integrability of the solution is strongly related to the net force exerted by the fluid on the boundary of the solid.\

High order conservative semi-Lagrangian schemes for the ES-BGK model of the Boltzmann equation

Schedule: December 18 9:30-10:00 Conference Hall B (C)

Seung Yeon Cho
Department of Mathematics, Gyeongsang National University
Korea

Co-Author(s): Sebastiano Boscarino, Giovanni Russo, Seok-Bae Yun

Abstract:
In this talk, we introduce finite difference high order conservative semi-Lagrangian schemes for the ellipsoidal BGK model of the Boltzmann equation. To avoid the time step restriction induced by the convection term, we adopt the semi-Lagrangian approach. For treating the nonlinear stiff relaxation operator with small Knudsen number, we employ high order L-stable diagonally implicit Runge-Kutta time discretization or backward difference formula. The proposed implicit scheme is designed to update solutions explicitly without resorting to any Newton solver. We present several numerical tests to demonstrate the accuracy and efficiency of the proposed method. In particular, we show that our method is able to capture the behavior of Navier-Stokes equations for moderate values of Knudsen number, and provide good approximation of the solution to Boltzmann equation for relatively large values of Knudsen number.

Liouville-type theorems for the stationary Navier-Stokes equations

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Schedule: December 18 18:00-18:30 Conference Hall B (C)

Youseung Cho
Yonsei University
Korea

Co-Author(s): Jiri Neustupa, Minsuk Yang

Abstract:
In this talk, we consider the Liouville-type theorems for the stationary Navier-Stokes equations. The classical Liouville theorem states that any bounded and entire holomorphic function must be constant. In recent times, the Liouville theorem has been developed for elliptic equations. We discuss the conditions that guarantees the triviality of the solution of the Navier-Stokes equations. This talk is based on the joint work with Professor Ji\v{r}\`{\i} Neustupa and Minsuk Yang.

Emergent dynamics of infinitely many Kuramoto oscillators

Schedule: December 18 14:45-15:15 Conference Hall B (C)

Seung Yeal Ha
Seoul National University
Korea

Co-Author(s): Euntaek Lee, Woojoo Shim

Abstract:
In this talk, we propose an infinite Kuramoto model for a countably infinite set of Kuramoto oscillators and study its emergent dynamics for two classes of network topologies. For a class of symmetric and row (or columm)-summable network topology, we show that a homogeneous ensemble exhibits complete synchronization, and the infinite Kuramoto model can cast as a gradient flow, whereas we obtain a weak synchronization estimate, namely practical synchronization for a heterogeneous ensemble. Unlike with the finite Kuramoto model, phase diameter can be constant for some class of network topologies which is a novel feature of the infinite model. We also consider a second class of network topology (so-called a sender network) in which coupling strengths are proportional to a constant that depends only on sender`s index number. For this network topology, we have a better control on emergent dynamics. For a homogeneous ensemble, there are only two possible asymptotic states, complete phase synchrony or bi-cluster configuration in any positive coupling strengths. In contrast, for a heterogeneous ensemble, complete synchronization occurs exponentially fast for a class of initial configuration confined in a quarter arc. This is a joint work with Euntaek Lee (SNU) and Woojoo Shim (Kyungpook National University).

Local bifurcation for the one dimensional Gray-Scott model

Schedule: December 18 12:30-13:00 Conference Hall B (C)

Jongmin Han
Kyung Hee University
Korea

Co-Author(s): Yuncherl Choi, Taeyoung Ha, Sewoong Kim, Doo Seok Lee

Abstract:
In this talk, we consider the local bifurcation near a ciritical control parmanter for the one dimensional Gray-Scott model. We study the bifurcation at both simple and double eigenvalues of the linearized operator at a constant solution. We show that the constant solution bifurcates to an attractor which determines final patterns of solutions.

Vanishing angular singularity limit for the Boltzmann equation without angular cutoff

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Schedule: December 18 8:30-9:00 Conference Hall B (C)

Jin Woo Jang
POSTECH
Korea

Co-Author(s): Bernhard Kepka, Alessia Nota, Juan J. L. Velazquez

Abstract:
In this talk, we will discuss the vanishing angular singularity limit of the Boltzmann equation. We first recall the derivation of Boltzmann`s collision kernel for inverse power law interactions $U_s(r) = 1/r^{s-1}$ for $s > 2$ in dimension $d = 3$. Then we study the limit of the non-cutoff kernel to the hard-sphere kernel. We also give precise asymptotic formulas of the singular layer near the angular singularity in the limit $s \to \infty$. Consequently, we show that solutions to the homogeneous Boltzmann equation converge to the respective solutions weakly in L^1 globally in time as $s \to \infty$ by looking at Arkeryd`s construction of a weak solution to the Boltzmann equation for hard-sphere collisions and Villani`s construction of an entropy solution for the Boltzmann equation for long-range inverse-power law potential. The spatially inhomogeneous case is still open.

Analysis of score-based diffusion models with multiplicative noise conditioning

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Schedule: December 18 15:45-16:15 Conference Hall B (C)

Doheon Kim
Hanyang University
Korea

Co-Author(s): Doheon Kim

Abstract:
Score-based diffusion models generate new samples by learning the score associated with a diffusion process. When the score is accurately approximated, the effectiveness of these models can be theoretically justified using differential equations related to the sampling process. Despite this, empirical evidence shows that models employing neural networks with multiplicative noise conditioning can still produce high-quality samples, even when their capacity is clearly insufficient to learn the correct score. We offer a theoretical explanation for this phenomenon by examining the qualitative behavior of the differential equations governing the diffusion processes, utilizing appropriate Lyapunov functions for analysis.

Asymptotic convergence of the heterogeneous first-order aggregation models: from the sphere to the unitary group

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Schedule: December 18 15:15-15:45 Conference Hall B (C)

Dohyun Kim
Sungkyunkwan University
Korea

Co-Author(s): Hansol Park

Abstract:
In this talk, we establish the convergence toward equilibrium for heterogeneous multi-agent systems on the unit sphere and the unitary group that can be understood as (small) perturbation of gradient flows. Due to the heterogeneity, one could expect that all relative distances converge to definite values and furthermore that each agent converges to a possibly different stationary point. For the desired convergence, we use the lifting method and dimension reduction method for the cases of the unit sphere and unitary group, respectively. This talk is based on the joint work with Dr. Hansol Park (Dalhousie University).

Interpolation inequalities in Lorentz spaces and their applications to a Stokes-Magneto system with fractional diffusions

Schedule: December 18 13:30-14:00 Conference Hall B (C)

Hyunseok Kim
Sogang University
Korea

Abstract:
It has been recently shown that the classical interpolation inequalities due to Ladyzhenskaya and Gagliardo-Nirenberg can be refined by using weak L^p-norms. The goal of the talk is to present further refinements via general Lorentz spaces. We provide interpolation inequalities in Sobolev-Lorentz spaces of arbitrary orders, as special cases of more general results on Triebel-Lizorkin-Lorentz spaces. Then as an application, we study global weak solutions to a Stokes-Magneto system with fractional diffusions.

Asymptotic behavior toward viscous shock for impermeable wall and inflow problems of barotropic Navier-Stokes equations

Schedule: December 18 14:00-14:30 Conference Hall B (C)

Jeongho Kim
Kyung Hee University
Korea

Co-Author(s): Xushan Huang, Moon-Jin Kang, Jeongho Kim and Hobin Lee

Abstract:
We consider the compressible barotropic Navier-Stokes equations in a half-line and study the time-asymptotic behavior toward the outgoing viscous shock wave. Precisely, we consider the two boundary problems: impermeable wall and inflow problems, where the velocity at the boundary is given as a constant state. For both problems, when the asymptotic profile determined by the prescribed constant states at the boundary and far-fields is a viscous shock, we show that the solution asymptotically converges to the shifted viscous shock profiles uniformly in space, under the condition that initial perturbation is small enough in H^1 norm. We do not impose the zero-mass condition on initial data, which improves the previous results by Matsumura and Mei \cite{MM99} for impermeable case, and by Huang, Matsumura and Shi \cite{HMS03} for inflow case. Moreover, for the inflow case, we remove the assumption $\gamma \leq 3$ in \cite{HMS03}. Our results are based on the method of a-contraction with shifts, as the first extension of the method to the boundary value problems.

Nontopological bubbling solutions for Chern-Simons system of rank 2

Schedule: December 18 17:00-17:30 Conference Hall B (C)

Namkwon Kim
Chosun university
Korea

Abstract:
We consider Chern-Simons gauge theory of rank two in the whole space. There are three types of solutions for the system. We deal with nontopological solutions among others. To understand the structure of the solutions space, It is helpful to understand bubbling solutions. We present complete classification of bubbling solutions for the system and, in particular, present existence theory for the $SU(3)$, $SO(5)$, and G_2 system.

Physics-informed Neural Networks for the Pseudo two dimensional model of Lithium ion battery

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Schedule: December 18 16:15-16:45 Conference Hall B (C)

Myeong-Su Lee
Korea Advanced Institute of Science and Technology
Korea

Co-Author(s): Youngjoon Hong, and Jaemin Oh

Abstract:
The pseudo-two-dimensional (P2D) model is a mathematical model that describes the electrochemical processes in Li-ion batteries. Thi model is composed of multiple nonlinear partial differential equations and nonlinear relations, such as the Butler-Volmer equation. In this talk, we investegate the application of Physics-informed neural networks(PINNs) for solving P2D model. Due to the aformentioned nonlinearities in the P2D model, the standard approach often lead to inaccurate solutions. To address these issues, we introduce additional strategies: (1) the incorporation of bypassing terms and (2) the implementation of secondary conservation laws, aimed at improving the stability and accuracy of the PINNs. We first show the efficiency and importance of these strategies through simple toy examples. And then, we present simulation results for the P2D model using PINNs enhanced with our proposed strategies.

Stability and optimal temporal decay result for the 3D Boussinesq equations with horizontal dissipation in anisotropic Sobolev spaces

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Schedule: December 18 17:30-18:00 Conference Hall B (C)

Bataa Lkhagvasuren
Chonnam National University
Korea

Co-Author(s): Hyeong-Ohk Bae, Bataa Lkhagvasuren

Abstract:
In this talk, we consider 3D anisotropic Boussinesq equations with horizontal dissipation. We prove that, for the perturbed equations, the time global solution exists for small initial data in the anisotropic Sobolev spaces $H^{0,s}$ with $\frac{1}{2} < s$ and the corresponding solution of the unperturbed equations approaches the hydrostatic equilibrium. Moreover, the optimal decay result is obtained in the anisotropic Sobolev spaces $H^{0,s}$, extending the result of isotropic Sobolev spaces.

Special Session 81 : Reaction-(cross-)diffusion models in mathematical biology

Introduction: The analysis of reaction-diffusion systems has been playing an essential role in the understanding of population dynamics at macroscopic levels. Accordingly, various classes of parabolic problems have been at the core of a meanwhile considerable number of models for spatio-temporal evolution processes at virtually all length- and timescales, where especially also certain cross-diffusive mechanisms have turned out to be essential ingredients for adequate descriptions in numerous cases. In this special session it is planned to inspire a discourse on recent developments in this persistently growing area, and to stimulate an exchange of ideas and especially of different analytical approaches. A special focus will be on the discussion of methodological aspects and on an appropriate balance between presentations of experienced experts on the one hand, and the inclusion of young researchers on the other.

Critical mass in quasilinear Keller-Segel systems

Schedule: December 19 18:30-19:00 Capital Suite 13

Xinru Cao
Donghua University
Peoples Rep of China

Abstract:
We present some results in quasilinear Keller-Segel systems.

Shrinking vs. expanding: the evolution of spatial support in degenerate Keller-Segel systems

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Schedule: December 19 16:15-16:45 Capital Suite 13

Mario Fuest
Leibniz University Hannover
Germany

Co-Author(s): Frederic Heihoff

Abstract:
We consider radially symmetric solutions to a degenerate parabolic--elliptic Keller--Segel system in bounded balls with initial data having compact support. Our main result shows that the initial evolution of the positivity set is essentially completely determined by the flatness/steepness of the initial data near a boundary point x_0 of the support. If they are sufficiently flat (respectively, steep), the support shrinks (respectively, expands) near x_0. We give concrete conditions for both behaviors and in particular show that there is a critical exponent and a critical parameter distinguishing between these cases. The proof is based on constructing suitable sub- and supersolutions to a transformed problem.

Long time dynamics for the Cauchy problem of the predator-prey model with cross-diffusion

Schedule: December 19 13:30-14:00 Capital Suite 13

Chunhua Jin
South China Normal University
Peoples Rep of China

Co-Author(s): Yifu Wang

Abstract:
In this talk, we focuses on the long-time dynamic behavior of the Cauchy problem related to a pursuit-evasion predator-prey model in N-dimensional spaces with $1 \leq N \leq 3$. The system clearly adheres to the law of mass conservation, as evidenced by the fact that the L^1- norm remains constant. Our findings reveal that any global strong solution of this system converges to to the heat kernel in the sense of L^p-norm for any $1 \leq p \leq \infty$. We also provide estimates on the decay rate of the solution, and obtain estimates on the decay rate of the solution that are consistent with those of the heat equation in $\mathbb{R}^N$ ($N = 2, 3$), indicating their optimality. However, unfortunately, for one-dimensional case, despite our attempts to provide decay rate estimates, it is evident that this rate is not optimal. Additionally, as a supplementary result, we also verify the global existence and long-time asymptotic behavior of strong solutions for small initial values.

Boundedness criterion for the three-species food chain model with taxis mechanisms: analysis and applications

Schedule: December 19 15:45-16:15 Capital Suite 13

Haiyang Jin
South China University of Technology
Peoples Rep of China

Co-Author(s): Feifei Zou

Abstract:
In this talk, we shall investigate a three-species food chain model with taxis mechanisms including prey-taxis and alarm-taxis in a smooth bounded domain with homogeneous Neumann boundary conditions.More precisely, we first establish the boundedness criterion for a general food chain model with various taxis mechanisms for arbitrary spatial dimensions by using the semirgoup estimates and coupled energy estimates. With the boundedness criterion in hand, we use the weighted energy estimates to show the global boundedness of solution for general functional response functions under some smallness assumptions on the taxis coefficients. On the other hand, for some special functional response functions including Beddington-DeAngelis type, ratio-dependent type and Harrison type, we also obtain the global existence of solution with uniform-in-time bound without any smallness assumptions on the taxis coefficients or initial data.

Taxis models on an ecological scale

Schedule: December 19 18:00-18:30 Capital Suite 13

Johannes Lankeit
Leibniz University Hannover
Germany

Abstract:
In this talk, I will present systems with chemotaxis-like cross-diffusion, whose interpretation stems from ecology. One system of particular interest to this talk involves so-called `alarm-taxis`. I will discuss questions of solvability (in different senses).

Traveling waves to a logarithmic chemotaxis model with fast diffusion and singularities

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Schedule: December 19 14:00-14:30 Capital Suite 13

Jingyu Li
Northeast Normal University
Peoples Rep of China

Co-Author(s): Xiaowen Li, Dongfang Li, Ming Mei

Abstract:
We are concerned with a chemotaxis model with logarithmic sensitivity and fast diffusion, which possesses strong singularities for the sensitivity at zero-concentration of chemical signal, and for the diffusion at zero-population of cells, respectively. The main purpose is to show the existence of traveling waves connecting the singular zero-end-state, and particularly, to show the asymptotic stability of these traveling waves. The challenge of the problem is the interaction of two kinds of singularities involved in the model: one is the logarithmic singularity of the sensitivity; and the other is the power-law singularity of the diffusivity. To overcome the singularities for the wave stability, some new techniques of weighted energy method are introduced artfully.

Critical blow-up exponent in a nonlinear chemotaxis system with indirect signal production

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Schedule: December 19 13:00-13:30 Capital Suite 13

Yuxiang Li
School of Mathematics, Southeast University
Peoples Rep of China

Co-Author(s): Taian Jin, Jianlu Yan

Abstract:
In this talk, we investigate the Neumann initial-boundary value problem for the following nonlinear chemotaxis system with indirect signal production:

$$\{ u_t = \Delta u - \nabla \cdot (f(u)\nabla v) \, , \; 0 = \Delta v - \mu(t) + w, \; w_t + w = u \qquad (\star)$$

in $\Omega \subset \mathbb{R}^n$ for $n \geq 2$. Here, $\mu(t) :=$ \fint$_\Omega w(x,t)\,\mathrm{d}x$ and $f \in C^2([0,\infty))$ is a nonnegative function. We establish the following results: \begin{itemize} \item If $\Omega = B_R(0)$ for some $R > 0$ and $f(s) \geq ks^p$ for all $s \geq 1$ with constants $k > 0$ and $p > \frac{2}{n}$, then there exist radially symmetric initial data for which the corresponding solution blows up in finite time, regardless of the mass level $m := \int_\Omega u_0 \,\mathrm{d}x > 0$. \item If $f(s) \leq K(s+1)^p$ for all $s \geq 0$ with constants $K > 0$ and $p < \frac{2}{n}$, then for any appropriately regular initial data, the corresponding solution exists globally and remains bounded. \end{itemize} Our findings extend the results of Tao and Winkler (2017) regarding blow-up phenomena for $(\star)$ with $f(u) = u$ in the two-dimensional setting.

Global classical solutions to a triply haptotactic cross-diffusion system modeling oncolytic virotherapy

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Schedule: December 20 8:00-8:30 Capital Suite 13

Suying Liu
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Xueli Bai, Fang Li, Jiale Shi

Abstract:
In this talk, we consider a triply haptotactic cross-diffusion system, which is proposed to describe the interaction among uninfected cancer cells, infected cancer cells, extracellular matrix (ECM) and oncolytic virus particles in oncolytic virotherapy. Our main result asserts that, in the two dimensional domain, an associated initial-boundary value problem has a unique classical solution, which exists globally and is uniformly bounded under suitable assumptions on the parameters and initial data of the system.

The Keller-Segel-Navier-Stokes system in bounded Lipschitz domains

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Schedule: December 19 8:30-9:00 Capital Suite 13

Patrick Tolksdorf
Karlsruhe Institute of Technology
Germany

Co-Author(s): Matthias Hieber, Hideo Kozono, Sylvie Monniaux

Abstract:
We study the coupled Keller-Segel-Navier-Stokes system in bounded Lipschitz domains. It is shown that the system admits local strong as well as global strong solutions for small data in the setting of critical Besov spaces. Moreover, non-trivial equilibria are shown to be exponentially stable. For smoother data, these solutions are shown to be globally bounded and to preserve positivity properties. The approach is based on optimal L^q-regularity properties of the Neumann Laplacian and the Stokes operator on bounded Lipschitz domains.

An SIS epidemic model with cross-diffusion: applications to quarantine measures

Schedule: December 19 15:15-15:45 Capital Suite 13

Zhi-An Wang
The Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Jiawei Chu

Abstract:
In this talk, we shall discuss an SIS modelwith a cross-diffusion dispersal strategy for the infected individuals describing the public health intervention measures (like quarantine) during the outbreak of infectious diseases. The model adopts the frequency-dependent transmission mechanism and includes demographic changes (i.e. population recruitment and death) subject to homogeneous Neumann boundary conditions. We establish the existence of globally bounded classical solutions and define the basic reproduction number R_0 by a weighted variational form. by a change of variable and the index theory along with the principal eigenvalue theory, we establish the threshold dynamics in terms of R_0. The global stability of the unique disease-free equilibrium and constant endemic equilibrium under some conditions is also obtained. Finally, we discuss some open questions and use numerical simulation to demonstrate the applications of our analytical results.

The qualitative analysis to a doubly degenerate chemotaxis-consumption system on non-convex domain

Schedule: December 19 16:45-17:15 Capital Suite 13

Duan Wu
Paderborn university
Peoples Rep of China

Co-Author(s): Tobias Black, Shohei Kohatsu

Abstract:
In this talk, we consider a doubly degenerate chemotaxis-consumption system in non-convex domain when $N \geq 2$. We prove that for any suitably regular initial data, this system admits global bounded weak solutions. Furthermore, we also study the large time behavior for the solutions we obtained by using the Moser iteration technique and obtaining a new Harnack-type inequality.

Liouville theorem for the fractional reaction-diffusion equations

Schedule: December 19 14:30-15:00 Capital Suite 13

Leyun Wu
South China University of Technology
Peoples Rep of China

Co-Author(s): Wenxiong Chen and Pengyan Wang

Abstract:
In this talk, I will introduce some Liouville theorems for fractional reaction-diffusion equations. First, I will present some key ingredients such as maximum principles for anti-symmetric functions and narrow region principles, then demonstrate how to derive the monotonicity and nonexistence of solutions to fractional reaction-diffusion equations in the whole space or in a half space.

Global existence and stabilization of solutions to a Keller-Segel-(Navier-)Stokes system with prescribed signal concentration on the boundary

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Schedule: December 19 17:30-18:00 Capital Suite 13

Zhaoyin Xiang
University of Electronic Science and Technology of China
Peoples Rep of China

Co-Author(s): Yifei Sun, Yu Tian

Abstract:
In this talk, we focus on the Keller-Segel-(Navier-)Stokes system with tensor-valued sensitivity and logistic source in a bounded domain $\Omega \subset \mathbb{R}^N$ subject to no-flux/Dirichlet/Dirichlet boundary conditions for cells/signal/fluid, respectively. We will show that when $N = 2$, the Keller-Segel-Navier-Stokes system admits a global bounded classical solution for any regular initial data. When $N = 3$ similar conclusion holds for the Keller-Segel-Stokes system provided that the logistic damping is strong enough in some sense. We will also give some stabilization analysis under some additional assumptions. This is a joint work with Dr Yifei Sun and Dr Yu Tian.

Boundedness and finite-time blow-up in a repulsion-consumption system with nonlinear chemotactic sensitivity

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Schedule: December 19 19:00-19:30 Capital Suite 13

Ziyue Zeng
School of Mathematics, Southeast University
Peoples Rep of China

Co-Author(s): Yuxiang Li

Abstract:
In this presentation, we will discuss recent progress for a repulsion-consumption system with nonlinear chemotactic sensitivity. The consumption system differs from Keller-Segel production systems, and the literature on solutions for consumption systems primarily focuses on global existence. Inspired by [J. Ahn and M. Winkler, Calc. Var. 64 (2023).] and [Y. Wang and M. Winkler, Proc. Roy. Soc. Edinburgh Sect. A, 153 (2023).], we investigate the effect of the nonlinear chemotactic sensitivity $S(u) = (1+u)^{\beta}$ on the occurrence of blow-up phenomenon for the repulsion-consumption parabolic-elliptic system and establish the boundedness of solutions for the repulsion-consumption system to find the critical exponent. Under radially symmetric assumptions, we prove that 1) The signal consumption equation is elliptic and $n = 2$. For $\beta > 1$ and the boundary signal level large enough, the corresponding radially symmetric solution blows up in finite time. 2) When the signal consumption equation is elliptic or parabolic and $n \geq 2$. For $\beta \in \left(0, \frac{n+2}{2n}\right)$ the problem $(\star)$ possesses a global bounded classical solution.

Global well-posedness for the 2D chemotaxis-Euler system with logistic source for large initial data

Schedule: December 19 9:00-9:30   Capital Suite 13

Qian Zhang
Hebei University
Peoples Rep of China

Co-Author(s): Peiguang Wang

Abstract:
In this paper, the two-dimensional incompressible chemotaxis-Euler system with logical source is studied as following:

$$\{ n_t + u \cdot \nabla n = \Delta n - \nabla \cdot (n \nabla c) + n - n^3, \qquad c_t + u \cdot \nabla c = \Delta c - nc, \; u_t + u \cdot \nabla u + \nabla P = -n \nabla \phi, \qquad \nabla \cdot u = 0.$$

By taking advantage of a coupling structure of the equations and using a scale decomposition technique, the global existence and uniqueness of weak solutions to the above system for large initial data is obtained.

Localization in space and Cauchy problem of chemotaxis system with logistic source

Schedule: December 19 8:00-8:30   Capital Suite 13

Xiaoxin Zheng
Beihang University
Peoples Rep of China

Co-Author(s): Yao Nie

Abstract:
In this talk, we consider Cauchy problem of chemotaxis system with logistic source. In terms of the nonlocal effect of the logistic source and maximal regularity for the heat kernel, we establish the global-in-time bound of smooth solution.

Special Session 82 : Recent Advances in Nonlinear PDEs and Free Boundary Problems

Introduction: This session will showcase the current trends, challenges, and breakthroughs in Nonlinear PDEs and Free Boundary Problems, emphasizing their applications in various scientific disciplines. It aims to cover developments related to the existence, regularity and further qualitative properties of solutions alongside an in-depth look at Free Boundary Problems of both local and nonlocal types.

Nonlinear gradient estimates for degenerate elliptic equations with nonstandard growth

Schedule: December 16 14:45-15:15 Capital Suite 4

Sun-Sig Byun
Seoul National University
Korea

Co-Author(s): Sun-Sig Byun

Abstract:
This talk is primarily concerned with providing an optimal regularity theory for nonlinear elliptic equations with matrix weights

Regularity Results for Stationary Mean-Field Games with Logarithmic Couplings

Schedule: December 16 14:00-14:30 Capital Suite 4

Diogo Gomes
KAUST
Saudi Arabia

Co-Author(s): Tigran Bakaryan and Giuseppe Di Fazio

Abstract:
In this joint work with Tigran Bakaryan and Giuseppe Di Fazio, we present recent findings on the regularity properties of stationary mean-field games (MFGs) on the torus, focusing on systems with Lipschitz non-homogeneous diffusion and logarithmic-like couplings. The goal is to bridge the gap between known low-regularity results for bounded diffusions and the smooth solutions typically associated with the Laplacian. By employing the Hopf-Cole transformation, we reformulate the system into a scalar elliptic equation, enabling us to establish the existence of $C^{1,\alpha}$ solutions. These results have significant implications for understanding the fine structure of equilibria in MFG models, especially in applications with non-linear and non-smooth dynamics.

Existence of weak solutions of nonlinear drift-diffusion equations

Schedule: December 16 17:30-18:00 Capital Suite 4

Sukjung Hwang
Chungbuk National University
Korea

Abstract:
In this presentation, we discuss recent existence results for porous medium and fast diffusion equations with a divergence-type drift term, which are widely applicable to various reaction-diffusion equations, including Keller-Segel models. Our focus is on identifying suitable functional spaces for the drift, primarily determined by the nonlinear diffusion and the initial data. By adapting techniques from Wasserstein spaces, we construct weak solutions and establish some regularity properties of the solutions.

One bubble dynamics for the Sobolev critical fast diffusion equation in bounded domains

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Schedule: December 16 13:30-14:00 Capital Suite 4

Tianling Jin
The Hong Kong University of Science and Technology
Hong Kong

Co-Author(s): Jingang Xiong

Abstract:
We will discuss the extinction behavior of nonnegative solutions to the Sobolev critical fast diffusion equation in bounded smooth domains with the Dirichlet zero boundary condition. Under the two-bubble energy threshold assumption on the initial data, we will show the dichotomy that every solution converges uniformly, in terms of relative error, to either a steady state or a blowing-up bubble.

The Well-posedness of Cylindrical Jets with Surface Tension

Schedule: December 16 15:45-16:15 Capital Suite 4

Aram Karakhanyan
The University of Edinburgh
Scotland

Co-Author(s): Dr Yukon Huang

Abstract:
In 1879 Rayleigh studied the stability of infinite cylindrical jets, inspired by the experiments of Plateau. The principal question that Rayleigh asked is: under what circumstances the jet is stable, for small displacements. In this talk I will discuss the short time stability for the initial condition belonging to some Sobolev space, and the initial jet boundary being uniformly bounded away from the axis of symmetry. This is proved by the method of paradifferential calculus and paralinearization. The salient feature of these results is that no smallness assumption is imposed on the initial condition. The results are taken from a joint paper with Dr Yucong Huang.

Sharp regularity for singular/degenerate fully nonlinear free boundary problems with singular absorption terms

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Schedule: December 16 18:00-18:30 Capital Suite 4

Seunghyun Kim
Seoul National University
Korea

Co-Author(s): Jose Miguel Urbano

Abstract:
We investigate the sharp local regularity of viscosity solutions to singular or degenerate fully nonlinear elliptic free boundary problems with singular absorption terms. By employing suitable substitutions and the Ishii-Lions method, we establish regularity estimates for the associated auxiliary problems. Additionally, we explore the parabolic case.

A Free Boundary Problem with Nonlocal Obstacle

Schedule: December 16 16:15-16:45 Capital Suite 4

Hayk Mikayelyan
University of Nottingham Ningbo China
Peoples Rep of China

Co-Author(s): Michel Chipot, Zhilin Li

Abstract:
Consider the following optimal minimization problem in the cylindrical domain $\Omega = D \times (0,1)$:

$$\min_{\bar{\mathcal{R}}_\beta^D} \Phi(f)$$

where

$$\bar{\mathcal{R}}_\beta^D = \left\{ f(x) \in L^\infty(\Omega) : f(x', x_n) = f(x'),\ 0 \le f \le 1,\ \int_D f dx = \beta \right\},$$

$u_f \in W_0^{1,2}(\Omega)$ is the unique solution of $\Delta u_f = 0$, and $\Phi(f) = \int_\Omega |\nabla u_f|^2 dx$. We show the existence of the unique minimizer. Moreover, we show that for a particular $\alpha > 0$ the function $U = \alpha - u_f$ minimizes the functional with nonlocal obstacle acting on function $V(x') = \int_0^1 U(x', t) dt$

$$\int_\Omega \frac{1}{2} |\nabla U(x)|^2 dx + \int_D V(x')^+ \, dx',$$

and solves the equation

$$\Delta U(x', x_n) = \chi_{\{V>0\}}(x') + \chi_{\{V=0\}}(x')[\partial_\nu U(x', 0) + \partial_\nu U(x', 1)],$$

where $\partial_\nu U$ is the exterior normal derivative of U. Several further regularity results are proven. It is shown that the comparison principle does not hold for minimizers, which makes numerical approximation we developed in [LM] somewhat challenging.

Keywords: rearrangement problems, free boundary, nonlocal obstacle

MSC Classification: 35R11, 35J60, 35R35, 35B51, 49J20, 65N06

[CM] Chipot, Michel; Mikayelyan, Hayk, *On some nonlocal problems in the calculus of variations*, Nonlinear Anal. 217 (2022), Paper No. 112754, 17 pp.

[LM] Li, Zhilin; Mikayelyan, Hayk, *Numerical analysis of a free boundary problem with non-local obstacles*, Appl. Math. Lett. 135 (2023), Paper No. 108414, 6 pp.

[M] Mikayelyan, Hayk, *Cylindrical optimal rearrangement problem leading to a new type obstacle problem*, 2018, ESAIM - Control, Optimisation and Calculus of Variations. 24, 2, p. 859-872 14 p.

Variational principles in mean-field games and related problems

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Schedule: December 16 18:30-19:00 Capital Suite 4

Levon Nurbekyan
Emory University
USA

Abstract:
Mean-field game (MFG) systems are challenging nonlinear PDEs, often requiring a non-standard analysis approach. In this talk, I`ll discuss several variational principles for MFG that substantially aid the analyses by importing tools from the calculus of variations. I`ll also discuss ensuing future research directions.

Regularity results for n-Laplace systems with antisymmetric potential

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Schedule: December 16 13:00-13:30 Capital Suite 4

Armin Schikorra
University of Pittsburgh
USA

Abstract:
n-Laplace systems with antisymmetric potential are known to govern geometric equations such as n-harmonic maps between manifolds and generalized prescribed H-surface equations. Due to the nonlinearity of the leading order n-Laplace and the criticality of the equation they are very difficult to treat. I will discuss some progress we obtained, combining stability methods by Iwaniec and nonlinear potential theory for vectorial equations by Kuusi-Mingione. Joint work with Dorian Martino

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Elliptic regularity estimates with optimized constants and applications

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Schedule: December 16 15:15-15:45 Capital Suite 4

Boyan Sirakov
PUC-Rio
Brazil

Co-Author(s): Philippe Souplet

Abstract:
We revisit the classical theory of linear second-order uniformly elliptic equations in divergence form whose solutions have H\older continuous gradients, and prove versions of the generalized maximum principle, the $C^{1,\alpha}$-estimate, the Hopf-Oleinik lemma, the boundary weak Harnack inequality and the differential Harnack inequality, in which the constant is optimized with respect to the norms of the coefficients of the operator and the size of the domain. Our estimates are complemented by counterexamples which show their optimality. We also give applications to the Landis conjecture and spectral estimates.

Special Session 83 : Optimal Control Theory and Applications

Introduction: The new developments in the theory of optimal control and its applications to life science, medicine, and economics will be presented on this session.

Finding Optimal Treatment Protocols in Adaptive Prostate Cancer Therapy

Schedule: December 19 17:30-18:00 Conference Hall B (C)

Ellina Grigorieva
Texas Woman’ s University
USA

Co-Author(s): Khailov Evgenii

Abstract:
Most patients diagnosed with prostate cancer (PC) are cured with surgery or radiation therapy. Those with metastases or relapse require additional systemic hormonal therapy. Unfortunately, over time, cancer cells develop resistance, which is usually first clinically observed as a rise in PSA levels followed by disease progression. Drug resistance varies from patient to patient, ranging from a few months to two years. The role of intermittent (adaptive) therapy~(IAS), as opposed to continuous hormonal therapy~(CAS), is currently being actively studied to prolong quality of life and investigate the sensitivity of PC to pharmacological intervention. IAS stops hormonal therapy when a clinical goal is reached or PSA levels fall. Then, after a certain period of time, when the cancer returns or the PSA threshold~ rerises, this process continues in a cyclical manner until resistance develops and the disease treatment requires other medical interventions. During IAS, patients are switched between on and off therapy according to the PSA threshold or alternately at regular intervals until treatment becomes ineffective. In this study, we constructed a bilinear control model that describes the relationship between a population of androgen-dependent cancer cells and two populations of androgen-independent cancer cells, both during and without hormonal therapy. Using the properties of the reachable set and Pontryagin maximum principle, we solve an optimal control problem of minimization of the total cancer load at the end of the treatment period and answer the following important questions: 1) will a certain treatment (such as CAS or IAS) be effective? 2) how long will it take for the treatment to become effective? 3) what is the optimal schedule for the on`` and off`` periods?

On Optimal Control Problem related to the Infinity Laplacian

Schedule: December 19 18:30-19:00 Conference Hall B (C)

Henok Z Mawi
Howard University
USA

Co-Author(s): Cheikh Ndiaye

Abstract:
The infinity Laplacian equation is given by

$$\Delta_\infty u := u_{x_i} u_{x_j} u_{x_i x_j} = 0 \qquad \text{in} \quad \Omega$$

where Ω is an open bounded subset of $\mathbb{R}^n$. This equation is a kind of an Euler-Lagrange equation of the variational problem of minimizing the functional

$$I[v] := \text{ess sup}\,|Dv|,$$

among all Lipschitz continuous functions v, satisfying a prescribed boundary value on $\partial\Omega$. The infinity obstacle problem is the minimization problem

$$\min\{I[v] : v \in W^{1,\infty}, \quad v \geq \psi\}$$

for a given function $\psi \in W^{1,\infty}$ which we refer to as the \emph{obstacle}. In this talk we will discuss an optimal control problem related to the infinity obstacle problem.

Optimal Control of Personal Protective Costs for Dengue Prevention

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Schedule: December 19 18:00-18:30 Conference Hall B (C)

Helena Sofia Rodrigues
Polytechnic Institute de Viana do Castelo and CIDMA- University of Aveiro
Portugal

Co-Author(s): Artur M. C. Brito da Cruz

Abstract:
Dengue fever is a widespread vector-borne disease with significant economic impacts, particularly in endemic regions. This study examines the costs and effects of individual protective behaviors aimed at reducing mosquito bites and preventing dengue transmission. An epidemiological model is developed, incorporating human and mosquito populations to simulate the dynamics of dengue transmission. The model focuses on personal protection measures, including the use of insect repellent, treated clothing, and treated bed nets. The study evaluates the associated household costs of these self-protection strategies and their effectiveness in controlling the disease. Results show that personal protective measures can reduce the number of infected individuals and shorten the duration of outbreaks. However, the costs of these measures can place a financial strain on households, influencing the adoption of protective behaviors and potentially affecting the disease`s progression.

Optimal control of an infinite-dimensional problem with a state constraint arising in the spatial economic growth theory

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Schedule: December 19 19:00-19:30 Conference Hall B (C)

Weihua Ruan
Purdue University Northwest
USA

Co-Author(s): Raouf Boucekkine and Carmen Camacho

Abstract:
We use Ekeland`s variational principle together with Pontryagin`s maximum principle to solve an optimal spatiotemporal economic growth model with a state constraint (no-negative capital stock) where capital law of motion follows a diffusion equation. We obtain the set of necessary optimal conditions for the solution to meet the state constraints for all time and locations. The maximum principle allows to reduce the infinite-horizon optimal control problem into a finite-horizon one ultimately leading to prove the uniqueness of the optimal solution with positive capital, and non-existence of the optimal solution with eventually strictly positive capital when the time discount rate is too large or too small.

Special Session 84 : Regularity results of solutions of problems having nonstandard growth and nonuniform ellipticity

Introduction: In continuation with the session of the previous edition, AIMS WILMINGTON 2023, in the session the organizers focus the attention in the vaste problem of regularity for minimizers of quadratic and nonquadratic growth functionals where the integrand is dependent on x,u, Du. Is pointed out that about the dependence on the variable x is assumed only that A(x ,u, p) is in the class VMO, Vanishing Mean Oscillation class, as a function of x. Namely, is not assumed the continuity of A(x, u, p) with respect to x. Are considered both partial and global regularity of the minimizer u . Keywords:: minimizer, partial and boundary regularity MSC2010 Classification: 49N60, 35J50.

Relationship Between Dynamical System and Algebra

Schedule: December 16 13:30-14:00 Capital Suite 15

Ahmad M Alghamdi
Umm Al-Qura University
Saudi Arabia

Co-Author(s): -------------

Abstract:
The aim of the talk is to discuss the strong relationship between dynamical system and group action on a non-empty set. Let G be a group and X be a non-empty set. The notion of the action of G on the set X is very important in mathematics. If X has also an algebraic structure then such action is more important. For instance, if X is a vector space or a group or a topological structure and so on. The symmetric structure of the notion of groups reflects a lot of behaviours and results which are related to the so-called orbits, stabilizer, fixed points and invariants. On the other hand, dynamical system meets with group action in many places as it studies the evolution and the symmetry for discrete and continuous objects. We believe that the relationship between dynamical systems and algebra is very strong and we are searching in this direction. In this talk, we shall represent examples and environment in which such relationship makes sense and try to envisage common analytical process to exploit this connexion. We shall mention also the relationship between dynamical systems with: ergodic , topology, geometry, logic, numbers, probability, analysis, and category.

Relationship Between Dynamical Systems and Algebra

Schedule: December 16 14:00-14:30 Capital Suite 15

Ahmad M Alghamdi
Umm Al-Qura University
Saudi Arabia

Co-Author(s): ---------------------------------------

Abstract:
The aim of the talk is to discuss the strong relationship between dynamical system and group action on a non-empty set. Let G be a group and X be a non-empty set. The notion of the action of G on the set X is very important in mathematics. If X has also an algebraic structure then such action is more important. For instance, if X is a vector space or a group or a topological structure and so on. The symmetric structure of the notion of groups reflects a lot of behaviours and results which are related to the so-called orbits, stabilizer, fixed points and invariants. On the other hand, dynamical system meets with group action in many places as it studies the evolution and the symmetry for discrete and continuous objects. We believe that the relationship between dynamical systems and algebra is very strong and we are searching in this direction. In this talk, we shall represent examples and environment in which such relationship makes sense and try to envisage common analytical process to exploit this connexion. We shall mention also the relationship between dynamical systems with: ergodic , topology, geometry, logic, numbers, probability, analysis, and category.

Fractional Sobolev spaces and zeta functions

Schedule: December 16 13:00-13:30 Capital Suite 15

Emanuel Guariglia
Wenzhou-Kean University
Peoples Rep of China

Abstract:
This talk deals with fractional Sobolev spaces and zeta functions. The main properties of this fractional derivative are given and discussed. Moreover, we prove some results linked with the introduction of a new function space. Finally, we discuss fractional calculus of zeta functions and the class of zeta functions in a fractional Sobolev space.

A rigidity result for Kolmogorov-type operators

Schedule: December 16 16:15-16:45 Capital Suite 15

Alessia Kogoj
University of Urbino
Italy

Co-Author(s): E.Lanconelli

Abstract:
Let D be a bounded open subset of $\mathbb{R}^N$ and let z_0 be a point of D. Assume that the Newtonian potential of D is proportional outside D to the potential of a mass concentrated at z_0. Then D is a Euclidean ball centred at z_0. This theorem, proved by Aharonov, Shiffer and Zalcman in 1981, was extended to the caloric setting by Suzuki and Watson in 2001. In this talk we extend the Suzuki--Watson Theorem to a class of hypoellliptic operators of Kolmogorov-type.

Strong maximum principle and Harnack inequality for classical solutions to subelliptic partial differential equations

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Schedule: December 16 15:15-15:45 Capital Suite 15

Sergio Polidoro
Dipartimento FIM - Universit\`{a} di Modena e Reggio Emilia
Italy

Abstract:
Mean value formulas for classical solutions to degenerate linear second order equations in divergence form have been proved in a study in collaboration with Diego Pallara. These results heavily rely on the De Giorgi`s perimeters theory and on its extension to Carnot groups. Based on the classical PDEs theory and on the above mentioned mean value formulas, strong maximum principle and Harnack inequality for classical solutions to stationary subelliptic partial differential equations on Carnot groups have been recently proved by Giulio Pecorella in {\it Fundamental solution, maximum principle and Harnack inequality for second order subelliptic operators} (to appear on Journal of Elliptic and Parabolic Equations). Analogous results have been proved by Annalaura Rebucci in {\it Harnack inequality and maximum principle for degenerate Kolmogorov operators in divergence form} JMAA 128371 (2024) for degenerate Kolmogorov equations. In this seminar we give an overview of the state of research on this subject.

On regularity results of solutions of minimizers of systems having discontinuous coefficients

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Schedule: December 16 12:30-13:00 Capital Suite 15

Maria Alessandra Ragusa
University of Catania
Italy

Abstract:
Is showed a problem studied in cooperation with Professor Atsushi Tachikawa. We treat the regularity problem for minimizers u(x) of quadratic and nonquadratic growth functional having integrand A(x, u, Du). We point out that concerning the dependence on the variable x is assumed only that A(x,u, p) is in the class of Vanishing Mean Oscillation class, as a function of x. Namely, is not assumed the continuity of A(x, u, p) with respect to x. Are treated partial regularity and global regularity of the minimizer u.

Existence results for some classes of nonlinear problems

Schedule: December 16 15:45-16:15 Capital Suite 15

Andrea Scapellato
University of Catania
Italy

Abstract:
The talk deals with some existence results for different classes of nonlinear problems driven by p-Laplacian-type operators. We also examine some multiplicity results. In some cases, the Ambrosetti-Rabinowitz condition is not imposed. Moreover, we present a problem related to the nonlocal fractional $p(\cdot)$-Laplacian.

Multiplicity of solutions for certain types of nonlinear p-laplacian problems

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Schedule: December 16 14:45-15:15 Capital Suite 15

Angela Sciammetta
University of Palermo
Italy

Abstract:
The talk addresses various existence and multiplicity results for different classes of Laplacian problems with Dirichlet boundary conditions. Specifically, we prove the existence of two nontrivial weak solutions, both with and without assuming the Ambrosetti-Rabinowitz condition. Additionally, we establish the existence of three solutions for a specific class of Laplacian problems.

Special Session 85 : New Trends in The Mathematical Modeling of Epidemiology and Immunology

Introduction: The COVID-19 pandemic has made it abundantly clear that mathematical modeling is an indispensable tool for public health professionals and decision-makers. Optimal management of any infectious disease requires the synchronization of epidemiological and immunological findings. To this end, we have organized a special session featuring renowned scientists in the field of mathematical modeling of infectious diseases. Our aim is to showcase their latest research on the spread of diseases in the population, as well as the human immune system (adaptive and humoral). The contributors will employ a variety of mathematical approaches, including ordinary and delay differential equations, partial differential equations, hybrid models, and optimal control approaches.

Unraveling Dengue Dynamics with Data Calibration from Palu and Jakarta: Optimizing Active Surveillance and Fogging Interventions

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Schedule: December 16 15:15-15:45 Capital Suite 9

Dipo Aldila
Universitas Indonesia
Indonesia

Co-Author(s): Joseph Paez Chavez, Chidozie W. Chukwu, Athaya Y. Fathiyah, Juni W. Puspita, Putri Z. Kamalia

Abstract:
In this talk, we examine the role of active case finding and mosquito population reduction through fogging in dengue control using a mathematical model approach. Active case finding aims to identify undetected dengue cases, both asymptomatic and symptomatic, which can help prevent further transmission and reduce the likelihood of severe symptoms by enabling earlier treatment. The model was developed using a system of nine-dimensional nonlinear ordinary differential equations. We conducted a mathematical analysis of the equilibria and their stability based on the basic reproduction number ($\mathcal{R}_0$). Our analysis shows that the disease-free equilibrium is locally asymptotically stable when $\mathcal{R}_0

The effect of model structure and data availability on virus dynamics at three biological scales

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Schedule: December 16 13:00-13:30 Capital Suite 9

Stanca M Ciupe
Virginia Tech
USA

Co-Author(s): Nora Heitzman-Breen; Yuganthi R. Liyanage; Nisha Duggal; Necibe Tuncer

Abstract:
Understanding the epidemiology of emerging vector-borne pathogens in avian populations requires systems investigation at each scale involved in the host, virus transmission cycle, from individual bird infections, to bird-to-vector transmissions, and to viral incidence in bird and vector populations. For new pathogens field data are sparse, and predictions can be aided by the use of laboratory-type inoculation and transmission experiments combined with dynamical mathematical modelling. In this talk, I will present the differences in the dynamics of two strains of such a pathogen - the Usutu virus. I will construct mathematical models for the within-host scale, bird-to-vector transmission scale and vector-borne epidemiological scale and use individual within-host infectious virus data and per cent mosquito infection data to predict virus incidence in birds and mosquitoes. I will address the dependence of predictions on model structure, data uncertainty and experimental design.

Modelling of the spread of diseases with time-change processes

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Schedule: December 16 17:30-18:00 Capital Suite 9

Jasmina Dordevic
Faculty of Sciences and Mathematics, University of Nis
Yugoslavia

Co-Author(s): Giulia Di Nunno, Nenad \v Suvak

Abstract:
The stochastic version of the SIRV (susceptible-infected-recovered- vaccinated) model in the population of non-constant size and finite period of immunity is considered. Among many parameters, the most important is the contact rate, i.e. the average number of adequate contacts of an infective person. It is expected that this parameter exhibits time-space clusters which reflects in interchanging periods of low and steady transmission and periods of high and volatile transmission of the disease. The stochastics in the SIRV model considered here comes from the noise represented as the sum of the conditional Brownian motion and Poisson random field, closely related to the corresponding time-changed Brownian motion and the time-changed Poisson random measure. From a modeling perspective, incorporating time-charged noise is an effective method for capturing temporal dependencies in noise, such as clustering and stretching periods.. The existence and uniqueness of positive global solution of the stochastic SIRV process is proven by classical techniques. Furthermore, persistence and extinction of infection in population in long-run scenario are analyzed.

Threshold dynamics in a periodic epidemic model with imperfect quarantine, isolation and vaccination

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Schedule: December 16 18:00-18:30 Capital Suite 9

Mahmoud A. Ibrahim
Bolyai Institute, university of Szeged
Hungary

Abstract:
In this talk, I will present a non-autonomous mathematical model that explore the complex dynamics of disease spread over time, incorporating a time-periodic transmission parameter and imperfections in quarantine, isolation and vaccination strategies. Through a detailed examination of threshold dynamics, it is revealed that the global dynamics of disease transmission are influenced by the basic reproduction number ($\mathcal{R}_0$), a critical threshold that determines extinction, persistence, and the presence of periodic solutions. It is shown that the disease-free equilibrium is globally asymptotically stable if $\mathcal{R}_0 1$. To support and validate our analytical results, the basic reproduction number and the dynamics of the disease are estimated by fitting monthly data from two Asian countries, namely Saudi Arabia and Pakistan. Furthermore, a sensitivity analysis of the time-averaged reproduction number ($\langle \mathcal{R}_0 \rangle$) of the associated time-varying model showed a significant sensitivity to key parameters such as infection rates, quarantine rate, vaccine coverage rate, and recovery rates, supported by numerical simulations. These simulations validate theoretical findings and explore the impact of seasonal contact rate, imperfect quarantine, isolation, imperfect vaccination, and other parameters on the dynamics of measles transmission. The results show that increasing the rate of immunization, improving vaccine management, and raising public awareness can reduce the incidence of the epidemic. The study highlights the importance of understanding these patterns to prevent future periodic epidemics.

Delay induced periodic solutions in a dendritic cell therapy model

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Schedule: December 16 12:30-13:00 Capital Suite 9

Yang Kuang
Arizona State University
USA

Co-Author(s): Lauren R. Dickman and Yang Kuang

Abstract:
We formulate a tumor-immune interaction model with a constant delay (time needed for a dendritic cell to become an effector cell) to capture the behavior following application of a dendritic cell therapy. The model is validated using experimental data from melanoma- induced mice. Through theoretical and numerical analyses, the model is shown to produce rich dynamics, such as a Hopf bifurcation and bistability. We provide thresholds for tumor existence and, in a special case, tumor elimination. Our work indicates a sensitivity in model outcomes to the immune response time. We provide a stability analysis for the high tumor equilibrium. For small delays in response, the tumor and immune system coexist at a low level. Large delays give rise to fatally high tumor levels. Our computational and theoretical work reveals that there exists an intermediate region of delay that generates complex oscillatory, even chaotic, behavior. The model then reflects uncertainty in treatment outcomes for varying initial tumor burdens, as well as tumor dormancy followed by uncontrolled growth to a lethal size, a phenomenon seen in vivo. Theoretical and computational analyses suggest efficacious treatments to use in conjunction with the dendritic cell vaccine. Analysis of a highly aggressive tumor confirms the importance of representation with a time delay, as periodic solutions are generated when a delay is present.

Analysis of Malaria Model Using Deep Learning

Schedule:

Manoj Kumar
IIT Madras Zanzibar
Tanzania

Co-Author(s): Manoj Kumar, Adithya Rajnarayanan

Abstract:
Malaria is one of the deadliest diseases in the world, every year millions of people become victims of this disease and out of these millions thousands of people become victims of this disease. In this work, the dynamics of malaria is analyzed using deep learning by implementing the SIR-SI compartment model. The main factor that controls disease transmission is the transmission rate and two of the most important factors that influence the transmission rate are temperature and altitude, thus in this work the transmission rate is analyzed with respect to temperature and altitude. We have performed the stability analysis of steady state solutions. After the mathematical analysis, Artificial neural network (ANN) was applied to the formulated model to predict the trajectory of all of the five compartments. As mentioned earlier the dynamics of disease are controlled by the parameters associated with the disease transmission and thus in this work three different neural network architectures namely Artificial neural network (ANN), convolution neural network (CNN), and Recurrent neural network (RNN) have been built to estimate these parameters from the trajectory of the data.

Threshold Dynamics in a Within-Host Infection Model with Crowley-Martin Functional Response Considering Periodic Effects

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Schedule: December 16 14:00-14:30 Capital Suite 9

Ibrahim Nali
University of Szeged
Hungary

Co-Author(s): Monika polner, Attila d\`{e}nes, Abdessamad tridane

Abstract:
We present a mathematical model for within-host viral infections that incorporates the Crowley-Martin functional response, focusing on the dynamics influenced by periodic effects. This study establishes key properties of the model, including the existence, uniqueness, positivity, and boundedness of periodic orbits within the non-autonomous system. We demonstrate that the global dynamics are governed by the basic reproduction number, denoted as $\mathcal{R}_0$, which is calculated using the spectral radius of an integral operator. Our findings reveal that $\mathcal{R}_0$ serves as a threshold parameter: when $\mathcal{R}_0 < 1$, the virus-free periodic solution is globally asymptotically stable, indicating that the infection will die out. Conversely, if $\mathcal{R}_0 > 1$, at least one positive periodic solution exists, and the disease persists uniformly, with trajectories converging to a limit cycle. Additionally, we provide numerical simulations that support and illustrate our theoretical results, enhancing the understanding of threshold dynamics in within-host infection models.

Stability switches induced by immune system boosting in an SIRS model with delays

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Schedule: December 16 15:45-16:15 Capital Suite 9

M\`onika Polner
Bolyai Institute, University of Szeged
Hungary

Co-Author(s): M. V. Barbarossa and G. R\ost

Abstract:
We consider an epidemiological model that includes waning and boosting of immunity. Assuming that repeated exposure to the pathogen fully restores immunity, we derive an SIRS-type model with discrete and distributed delays. First we prove usual results, namely that if the basic reproduction number, $\mathcal{R}_0$, is less or equal than 1, then the disease free equilibrium is globally asymptotically stable, whereas for $\mathcal{R}_0 > 1$ the disease persists in the population. The interesting features of boosting appear with respect to the endemic equilibrium, which can go through multiple stability switches by changing the key model parameters. We construct two-parameter stability charts, showing that increasing the delay can stabilize the positive equilibrium. Increasing $\mathcal{R}_0$, the endemic equilibrium can cross two distinct regions of instability, separated by Hopf bifurcations. Our results show that the dynamics of infectious diseases with boosting of immunity can be more complex than most epidemiological models and calls for careful mathematical analysis.

Mathematical Modeling of addiction with frequency of contact incidence term

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Schedule: December 16 16:15-16:45 Capital Suite 9

Ghilmana Sarmad
UAE University
United Arab Emirates

Co-Author(s): Dr. Abdessamad Tridane

Abstract:
This work proposes a novel approach for examining a SATR model using epidemiological modeling. Using a convex incidence function, which is a measure of the frequency of interaction between an addict and a non-addict, we want to explore the dynamics of addiction transmission within a community. We establish the well-posedness of the model, which ensures the existence, uniqueness, and positivity of the solution. We also determine the next-generation operator, which allows us to calculate $\mathcal{R}_0$, the fundamental reproduction number. We examine in detail how $\mathcal{R}_0$ serves as a threshold quantity to regulate the behavior of the addiction. Specifically, we show that when $\mathcal{R}_0 < 1$, the addiction-free steady state is globally asymptotically stable for all values of q. Conversely, we establish the uniform persistence of the associated equilibrium when $\mathcal{R}_0 > 1$ and construct a steady state of addiction that is globally asymptotically stable for all values of q. We also analyze the asymptotic profile of the addiction stable state, considering the effects of small and high addiction rates on the state dynamics. To validate our theoretical findings, we provide numerical simulations that both confirm our findings and provide additional insights into the dynamics of the addiction.

Mathematical analysis of a generalized nonlocal dispersion epidemic model

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Schedule: December 16 14:45-15:15 Capital Suite 9

Abdessamad Tridane
United Arab Emirates University
United Arab Emirates

Abstract:
This work investigates a generalized nonlocal dispersion epidemic model subject to the Neumann boundary conditions and spatial heterogeneity. We use a convolution operator to describe the nonlocal spatial movements of individuals. Our primary goal is to investigate this model, focusing on a generalized incidence function, which presents an additional challenge in the model analysis. We also investigate the existence and uniqueness of an endemic steady state and study the significant effects of dispersal rates on the asymptotic profiles of the steady endemic state. Finally, we discussed the global asymptotic behavior of the solution for different dispersal coefficients.

Traveling Wave Speed and Profile of Rabies Model: Insights from the Go or Grow Hypothesis

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Schedule: December 16 13:30-14:00 Capital Suite 9

Aisha Tursynkozha
Nazarbayev University
Kazakhstan

Co-Author(s): Yang Kuang, Ardak Kashkynbayev

Abstract:
Rabies is a viral infection that affects the central nervous system, primarily transmitted through direct contact with infected animals. The disease exhibits a characteristic traveling wave pattern of spread, which can be effectively captured through mathematical modeling. In this work, we propose a two-population reaction-diffusion model for the red fox based on the Go or Grow hypothesis, which incorporates the movement and interaction between susceptible and infectious populations. Using approximation methods, we analyze various traveling wave solutions and provide new insights into the progression of the infection, offering a more accurate representation of rabies spread.

Understanding Seasonal Variations of Dengue in Brazil

Schedule: December 16 18:30-19:00 Capital Suite 9

Mondal H Zahid
University of Florida
USA

Co-Author(s): Mondal Hasan Zahid, Bachir Asao Neino, Bernardo Garcia Carreras, Angkana T. Huang, Matt D T Hitchings, Derek A T Cummings

Abstract:
The timing of peak dengue cases in Brazil remains inconsistent from year to year. Our analysis of surveillance data from 2000 to 2014 reveals this variability both over time and across states. We hypothesise that several factors, including climate variability, the circulation of different dengue serotypes, and the introduction of new serotypes may be driving the shifting. To better understand these dynamics, we employed temperature-driven multi-strain dengue transmission models. Preliminary findings suggest that the timing of introducing a new serotype can cause the timing of outbreaks to vary across locations, likely as a result of variations in environmental conditions, particularly temperature, across Brazil.

Special Session 87 : Large Population Optimization, Stochastic Filtering and Mathematical Finance

Introduction: The large population systems arise naturally in various different fields (e.g., engineering, social science, economics and finance, operational research and management, etc). In recent years, the dynamic optimization or control of stochastic large population system has attracted consistent and intense attentions by research communities. One powerful technique to deal with large population problems is the so-called mean field game. It is also remarkable that, in reality the market information that the agents obtained are always incomplete or asymmetric. Stochastic filtering is an important tool to solve these problems. As a result, theories of large population, mean field game, stochastic filtering, etc, are applied to model and illustrate some practical issues, such as mathematical financial issues. The purposes of this special session are to present the frontier progress and developments, and to discuss the future directions in large population, mean field game, stochastic filtering and mathematical finance. The main topics are focused on, but are not limited to: (1) stochastic large population problems, (2) mean field game and mean field control, (3) stochastic filtering and related fields, (4) Stackelberg games, (5) Pareto games, etc.

On Poles and Zeros of Linear Quantum Systems

Schedule: December 17 18:30-19:00 Capital Suite 3

Zhiyuan Dong
Harbin Institute of Technology, Shenzhen
Peoples Rep of China

Co-Author(s): Guofeng Zhang, Heung-wing Joseph Lee

Abstract:
The non-commutative nature of quantum mechanics imposes fundamental constraints on system dynamics, which in the linear realm are manifested by the physical realizability conditions on system matrices. These restrictions endow system matrices with special structure. The purpose of this paper is to study such structure by investigating zeros and poses of linear quantum systems. In particular, we show that $-s_0^*$ is a transmission zero if and only if s_0 is a pole, and which is further generalized to the relationship between system eigenvalues and invariant zeros. Additionally, we study left-invertibility and fundamental tradeoff for linear quantum systems in terms of their zeros and poles.

Pareto game of stochastic differential system with terminal state constraint

Schedule: December 17 17:30-18:00 Capital Suite 3

Pengyan Huang
Shandong University of Finance and Economics
Peoples Rep of China

Co-Author(s): Guangchen Wang and Shujun Wang

Abstract:
In this work, we focus on a type of Pareto game of stochastic differential equation with terminal state constraint. Firstly, we transform equivalently a nonlinear Pareto game problem with convex control space and terminal state constraint into a constrained stochastic optimal control problem. By virtue of duality theory and stochastic maximum principle, a necessary condition for Pareto efficient strategy is established. With some convex assumptions, we also give a sufficient condition for Pareto efficient strategy. Secondly, we consider a linear-quadratic (LQ) Pareto game with terminal state constraint, and a feedback representation for Pareto efficient strategy is derived. Finally, as an application, we solve a government debt stabilization problem and give some numerical results.

Cyber Risk Management Through Investment in Cybersecurity Technology

Schedule: December 17 12:30-13:00 Capital Suite 3

Zhuo Jin
Macquarie University
Australia

Co-Author(s): Jiannan Zhang, Sizhe Chen, Hailiang Yang

Abstract:
Investment in cybersecurity measures has become a significant aspect of our modern society, with the cost of cybersecurity technology fluctuating due to technological innovations and changes in market dynamics. In this paper, we investigate the optimal timing for a company to invest in cybersecurity technology to reduce cyberattack losses.

Zero-Sum Differential Games in the Wasserstein Space

Schedule: December 17 13:00-13:30 Capital Suite 3

Jun Moon
Hanyang University
Korea

Co-Author(s): Tamer Basar

Abstract:
We consider two-player zero-sum differential games (ZSDGs), where the state process (dynamical system) depends on the random initial condition and the state process`s distribution, and the objective functional includes the state process`s distribution and the random target variable. Unlike ZSDGs studied in the existing literature, the ZSDG of this paper introduces a new technical challenge, since the corresponding (lower and upper) value functions are defined on $\mathcal{P}_2$ (the set of probability measures with finite second moments) or $\mathcal{L}_2$ (the set of random variables with finite second moments), both of which are infinite-dimensional spaces. We show that the (lower and upper) value functions on $\mathcal{P}_2$ and $\mathcal{L}_2$ are equivalent (law invariant) and continuous, satisfying dynamic programming principles. We use the notion of derivative of a function of probability measures in $\mathcal{P}_2$ and its lifted version in $\mathcal{L}_2$ to show that the (lower and upper) value functions are unique viscosity solutions to the associated (lower and upper) Hamilton-Jacobi-Isaacs equations, which are (infinite-dimensional) first-order PDEs on $\mathcal{P}_2$ and $\mathcal{L}_2$, where the uniqueness is obtained via the comparison principle. Under the Isaacs condition, we show that the ZSDG has a value.

On Well-posedness of Mean Field Game Master Equations: a Unified Approach

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Schedule: December 17 13:30-14:00 Capital Suite 3

Chenchen Mou
City University of Hong Kong
Peoples Rep of China

Co-Author(s): Jianfeng Zhang, Jianjun Zhou

Abstract:
There have been many serious studies on mean field game master equations in the literature. It is well known that the a priori Lipschitz estimates of solutions to master equations with respect to the probability measure variable are essentially necessary for their global well-posedness. The Lasry-Lions monotonicity, displacement monotonicity and anti-monotonicity conditions are found to be sufficient conditions to these Lipschitz estimates. However, whether these monotonicity conditions are necessary is unknown. In this talk, an essentially necessary and sufficient condition to these a priori Lipschitz estimates will be discussed and a unified approach to uniquely solve master equations will be established. The talk is based on a joint work with Jianfeng Zhang and Jianjun Zhou.

Diffusion Approximation and Stability of Stochastic Differential Equations with Singular Perturbation

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Schedule: December 17 15:15-15:45 Capital Suite 3

Fuke Wu
Huazhong University of Science and Technology
Peoples Rep of China

Co-Author(s): Huagui Liu, Shujun Liu

Abstract:
This paper investigates diffusion approximation of non-homogeneous singularly perturbed stochastic differential equations with locally Lipschitz continuous coefficients by using the first-order perturbation test function method and formulation of the martingale problem. Under appropriate conditions, if the averaging system is exponential stable, the slow component is also uniformly asymptotically stable. Since the averaging system is often simpler than the original system, this stability result is interesting.

Synchronous Stability Analysis of Power Systems Under Stochastic Disturbances

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Schedule: December 17 14:00-14:30 Capital Suite 3

Kaihua Xi
Shandong University
Peoples Rep of China

Abstract:
For the enhancement of the transient stability of power systems, the key is to define a quantitative optimization formulation with system parameters as decision variables. In this paper, we model the disturbances by Gaussian noise and define a metric named Critical Escape Probability (CREP) based on the invariant probability measure of a linearised stochastic processes. CREP characterizes the probability of the state escaping from a critical set. CREP involves all the system parameters and reflects the size of the basin of attraction of the nonlinear systems. An optimization framework that minimizes CREP with the system parameters as decision variables is presented. Simulations show that the mean of the first hitting time when the state hits the boundary of the critical set, that is often used to describe the stability of nonlinear systems, is dramatically increased by minimizing CREP. This indicates that the transient stability of the system is effectively enhanced. It also shown that suppressing the state fluctuations only is insufficient for enhancing the transient stability. This new metric opens a new avenue for the transient stability analysis of future power systems integrated with large amounts of renewable energy.

A Mean-Field Game for a Forward-Backward Stochastic System With Partial Observation and Common Noise

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Schedule: December 17 17:00-17:30 Capital Suite 3

Hua Xiao
Shandong University
Peoples Rep of China

Co-Author(s): Pengyan Huang, Guangchen Wang, Shujun Wang

Abstract:
This paper considers a linear-quadratic (LQ) mean-field game governed by a forward-backward stochastic system with partial observation and common noise, where a coupling structure enters state equations, cost functionals and observation equations. Firstly, to reduce the complexity of solving the mean-field game, a limiting control problem is introduced. By virtue of the decomposition approach, an admissible control set is proposed. Applying a filter technique and dimensional-expansion technique, a decentralized control strategy and a consistency condition system are derived, and the related solvability is also addressed. Secondly, we discuss an approximate Nash equilibrium property of the decentralized control strategy. Finally, we work out a financial concern with some numerical simulations.

Recursive stochastic differential games with non-Lipschitzian generators and viscosity solutions of Hamilton-Jacobi-Bellman-Isaacs equations

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Schedule: December 17 18:00-18:30 Capital Suite 3

Zhuangzhuang Xing
Henan Normal University
Peoples Rep of China

Co-Author(s): Guangchen Wang

Abstract:
This investigation is dedicated to a two-player zero-sum stochastic differential game (SDG), where a cost function is characterized by a backward stochastic differential equation (BSDE) with a continuous and monotonic generator regarding the first unknown variable, which possesses immense applicability in financial engineering. A verification theorem by virtue of classical solution of derived Hamilton-Jacobi-Bellman-Isaacs (HJBI) equation is given. The dynamic programming principle (DPP) and unique weak (viscosity) solvability of the HJBI equation are formulated through a comparison theorem for BSDEs with monotonic generators and stability of viscosity solution. Some new regularity properties of the value function are presented. Finally, we propose three concrete examples, which are concerned with, resp., classical and viscosity solutions of the HJBI equation, as well as a financial application where an investor with a non-Lipschitzian Epstein-Zin utility deals with market friction to maximize her utility preference.

On optimal carbon tax in China: implications for net-zero emissions and development

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Schedule: December 17 16:15-16:45 Capital Suite 3

Detao Zhang
School of Economics, Shandong University
Peoples Rep of China

Co-Author(s): Jingjing Zhang, Pan Chen, Mondher Bellalah, Detao Zhang

Abstract:
The carbon pricing is recognized as an effective tool of carbon reduction. Hence, China urgently needs to improve the carbon pricing system. This paper constructs a dynamic stochastic general equilibrium model with the inter-temporal accumulation of carbon emissions and climate damage function to optimize the estimation of the carbon tax rate in China. It develops a four-sector dynamic general equilibrium model to investigate the effects of a carbon tax. We find that China`s optimal carbon tax rate is increasing with economic growth, and levying a carbon tax can achieve the double bonus of decreasing carbon and expanding the economy. Moreover, the synergy of the carbon tax with related green policies, such as green finance, enhancing green industries competitive advantage, government environmental regulation, and green transformation goals, further amplifies the green effects of a carbon tax. Our conclusions provide a reference for implementing carbon tax system when facing the pressure of carbon reduction, thus promoting global low-carbon development.

Viscosity Solutions for HJB Equations on the Process Space: Application to Mean Field Control with Common Noise

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Schedule: December 17 15:45-16:15 Capital Suite 3

Jianjun Zhou
Northwest A&F University
Peoples Rep of China

Co-Author(s): Nizar Touzi; Jianfeng Zhang

Abstract:
In this talk, we investigate a path dependent optimal control problem on the process space with both drift and volatility controls, with possibly degenerate volatility. The dynamic value function is characterized by a fully nonlinear second order path dependent HJB equation on the process space, which is by nature infinite dimensional. In particular, our model covers mean field control problems with common noise as a special case. We shall introduce a new notion of viscosity solutions and establish both existence and comparison principle, under merely Lipschitz continuity assumptions. The main feature of our notion is that, besides the standard smooth part, the test function consists of an extra singular component which allows us to handle the second order derivatives of the smooth test functions without invoking the Ishii`s lemma. We shall use the doubling variable arguments, combined with the Ekeland-Borwein-Preiss Variational Principle in order to overcome the noncompactness of the state space. A smooth gauge-type function on the path space is crucial for our estimates.

Optimal control of LQ problem with anticipative partial observations

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Schedule: December 17 14:45-15:15 Capital Suite 3

Yonghui Zhou
Guizhou Normal University School of Big Data and Computer Science
Peoples Rep of China

Abstract:
A stochastic linear-quadratic (LQ for short) problem with anticipative (i.e., not adapted) partial observations is studied. With the help of enlargement of filtration, we turn the anticipative signal observation system into a higher-dimensional adapted one, and obtain a linear filtering equation of the latter by the martingale representation theorem and a related equivalent control problem. By introducing a Riccati equation and an ordinary differential equation, we provide a unique optimal feedback control for another equivalent optimal control problem with the controlled state being the linear filtering equation. Finally, the optimal cost function for the original anticipative LQ problem is obtained, which is represented by the filtering of the extended adaptive system and some modified coefficients. Our result covers that of the classical stochastic LQ problem with adapted partial observations. As an application, the optimal control of an interception problem with anticipative radar tracking is explicitly given.

Special Session 88 : Recent developments in stochastic analysis and related topics

Introduction: This Special Session will be focused on recent developments in stochastic analysis and related topics. Key topics include existence, uniqueness, smoothness and regularity of solutions of various SDEs and SPDEs, as well as long time behavior, large deviation principles etc. Participants in this session are expected to exchange novel ideas, discuss unresolved issues, investigate new topics and subjects, and foster new partnerships and connections. We hope to encourage vital discussions between researchers from Probability Theory, Dynamical systems and PDEs, fostering collaborations and connections.

Random Attractors for McKean-Vlasov S(P)DEs

Schedule: December 17 16:15-16:45 Capital Suite 21 B

Mengyu Cheng
Beijing Institute of Technology
Peoples Rep of China

Abstract:
Random attractor is an important concept of understanding the long-tine behavior of random systems induced by stochastic evolution equations. In this talk, we will consider the existence of random attractors for McKean-Vlasov S(P)DEs on the product space $\mathbb{R}^n \times \mathcal{P}(\mathbb{R}^n)$.

Symmetry and functional inequalities for stable Levy-type operators

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Schedule: December 17 17:30-18:00 Capital Suite 21 B

Lu-Jing Huang
Fujian Normal University
Peoples Rep of China

Co-Author(s): Tao Wang

Abstract:
In this talk, we establish the sufficient and necessary conditions for the symmetry of the following stable L\`evy-type operator $\mathcal{L}$ on $\mathbb{R}$:

$$\mathcal{L} = a(x)\Delta^{\alpha/2} + b(x)\frac{\mathrm{d}}{\mathrm{d}x},$$

where a, b are the continuous positive and differentiable functions, respectively. We then study the criteria for functional inequalities, such as logarithmic Sobolev inequalities, Nash inequalities and super-Poincar\`e inequalities under the assumption of symmetry. Our approach involves the Orlicz space theory and the estimates of the Green functions. This is based on a joint work with Tao Wang.

Moments and tails of the Gaussian multiplicative chaos

Schedule: December 17 13:30-14:00 Capital Suite 21 B

Yichao Huang
Beijing Institute of Technology
Peoples Rep of China

Abstract:
The Seiberg bounds form a set of necessary and sufficient conditions under which correlations functions in Liouville conformal field theory are well-defined. Since the probabilistic construction of Liouville correlations functions by David, Kupiainen, Rhodes and Vargas, a probabilistic version of the Seiberg bounds can be obtained via the theory of Gaussian Multiplicative Chaos. We will give a brief review on this construction, and then explain its boundary version, where a new class of Gaussian Multiplicative Chaos emerges naturally. We will discuss finer estimates on the right tail of the Gaussian multiplicative chaos measures if time permits.

Long time behaviors of mean field interacting particle systems and McKean-Vlasov equations

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Schedule: December 17 15:45-16:15 Capital Suite 21 B

Wei Liu
Wuhan University
Peoples Rep of China

Co-Author(s): Arnaud Guillin, Liming Wu and Chaoen Zhang.

Abstract:
In this talk, we will present our recent studies about the long time behaviors of mean-field interacting particle systems and the McKean-Vlasov equation, by using two different methods: coupling method and functional inequalities.

Kernel Variable Importance Measure with Applications

Schedule: December 17 13:00-13:30 Capital Suite 21 B

Yanyan Liu
Wuhan University
Peoples Rep of China

Co-Author(s): Huang bingyao, Peng Liuhua, Liuyanyan

Abstract:
This paper proposes a kernel variable importance measure (KvIM) based on the maximum mean discrepancy (MMD). KvIM can effectively measure the importance of an individual dimension in contributing to the distributional difference by constructing weighted MMD and applying perturbations to evaluate MMD changes through assigned weights. It has advantages such as non-parametric, model-free, comprehensive consideration of the dependencies among dimensions, and suitability for high-dimensional data. Furthermore, the consistency of empirical KvIM under general conditions and its theoretical properties in high-dimensional settings were studied. In addition, we also apply KvIM to classification problems and streaming datasets and propose a KvIM-enhanced classification approach and renewable empirical KvIM accordingly. Numerous numerical studies illustrate that the proposed method is feasible and effective.

Existence and uniqueness results for strongly degenerate McKean-Vlasov equations with rough coefficients

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Schedule: December 17 15:15-15:45 Capital Suite 21 B

Andrea Pascucci
University of Bologna
Italy

Co-Author(s): Alessio Rondelli, Alexander Yu Veretennikov

Abstract:
We present existence results for weak solutions to a broad class of degenerate McKean-Vlasov equations with rough coefficients, expanding upon and refining the techniques recently introduced by the third author. Under certain structural conditions, we also establish results concerning both weak and strong well-posedness.

Asymptotic behavior of multi-scale stochastic systems

Schedule: December 17 14:00-14:30 Capital Suite 21 B

Xiaobin Sun
Jiangsu Normal University
Peoples Rep of China

Abstract:
In this talk, we explore the asymptotic behavior of various kinds of multi-scale stochastic (partial) differential equations. Specifically, we prove the strong and weak averaging principles, the central limit theorem, as well as diffusion approximation within the context of these multi-scale stochastic systems. Additionally, we present the key ideas in the proofs of the optimal convergence rates.

Wright-Fisher stochastic heat equations with irregular drifts

Schedule: December 17 18:30-19:00 Capital Suite 21 B

Zhenyao Sun
Beijing Institute of Technology
Peoples Rep of China

Co-Author(s): Clayton Barnes and Leonid Mytnik

Abstract:
Consider $[0,1]$-valued random field solution $(u_t(x))_{t\geq 0, x\in\mathbb{R}}$ to the one-dimensional stochastic heat equation

$$\partial_t u_t = \frac{1}{2}\Delta u_t + b(u_t) + \sqrt{u_t(1-u_t)}\dot{W}$$

where $b(1) \leq 0 \leq b(0)$ and $\dot{W}$ is a space-time white noise. In this talk, we present the weak existence and uniqueness of the above equation for a class of drifts $b(u)$ that may be irregular at the points where the noise is degenerate, that is, at $u = 0$ or $u = 1$. This class of drifts includes non-Lipschitz drifts like $b(u) = u^q(1-u)$ for every $q \in (0,1)$, and some discontinuous drifts like $b(u) = \mathbf{1}_{(0,1]}(u) - u$. This demonstrates a regularization effect of the multiplicative space-time white noise without assuming the standard assumption that the noise coefficient is Lipschitz and non-degenerate. The method we apply is a further development of a moment duality technique that uses branching-coalescing Brownian motions as the dual particle system. To handle an irregular drift in the above equation, particles in the dual system are allowed to have a number of offspring with infinite expectation, even an infinite number of offspring with positive probability. We show that, even though the branching mechanism with infinite number of offspring causes explosions in finite time, immediately after each explosion the total population comes down from infinity due to the coalescing mechanism. Our results on this dual particle system are of independent interest.

Exponential contractivity of modified Euler schemes for SDEs with super-linearity

Schedule: December 17 17:00-17:30 Capital Suite 21 B

Jian Wang
Fujian Normal University
Peoples Rep of China

Abstract:
As a well-known fact, the classical Euler scheme works merely for SDEs with coefficients of linear growth. In this paper, we propose a novel variant of Euler schemes, which is applicable to SDEs with super-linear drifts and encompasses the classical Euler scheme, the tamed Euler scheme and the truncated Euler scheme, as three typical candidates. On the one hand, by exploiting an approach based on the refined basic coupling, we show that the proposed Euler recursion is exponentially contractive under a mixed probability distance (i.e., the total variation distance plus the L^1-Wasserstein distance). On the other hand, by invoking a trick on the coupling by reflection, we, in particular, demonstrate that the tamed Euler scheme is exponentially contractive under the L^1-Wasserstein distance. In addition, as an important application, a quantitative L^1-Wasserstein error bound between the exact invariant probability measure and the numerical counterpart concerning the SDEs under consideration and the associated tamed Euler scheme, respectively. Last but not least, we want to stress that the theory derived in the present work is available for SDEs, where, most importantly, the drifts involved are allowed to be highly nonlinear.

The first eigenvalue of one-dimensional elliptic operators with killing

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Schedule: December 17 12:30-13:00 Capital Suite 21 B

Yingchao Xie
Jiangsu Normal University
Peoples Rep of China

Abstract:
In this talk, we investigate the first eigenvalue for one-dimensional elliptic operators with killing. Two-sided approximation procedures and basic estimates of the first eigenvalue are given in both the half line and the whole line. The proofs are based on the h-transform, Chen`s dual variational formulas and the split technique. In particular, a few examples are presented to illustrate the power of our results.

W_d-convergence rate of EMs for invariant measures of supercritical stable SDEs

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Schedule: December 17 18:00-18:30 Capital Suite 21 B

Xiaolong Zhang
Beijing Institute of Technology
Peoples Rep of China

Co-Author(s): Peng Chen, Lihu Xu, Xiaolong Zhang and Xicheng Zhang

Abstract:
Through establishing the regularity estimates for nonlocal Poisson/Stein equations under certain H\older and dissipativity conditions on the coefficients, we derive the W_d-convergence rate for the Euler-Maruyama schemes applied to the invariant measure of SDEs driven by α-stable noises with $\alpha \in (\frac{1}{2}, 2)$, where W_d denotes the Wasserstein metric corresponding to the distance $d(x, y) = |x - y|^{\vartheta} \wedge 1$, with $\vartheta \in (0, 1] \cap (0, \alpha)$.

Singular McKean-Vlasov equations

Schedule: December 17 14:45-15:15 Capital Suite 21 B

Xicheng Zhang
Beijing Institute of Technology
Peoples Rep of China

Co-Author(s): Z. Hao, S. Menozzi, F. Jabir, M. R\ockner

Abstract:
We establish the local and global well-posedness of weak and strong solutions for second-order fractional mean-field SDEs. These equations involve singular or distribution interaction kernels and measure initial values, with examples including Newton or Coulomb potentials, Riesz potentials, Biot-Savart law, among others. Our analysis relies on the theory of anisotropic Besov spaces. Building on the well-posedness results of the McKean-Vlasov equations, we investigate the propagation of chaos for moderately interacting particle systems with singular kernels and derive quantitative convergence rates.

Special Session 89 : DYNAMICS AND SPECTRA OF QUASIPERIODIC SCHRODINGER OPERATORS

Introduction: Quasiperiodic operators, developed as a part of the general theory of ergodic operators, have been one of the central research areas since the late 1970s. The theory was motivated by the studies of electron transport in various materials, such as crystals and quasicrystals, and serves as the theoretical underpinning of the Quantum Hall Effect, as well as other important physics phenomena. This session aims to facilitate academic discussions on the dynamics and spectral theory of quasiperiodic operators, covering topics such as Anderson localization, fractal related problems, KAM theory, and dynamics of cocycles. This section will bring together leading experts and promising junior researchers with interests in the study of the effects of quasiperiodicity, or other stationary environments of physics interest, and contribute to a more profound comprehension of its implications in the context of quantum theory.

Reducibility without KAM

Schedule: December 16 18:00-18:30 Conference Hall B (B)

Fernando Argentieri
University of Zurich
Switzerland

Co-Author(s): Fernando Argentieri and Bassam Fayad

Abstract:
We prove reducibility results for close to constant 1-frequency quasi-periodic matrix valued cocycles in finite and smooth regularity without the use of a quadratic scheme. Reducibility results to rotations matrices are obtained regardless of the arithmetics of the irrational base frequency.

Semiclassical limits of quasiperiodic media

Schedule: December 16 16:15-16:45 Conference Hall B (B)

Simon Becker
ETH Zurich
Switzerland

Abstract:
I will review the study of continuum models of periodic media in (almost) magnetic fields and outline how the semiclassical reduction leads to generalized discrete infinite range models that are perturbations of the standard representatives in the study of quasiperiodic operators. We will consider different scaling regimes leading to different spectral problems. I will then describe how effects like metal/insulator transitions manifest themselves in the continuum.

Regularizing effect of randomness on quasiperiodic dynamics

Schedule: December 16 15:45-16:15 Conference Hall B (B)

Ao Cai
Soochow University
Peoples Rep of China

Co-Author(s): Pedro Duarte and Silvius Klein

Abstract:
We prove that there is an instant enhancement on the regularity, i.e. from discontinuity to H\older continuity, of the Lyapunov exponent of quasiperiodic Schr\odinger operators when randomness is involved in. This is based on a long-term project joint with Pedro Duarte (ULisboa) and Silvius Klein (PUC-Rio).

Exact local distribution of the absolutely continuous spectral measure

Schedule: December 16 19:00-19:30 Conference Hall B (B)

Xianzhe Li
Nankai University
Peoples Rep of China

Co-Author(s): Jiangong You and Qi Zhou

Abstract:
It is well-established that the spectral measure for one-frequency Schr\odinger operators with Diophantine frequencies exhibits optimal $1/2$-H\older continuity within the absolutely continuous spectrum. This study extends these findings by precisely characterizing the local distribution of the spectral measure for dense small potentials, including a notable result for any subcritical almost Mathieu operators. Additionally, we investigate the stratified H\older continuity of the spectral measure at subcritical energies.

Reducibility of quasi-periodic symplectic cocycles

Schedule: December 16 17:30-18:00 Conference Hall B (B)

Yi Pan
Institute of Science and Technology Austria
Austria

Co-Author(s): Artur Avila, Raphael Krikorian

Abstract:
Reducibility of quasi-periodic cocyles valued in symplectic groups is related to the spectrum of discrete Schrodinger operators on strips. We will talk about a global reducibility result: given one parameter family of such cocycles, for almost every parameter, either the maximal Lyapunov exponent is positive, or the cocycle is almost conjugate to some precise model. The techniques include Kotani theory, KAM theory and in particular study of hyperbolicity of renormalization operator. This is a joint work with Artur Avila and Raphael Krikorian.

Absolute continuity and Holder continuity of the integrated density of states (IDS) for the analytic quasiperiodic Schrodinger operators

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Schedule: December 16 18:30-19:00 Conference Hall B (B)

Jing Wang
Nanjing University of Science and Technology
Peoples Rep of China

Co-Author(s): Xu Xu, Jiangong You, Qi Zhou

Abstract:
In this talk, we will consider the continuity of the IDS for analytic quasiperiodic Schrodinger operators. In the subcritical region, we prove that the IDS and Lyapunov exponents are log-Holder continuous for operators with Liouvillean frequency; in the supercritical region, we prove that the IDS is absolutely continuous for operators with trigonometric potential and Diophantine frequency. The main tool is quantitative almost reducibility and Aubry duality. This talk is based on joint works with Xu Xu, Qi Zhou and Jiangong You.

Lyapunov spectrum and hyperbolicity of one frequency quasi-periodic Sp(4)-cocycle.

Schedule: December 16 17:00-17:30 Conference Hall B (B)

Disheng Xu
Great Bay University
Peoples Rep of China

Co-Author(s): Duxiao Wang, Qi Zhou

Abstract:
We will talk about the Lyapunov exponents and hyperbolic behavior of one frequency quasi-periodic Sp(4) cocycle under certain assumptions. Joint work (in progress) with Duxiao Wang and Qi Zhou.

Delocalization of a general class of random block Schrodinger operators

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Schedule: December 16 15:15-15:45 Conference Hall B (B)

Fan Yang
Tsinghua University
Peoples Rep of China

Co-Author(s): Changji Xu, Horng-Tzer Yau, Jun Yin

Abstract:
Consider two generalizations of the famous Anderson model defined on a d-dimensional integer lattice of linear size L. The first generalization is the random band matrix model. In this model, the entries are independent centered complex Gaussian random variables, and the element H_{xy} is nonzero only when the distance $|x - y|$ is less than the band width W. The second generalization is the block Anderson model. In this model, the i.i.d. diagonal potential in the Anderson model is replaced by an i.i.d. diagonal block potential with a coupling strength parameter $\lambda > 0$, and the blocks have a linear size of W. Both models are non-mean-field models, where the parameter W describes the length of local interactions. Furthermore, it is conjectured that these models exhibit Anderson transitions as W or λ varies. In this talk, I will present some of our recent results on the Anderson delocalization of these two models when $d \geq 7$ and $W \geq L^{\delta}$, where $\delta > 0$ is a small constant. Additionally, I will discuss the quantum diffusion conjecture related to the delocalization of these models. The research is based on joint works with Changji Xu, Horng-Tzer Yau, and Jun Yin.

Anderson localization for potentials generated by hyperbolic transformations

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Schedule: December 16 14:45-15:15 Conference Hall B (B)

Zhenghe Zhang
UC Riverside
USA

Co-Author(s): Artur Avila, David Damanik

Abstract:
In this talk, I will prove Anderson localization for potentials generated by hyperbolic transformations via positivity and large deviations of the Lypapunov exponent. This is a joint work with Artur Avila and David Damanik.

Special Session 91 : Advances on Explainable Artificial Intelligence and related Mathematical Modeling

Introduction: Machine Learning Models, Deep learning neural networks, such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs) and Generative Adversarial Networks (GANs), have achieved remarkable success in various fields, such as computer vision and natural language processing and forecasting issues. Their effectiveness also extends to real-world applications in healthcare, business and autonomous vehicles, where they excel at analyzing and utilizing complex data and information. Although they achieve remarkable success, the complicated architectures and inherent opacity of deep learning neural networks and machine learning supervised often pose a challenge to full mastery and limit their use in important applications, especially in interdisciplinary domains. To address this problem and broaden the scope of research, we are expanding the focus of our collection to include the successful applications of deep learning neural networks. With this expansion, we aim to highlight their efficiency in extracting valuable insights from complex data and information to improve understanding and utilization in different contexts. We sincerely invite researchers and experts in the field of Explainable AI to contribute their original research papers to this Special Session

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Quasivariational Inequalities for Dynamic Competitive Economic Equilibrium Problems in Discrete Case

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Schedule: December 17 9:00-9:30 Capital Suite 15

David Barilla
Messina
Italy

Co-Author(s): Shapour Heidarkhani, Giuseppe Caristi

Abstract:
Equilibrium is a central concept in numerous disciplines including economics, management science, operations research, and engineering. We are concerned with an evolutionary quasivariational inequality which is connected discrete dynamic competitive economic equilibrium problem in terms of maximization of utility functions and of excess demand functions. We study the discrete equilibrium problem by means of a discrete time-dependent quasivariational inequality in the discrete space $\ell^2([0,T]\mathbb{Z},\mathbb{R})$. We ensure an existence result of discrete time-dependent equilibrium solutions. Finally, We show the stability of equilibrium in a completely decentralized Walrasian general equilibrium economy in which prices are fully controlled by economic agents, with production and trade occurring out of equilibrium.

Environmental Policy: The Coevolution of Pollution and Compliance

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Schedule: December 17 12:30-13:00 Capital Suite 15

Marta Biancardi
Univerity of Bari
Italy

Co-Author(s): Marta Biancardi,Yannis Petrohilos-Andrianos, Giovanni Villani , Anastasios Xepapadeas

Abstract:
The paper studies the evolution of compliance and non-compliace firms in a setup of taxable emissions. Firms can either choose to comply with the emissions standard imposed by a public authority or violate them. Two different scenarios are analyzed, in fact, violation is considered either as a single option or is let to vary between low and high emissions. The latter induce a different level of fine if firms get caught. In a context of replicator dynamics, firms can switch between strategies according to a proportional rule of strategy evolution and the conditions for stability are investigated accounting for two distinct types of probability of inspection.

On Duality for Nonsmooth Mathematical Problems with Vanishing Constraints

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Schedule: December 16 17:30-18:00 Capital Suite 15

Giuseppe Caristi
University of Messina
Italy

Co-Author(s): Nader Kanzi, Hamed Soroush, Giuseppe Caristi and David Barilla

Abstract:
In this paper, we provide a duality theory for nonsmooth optimization problems with vanishing constraints (MPVC) defined by locally Lipschitz functions. In order to do this, we first formulate a new mixed-type dual problem for an MPVC, which is a generalization of Wolf and Mond-Weir dual problems. Since this dual problem depends on the feasible points of the primal problem, we introduce another mixed-type dual problem that does not have this dependence. Then, we present the weak, the strong, the converse, the restricted converse, and the strict converse duality results for these parametric dual problems. Finally, we compare the results of the article written by Mishra (2016) with our results and state the correct version of some of its incorrect theorems.

Explainable Artificial Intelligence and Mathematical Modeling: New Challenges of Research on

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Schedule: December 16 17:00-17:30 Capital Suite 15

Massimiliano Ferrara
University Mediterranea of Reggio Calabria
Italy

Abstract:
\begin{abstract} The increasing complexity of artificial intelligence (AI) models has led to a rising demand for explainability in AI (XAI). Explainable Artificial Intelligence aims to make AI`s decision-making processes transparent and understandable to humans. This talk examines the integral connection between XAI and mathematics, highlighting how mathematical principles can enhance the interpretability, transparency, and trustworthiness of AI models. We explore the mathematical foundations that underpin XAI techniques, examine case studies where mathematics has improved explainability, and propose future directions for integrating mathematics into XAI frameworks.
\end{abstract}

EvoFolio: a portfolio optimization method based on multi-objective evolutionary algorithms

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Schedule: December 16 18:30-19:00 Capital Suite 15

Luca Grilli
University of Foggia
Italy

Co-Author(s): Alfonso Guarino, Domenico Santoro, Luca Grilli, Rocco Zaccagnino, Mario Balbi

Abstract:
\textit{Optimal portfolio selection} -- composing a set of stocks/assets that provide high yields/returns with a reasonable risk -- has attracted investors and researchers for a long time. As a consequence, a variety of methods and techniques have been developed, spanning from purely mathematics ones to computational intelligence ones. In this paper, we introduce a method for optimal portfolio selection based on multi-objective evolutionary algorithms, specifically \textit{Nondominated Sorting Genetic Algorithm}-II (NSGA-II), which tries to \textit{maximize} the yield and \textit{minimize} the risk, simultaneously. The system, named \textit{EvoFolio}, has been experimented on stock datasets in a three-years time-frame and varying the configurations/specifics of NSGA-II operators. \textit{EvoFolio} is an \textit{interactive} genetic algorithm, i.e., users can provide their own insights and suggestions to the algorithm such that it takes into account users` preferences for some stocks. We have performed tests with optimizations occurring quarterly and monthly. The results show how \textit{EvoFolio} can significantly reduce the risk of portfolios consisting only of stocks and obtain very high performance (in terms of return). Furthermore, considering the investor`s preferences has proved to be very effective in the portfolio`s composition and made it more attractive for end-users. We argue that \textit{EvoFolio} can be effectively used by investors as a support tool for portfolio formation.

Cellular Automata on Probability Measures: Induced Dynamics on Random Graphs and Applications in Explainable AI

Schedule: December 16 18:00-18:30 Capital Suite 15

Davide La Torre
SKEMA Business School, Cote d`Azur University
France

Co-Author(s): Enrico Formenti

Abstract:
In this talk, we present an extension of the traditional concept of cellular automata (CAs) by broadening the range of possible states. This new framework is inspired by the need to establish dynamics on random graphs. We propose that the state space consists of all probability measures defined over a fundamental alphabet A. This definition simplifies to the classical notion of cellular automata when we use Dirac probability measures for individual elements of the alphabet. We will discuss several results related to the convergence of these generalized cellular automata, particularly under specific conditions on the transition map. Additionally, we will provide various examples to illustrate how this extended approach can be applied in different scenarios. Furthermore, we will explore how cellular automata can be utilized to enhance the explainability of machine learning training processes. This talk aims to enhance our understanding of cellular automata while exploring their potential applications in complex systems.

Dynamics of a New Keynesian model with heterogeneous expectations: the role of monetary policy

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Schedule: December 17 8:30-9:00 Capital Suite 15

Nicolo Pecora
Catholic University
Italy

Co-Author(s): Anna Agliari, Alessandro Spelta

Abstract:
Modern monetary policy has emphasized that maintaining a stable monetary environment depends crucially on the ability of the policy regime to control inflation (and output) expectations. In fact, the activity of modern Central Banks is a form of management of expectations. The present work considers a standard New Keynesian model, described by a two-dimensional nonlinear map, to analyze the bifurcation structure when agents own heterogeneous expectations on inflation and output gap, and update their beliefs based on past performance. Agents are then allowed to switch among predictors over time. Depending on the degree of reactivity of the monetary policy to inflation and output deviations from the target equilibrium, different kind of dynamics may occur. Multiple equilibria and complicated dynamics, associated to codimension-2 bifurcations, may arise even if the monetary policy adheres to the Taylor principle. We show that if the monetary policy accommodates for a sufficient degree of output stabilization, complicated dynamics can be avoided and the number of coexisting equilibria reduces. In the second part of the analysis, an arbitrarily large number of agents` beliefs is considered by applying the concept of Large Type Limit. In this respect, the intensity of choice or the spread of beliefs is crucial for the extent of the Central Bank to stabilize the economy. When the predictors are largely dispersed around the target, the Taylor principle is a requisite for stability; when the set of beliefs is somehow anchored to the target, stability can be achieved with a weaker monetary policy.

More or Less. A comparison between Machine and Deep Learning Models on high stationarity data

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Schedule: December 17 13:00-13:30 Capital Suite 15

Domenico Santoro
University of Foggia
Italy

Co-Author(s): Domenico Santoro, Tiziana Ciano, Massimiliano Ferrara

Abstract:
Advances in sensor, computing, and communication technologies are enabling big data analytics by providing time series data. However, conventional models struggle to identify sequence features and forecast accuracy. This paper investigates time series features and shows that some Machine Learning algorithms can outperform Deep Learning models. In particular, the problem analyzed concerned the prediction of the number of vehicles passing through an Italian tollbooth in 2021. The dataset, composed of 8766 rows and 6 columns relating to additional tollbooths, proved to have high stationarity and was treated through Machine Learning methods such as Support Vector Machine, Random Forest, and eXtreme Gradient Boosting (XGBoost), as well as Deep Learning through Recurrent Neural Networks with Long Short-Term Memory (RNN-LSTM) cells. From the comparison of these models, the prediction through the XGBoost algorithm outperforms competing algorithms, particularly in terms of MAE and MSE. The result highlights how a shallower algorithm than a Neural Network is, in this case, able to obtain a better adaptation to the time series instead of a much deeper model that tends to develop a smoother prediction.

Ant colony optimization for Chinese postman problem

Schedule: December 17 13:30-14:00 Capital Suite 15

Giacinto Angelo GA Sgarro
University of studies of Foggia
Italy

Co-Author(s): Giacinto Angelo Sgarro, Luca Grilli, and Domenico Santoro

Abstract:
This paper aims to solve the Chinese Postman Problem (CPP) using an Ant Colony Optimization (ACO) algorithm. In graph theory, the CPP looks for the shortest closed path that visits every edge of a connected undirected graph. This problem has many applications, including route optimization, interactive system analysis, and flow design. Although numerous algorithms aimed at solving CPP are present in the literature, very few meta-heuristic algorithms are proposed, and no ACO applications have been proposed to solve them. This paper tries to fill this gap by presenting an ACO algorithm that solves CPP (ACO-CPP). To prove its consistency and effectiveness, ACO-CPP is compared with a Genetic Algorithm (GA) and a recursive algorithm throughout three experiments: (1) recursive-ACO-GA comparisons over randomly generated graphs for the attainment of the global optimum; (2) ACO-GA statistical comparisons over specifically generated graphs; (3) recursive-ACO-GA comparisons by changing ACO hyperparameters over randomly generated graphs for the attainment of the global optimum. The experiments prove that the ACO-CPP algorithm is efficient and exhibits a consistency similar to GA when the number of possible solutions to explore is relatively low. However, when that number greatly exceeds those explored, ACO outperforms GA. This suggests that ACO is more suitable for solving problems with a CPP structure.

Developing Neural Network Approaches for Analyzing Piecewise Functions in Tuberculosis Treatment Outcomes

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Schedule: December 17 9:30-10:00 Capital Suite 15

Ramsha Shafqat
Thammasat University, Rangsit Campus, Thailand
Thailand

Co-Author(s): Ramsha Shafqat, Ateq Alsaadi

Abstract:
The paper presents a mathematical analysis of tuberculosis, caused by Mycobacterium TB, which primarily affects the lungs. The bacteria spreads through coughing, sneezing, or speaking, and is classified into five categories: susceptible, infected with DS, infected with MDR, isolated, and recovered. The study uses a novel piecewise derivative approach that considers both singular and non-singular kernels to improve our understanding of rabies spread dynamics. The uniqueness of the solution is established using fixed point and piecewise derivative frameworks. A piecewise numerical iteration scheme based on Newton interpolation polynomials is used to obtain the approximate solution. The study contributes to understanding crossover dynamics and the concept of piecewise derivatives. Additionally, an Artificial Neural Network approach is employed for training, testing, and validating data to investigate the disease problem, ensuring high accuracy in training, testing, and validation.

Special Session 93 : Recent trends in elliptic and parabolic equations

Introduction: This special session is to bring together experts and young participates in the field of PDEs to share and exchange their ideas and recent results, to discuss open or challenging problems and also foster future collaborations and connections. The session mainly focuses on the gradient estimates, asymptotic/concentrated behaviors and quantitative properties of solutions to elliptic and parabolic equations with local/non-local/mixed operators, besides, other related topics are welcome.

Very Singular Solution to nonlinear equation with absorption

Schedule: December 19 9:00-9:30 Capital Suite 4

Said BENACHOUR
Institut Elie Cartan - Universit\` e de Lorraine.fr
France

Co-Author(s): Philippe Laurencot

Abstract:
Abstract:\ We investigate the existence of a Very Singular Solution at the origin to a viscous Hamilton-Jacobi equation.\ A Very Singular Solution Vat the origin is a non-negative solution which is smooth in $(0,+\infty)\times R^N$ and fulfills the fact that the singularity of V in $(t,x)=(0,0)$ is stronger than the singularity in $(t,x)=(0,0)$ of fundamental solutions, that is the solutions whose initial data is δ (the Dirac mass centered at $x=0$).\ Besides the description of the isolated singularities in $(t,x)=(0,0)$ the Very Singular Solutions (when they exist) also play an important role in the description of the large time behaviour of the solutions of PDE.\ The name Very Singular Solution has been introduced by Brezis, Peletier and Terman in 1984.

On Some Inverse Boundary Value Problems Arising from Cardiac Electrophysiology

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Schedule: December 19 13:00-13:30 Capital Suite 4

Elena Beretta
NYUAD
United Arab Emirates

Co-Author(s): Andrea Aspri Elisa Francini Dario Pierotti Sergio Vessella

Abstract:
Detecting ischemic regions is crucial for preventing lethal ventricular ischemic tachycardia. This is typically done by recording the heart`s electrical activity using either noninvasive or minimally invasive methods, such as body surface or intracardiac measurements. Mathematical and numerical models of cardiac electrophysiology can provide insight into how electrical measurements can be used to detect ischemia. The goal is to combine boundary measurements of potentials with a mathematical model of the heart`s electrical activity to identify the position, shape, and size of ischemia and/or infarctions. Ischemic regions can be modeled as electrical insulators using the monodomain model, which is a semilinear reaction-diffusion system that describes cardiac electrical activity comprehensively. In this talk, I will focus on the case of an insulated heart without coupling to the torso. I will first review some results related to reconstructing cavities for the stationary model, and then present some results obtained recently in the case of the time-dependent nonlinear monodomain model for different types of nonlinearities.

A phase field model of Cahn--Hilliard type for tumour growth with mechanical effects and damage

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Schedule: December 19 17:30-18:00 Capital Suite 4

Giulia Cavalleri
University of Pavia
Italy

Abstract:
We introduce a new diffuse interface model for tumour growth in the presence of a nutrient, in which we take into account mechanical effects and reversible tissue damage. The highly nonlinear PDEs system mainly consists of a Cahn--Hilliard type equation that describes the phase separation process between healthy and tumour tissue. This equation is coupled to a parabolic reaction-diffusion equation for the nutrient and a hyperbolic equation for the balance of forces, including inertial and viscous effects. The main novelty is the introduction of tissue damage, whose evolution is ruled by a parabolic differential inclusion. We prove a global-in-time existence result for weak solutions by passing to the limit in a time-discretized and regularized version of the system.

Quasi-periodic steady invariant structures in inviscid incompressible fluids

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Schedule: December 19 8:30-9:00 Capital Suite 4

Luca Franzoi
University of Milan
Italy

Co-Author(s): Nader Masmoudi, Riccardo Montalto

Abstract:
Invariant structures and asymptotic behaviours close to shear flows are of great interest in Fluid Dynamics. In this short talk, I present a recent result about the existence of nontrivial steady flows in the bounded 2D channel that are quasi-periodic in the horizontal space direction and solve the incompressible Euler equation. In particular, we work with steady Euler flows that solve some semilinear elliptic equations in the space domain, where we are led to use the horizontal direction as a time coordinate. Such solutions bifurcate from a prescribed shear equilibrium near the Couette flow, whose profile induces finitely many modes of oscillations in the horizontal direction that may be resonant. This leads to a small divisor problem and the consequent loss of derivatives is overcome with a Nash-Moser nonlinear iteration. This is a joint work with Nader Masmoudi and Riccardo Montalto

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The existence and concentration behavior of positive ground state solutions for a class of Choquard type equations involving nonlocal(mixed) operators

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Schedule: December 19 18:00-18:30 Capital Suite 4

Zu Gao
Wuhan University of Technology
Peoples Rep of China

Abstract:
In this paper, we first employ variational methods to show the existence of positive ground state solutions for f a class of Choquard type equations involving nonlocal(mixed) operators, where potential function is nonnegative and bounded away from 0 as |x| approaches infinity. Since the potential function possesses a homogeneous behavior, we then investigate the concentration behavior of positive ground state solutions.

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a system of superlinear elliptic equations in a cylinder

Schedule: December 19 14:00-14:30 Capital Suite 4

Yanyan guo
Central China Normal University
Peoples Rep of China

Co-Author(s): Bernhard Ruf

Abstract:
In this talk, we will discuss the existence of positive solutions of a semi-linear elliptic system defined in a cylinder $\Omega = \Omega`\times(0,a) \subset \mathbb{R}^n$, where $\Omega`\subset \mathbb{R}^{n-1}$ is a bounded and smooth domain. The system couples a superlinear equation defined in the whole cylinder Ω with another superlinear (or linear) equation defined at the bottom of the cylinder $\Omega`\times\{0\}$. We provide a priori L^∞ bounds for all positive solutions of the system when the nonlinear terms satisfy certain growth conditions. Using the a priori bounds and topological arguments, we prove the existence of positive solutions for these particular semi-linear elliptic systems.

On a non-isothermal phase-field model for tumor growth

Schedule: December 19 15:45-16:15 Capital Suite 4

Erica Ipocoana
Freie Universit\"{a}t Berlin
Germany

Co-Author(s): Stefania Gatti, Alain Miranville

Abstract:
We present a new diffuse interface model describing the growth of a tumor, whose evolution is assumed to be governed by biological mechanisms such as proliferation of cells via nutrient consumption and apoptosis. In this context, the tumor is seen as an expanding mass surrounded by healthy tissues, while the interface in between contains a mixture of both healthy and tumor cells. More precisely, we model the process through a non-isothermal Allen-Cahn system coupled with a reaction-diffusion equation for the nutrient, following the approach based on microforce balance and then study its well-posedness. Namely, we are able to prove the existence and uniqueness of a solution to our model by Galerkin`s approach.

On the bifurcation diagram for free boundary problems arising in plasma physics

Schedule: December 19 13:30-14:00 Capital Suite 4

Aleks Jevnikar
University of Udine
Italy

Co-Author(s): Daniele Bartolucci, Ruijun Wu

Abstract:
We are concerned with qualitative properties of the bifurcation diagram of a free boundary problem arising in plasma physics, showing in particular uniqueness and monotonicity of its solutions. We then discuss sharp positivity thresholds and spike condensation phenomenon.

Radial symmetry and sharp asymptotic behaviors of nonnegative solutions to critical quasi-linear static Schrodinger-Hartree equation involving p-Laplacian

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Schedule: December 19 15:15-15:45 Capital Suite 4

Zhao Liu
Jiangxi Science and Technology Normal University
Peoples Rep of China

Co-Author(s): Wei Dai, Yafei Li

Abstract:
In this talk, we are concerned with nonnegative weak solution to critical quasi-linear static Schrodinger-Hartree equation with p-Laplacian. We establish regularity and the sharp estimates on asymptotic behaviors for any positive solution u and gradient u to more general equation. Then, as a consequence, we prove that all the nontrivial nonnegative solutions are radially symmetric and strictly decreasing about some point.

Identification of a diffusion matrix in a linear parabolic equation

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Schedule: December 19 19:00-19:30 Capital Suite 4

Gianluca Mola
Sorbonne University Abu Dhabi
Italy

Abstract:
Let Ω be a bounded domain of $\mathbb{R}^n$ with smooth boundary $\partial\Omega$. We study the inverse problem consisting in the identification of the function $u:(0,\infty)\times\Omega\to\mathbb{R}$ and the $n\times n$ symmetric and positive definite matrix $\mathbb{A}$ ({\it diffusion matrix}) that fulfill the parabolic problem

$$\left\{ \frac{\partial}{\partial t}u - \nabla\cdot\mathbb{A}\nabla u = 0 \quad \text{in} \quad (0,\infty)\times\Omega,\ u(0,\cdot)=\phi \quad \text{in} \quad \Omega,\ u(t,\cdot)=0 \quad \text{on} \quad (0,\infty)\times\partial\Omega, \right.$$

along with the additional integral measurements at a fixed time $T>0$

$$\int_\Omega \frac{\partial}{\partial x_i}u(T,\boldsymbol{x})\cdot\frac{\partial}{\partial x_j}u(T,\boldsymbol{x})d\boldsymbol{x} = \mathbb{M}_{i,j}, \quad 1\le i\le j\le n.$$

Under suitable assumptions on the initial datum $\phi:\Omega\to\mathbb{R}$ and on the overdeterminating conditions $\mathbb{M}_{i,j}\in\mathbb{R}$, we shall prove that the solution $(u,\mathbb{A})$ of such a problem is unique and depends continuously (Lipschitz) on the data $(\phi,\mathbb{M}_{i,j})$.

Bounded solutions for Leray-Lions equations of $(p,q)-$type with potentials

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Schedule: December 19 14:30-15:00 Capital Suite 4

Dimitri Mugnai
Tuscia University
Italy

Abstract:
We consider some classes of quasilinear elliptic equation in R^N driven by Leray-Lions operators of $(p,q)-$type in presence of radial or unbounded potentials. By using a variational approach in intersections of Banach spaces introduced by Candela and Palmieri and some extensions of related results by Boccardo, Murat and Puel, we show the existence of entire bounded solutions.

Approximate Gidas-Ni-Nirenberg result in the unit ball

Schedule: December 19 18:30-19:00 Capital Suite 4

Luigi Pollastro
Universita` degli studi di Torino
Italy

Co-Author(s): G. Ciraolo, M. Cozzi, M. Perugini

Abstract:
In a celebrated paper published in 1979, Gidas, Ni \& Nirenberg proved a symmetry result for a rigidity problem. With minimal hypotheses, the authors showed that positive solutions of semilinear elliptic equations in the unit ball are radial and radially decreasing.\ This result had a big impact on the PDE community and stemmed several generalizations. In a recent work in collaboration with G. Ciraolo, M. Cozzi \& M. Perugini this problem was investigated from a quantitative viewpoint, starting with the following question: given that the rigidity condition implies symmetry, is it possible to prove that if said condition is \emph{almost} satisfied the problem is \emph{almost} symmetrical?\ With the employment of the method of moving planes and quantitative maximum principles we are able to give a positive answer to the question, proving approximate radial symmetry and almost monotonicity for positive solutions of the perturbed problem.

On the boundary behavior of solutions to fractional elliptic problems

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Schedule: December 19 8:00-8:30 Capital Suite 4

Nicola Soave
Universit\`a degli Studi di Torino
Italy

Co-Author(s): Serena Dipierro, Enrico Valdinoci

Abstract:
We present some results on the boundary behavior of solutions to fractional elliptic problems. In particular, we address the following problems: \ 1) can one prove a Hopf-type lemma for possibly sign-changing solutions? \ 2) given a non-trivial solution u, is it possible that u has infinitely many zeros accumulating at the boundary? \ We answer these questions, and we provide concrete examples to show that the results obtained are sharp.

Recent results on planar Schr\odinger Poisson equations

Schedule: December 19 16:15-16:45 Capital Suite 4

Cristina Tarsi
Universit\`a degli Studi di Milano
Italy

Abstract:
The Schr\odinger-Poisson equation has been first introduced in dimension $N=3$ in 1954 by Pekar to describe quantum theory of a polaron at rest, and then applied by Choquard in 1976 as an approximation to the Hartree-Fock theory of one-component plasma. It has been extensively studied in the higher dimensional case $N \geq 3$, due to the richness of plenty of applications and to the new mathematical challenges related to nonlocal problems. On the other hand, the literature is not abundant for the planar case $N=2$, due to the presence of a sign-changing and unbounded logarithmic integral kernel, which demands for new functional settings where implementing the variational approach.\ We review here some recent results on this topic and on some new related inequalities.

Stability of the Von K\`arm\`an regime for thin plates under Neumann boundary conditions

Schedule: December 19 16:45-17:15 Capital Suite 4

Edoardo Giovanni Tolotti
University of Pavia
Italy

Abstract:
We analyze the stability of the Von K\`arm\`an model for thin plates subject to pure Neumann conditions and to dead loads, with no restriction on their direction. We prove a stability alternative, which extends previous results by Lecumberry and M\uller in the Dirichlet case. Because of the rotation invariance of the problem, their notions of stability have to be modified and combined with the concept of optimal rotations due to Maor and Mora. Finally, we prove that the Von K\`arm\`an model is not compatible with some specific types of forces. Thus, for such, only the Kirchhoff model applies.

Special Session 94 : Computational and Mathematical Approaches to Understanding Complex Biological Systems

Introduction: The investigation of complex biological systems spans multiple spatial and temporal scales, posing significant challenges for analysis and practical applications. To address these challenges, researchers are increasingly turning to advanced mathematical and computational techniques to decode the complexities inherent in these systems. This special session provides a platform for scholars actively involved in the advancement and implementation of such approaches in the realm of mathematical biology. By highlighting the latest research findings, the session aims to stimulate dialogue, collaboration, and innovation, ultimately driving forward both methodological development and practical application in this dynamic field.

Estimating strain-specific intrinsic transmissibility through invasion-timescale thresholding

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Schedule: December 17 18:00-18:30 Capital Suite 9

Abdullah A Al-Shammari
Kuwait University
Kuwait

Co-Author(s): Abir R Aljassar

Abstract:
The rapid replacement of the SARS-CoV-2 Delta variant by Omicron highlights the importance of understanding the interplay between intrinsic transmissibility and immune evasion in multi-strain epidemics. In this talk, we present a novel method for finding bounds on Omicron`s basic reproduction number based on a two-strain SEIR modeling framework. A key finding is that Omicron consistently invaded and replaced Delta across diverse geographic regions within a characteristically short invasion timescale. Through stability analyses and simulations, we demonstrate that this timescale is primarily influenced by the intrinsic characteristics of the two strains, rather than external factors. This theory-driven approach offers a more direct and interpretable estimation of Omicron`s intrinsic transmissibility than traditional data-hungry fitting techniques.

Oscillations in a Spatial Oncolytic Virus Model

Schedule: December 17 13:00-13:30 Capital Suite 9

Arwa Baabdulla
United Arab Emirates University
United Arab Emirates

Co-Author(s): Thomas Hillen

Abstract:
Virotherapy treatment is a new and promising target therapy that selectively attacks cancer cells without harming normal cells. Mathematical models of oncolytic viruses have shown predator-prey like oscillatory patterns as result of an underlying Hopf bifurcation. In a spatial context, these oscillations can lead to different spatio-temporal phenomena such as hollow-ring patterns, target patterns, and dispersed patterns. In this talk, we present the systematic analysis of these spatial oscillations and discuss their relevance in the clinical context. We consider a bifurcation analysis of a spatially explicit reaction-diffusion model to find the above mentioned spatio-temporal virus infection patterns. The desired pattern for tumor eradication is the hollow ring pattern and we find exact conditions for its occurrence.

Mathematical study of Early Afterdepolarizations in realistic cardiomyocyte models

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Schedule: December 17 16:15-16:45 Capital Suite 9

Roberto Barrio
University of Zaragoza
Spain

Co-Author(s): R. Barrio, J.A. Jover-Galtier, H. Kitajima, M.A. Martinez, S. Serrano, T. Yazawa

Abstract:
Early Afterdepolarizations (EADs) are abnormal behaviors that can lead to cardiac failure and even cardiac death. In this presentation, we investigate mathematically the occurrence and development of these phenomena in two realistic ventricular myocyte models: the Sato (2009), rabbit, and the O`Hara (2011), human, models. We connect the results [1, 2] with a reduced low dimensional Luo-Rudy cardiac model. By examining the bifurcation structure of the model, we elucidate the dynamical elements associated with these patterns and their transitions [2]. Using a fast-slow analysis, we explore the emergence and evolution of EADs in the low dimensional model and we develop new methodologies for the fast-slow decomposition for the high-dimensional realistic O`Hara model [3]. [1] Roberto Barrio, M. Angeles Martinez, Sergio Serrano, and Esther Pueyo (2022). Dynamical mechanism for generation of arrhythmogenic early afterdepolarizations in cardiac myocytes: Insights from in silico electrophysiological models. Physical Review E, 106(2). [2] Roberto Barrio, Jorge A. Jover-Galtier, M. Angeles Martinez, Lucia Perez and Sergio Serrano (2023). Mathematical birth of Early Afterdepolarizations in a cardiomyocyte model. Mathematical Biosciences, 366, 109088. [3] Hiroyuki Kitajima, Toru Yazawa and Roberto Barrio (2024). Effect of Calcium ion concentration on early afterdepolarization generation in a realistic mathematical human ventricular myocyte model. Preprint.

A prey-predator model with cooperative hunting among predators

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Schedule: December 18 9:00-9:30 Capital Suite 9

Yoichi Enatsu
Tokyo University of Science
Japan

Co-Author(s): Jyotirmoy Roy, Malay Banerjee

Abstract:
We consider the dynamics of a prey-predator model with cooperative hunting among predators. We start with the analysis on the model without delay in which the consumption rate is described as Holling type I and II. We explore the effect of hunting time in the consumption rate on the coexistence of predator and their prey. The occurrences of a series of bifurcations that depend on the cooperation rate and the hunting time is also investigated. We numerically observe the occurrences of a series of bifurcations that depend on the cooperation rate and the hunting time. We also introduce a maturation delay for predator growth and analyze its impact on the dynamics. As the delay becomes larger, predator species become more likely to go extinct, as the long maturation delay hinders the growth of the predator population. Our numerical exploration reveals that the delay causes shifts in both the bifurcation curves and bifurcation thresholds of the non-delayed system. This work is based on a joint work with Jyotirmoy Roy and Malay Banerjee (IIT Kanpur).

Explicit impacts of harvesting in food chain models

Schedule: December 17 14:00-14:30 Capital Suite 9

Tapan K Kar
Indian Institute of Engineering Science and Technology, Shibpur
India

Abstract:
Harvesting strongly impacts the dynamics of interacting species of ecological systems. Depending on the harvesting strategy at different trophic levels, the long-run stationary biomass of the coexisting population becomes unstable and ultimately goes to extinction. Various patterns may be possible based on the intensity of harvesting efforts distributed among different trophic levels. If we aim to manage ecological systems with multiple objectives, only the yield-maximizing strategy may not fit the system. A balance between ecosystem services is essential for food chain systems. The hydra effect, one of the paradoxical results of theoretical and applied ecology, refers to the fact that increasing a population`s mortality rate enhances its stock. Hence, the existence of the hydra effect, at a stable steady state, needs to be investigated in food chain models. Parameters involved in any ecological system are inherent factors and change very slowly in comparison to the applied harvesting effort. Hence, harvesting effort can be used as a control parameter to regulate the system. Viewed from the perspective of dynamics, in this talk, I shall present mathematical approaches to the explicit impacts of harvesting in food chain systems. These investigations contribute to understanding population interactions, fishery management, and biological pest control tactics.

Transient Oscillations in Immune Response to Viral Infections due to Delay and Functional Forms

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Schedule: December 17 17:00-17:30 Capital Suite 9

Michael Li
University of Alberta
Canada

Co-Author(s): Michael Y Li

Abstract:
I will show some data on immune responses that exhibits robust and finite-time oscillations. We will examine models with different functional forms of response function and incorporation of time delay to identify mechanisms that can lead to transient oscillations.

Lyapunov Functions for Disease Models and Their Modifications

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Schedule: December 18 8:30-9:00 Capital Suite 9

Connell McCluskey
Wilfrid Laurier University
Canada

Abstract:
Lyapunov functions are a valuable tool for the global stability analysis of nonlinear dynamical systems. However, they are notoriously difficult to find, even for ODEs, and there is no general method for constructing them. Despite this, Lyapunov functions have been found for many dynamical systems, giving a ``library of pairs: [dynamical system, Lyapunov function] In the particular case of compartmental models for the transmission of infectious disease, there has been great progress in finding Lyapunov functions over the last 20 years, expanding the library. This library can be drawn upon when exploring the stability of a dynamical system that is similar to a system for which a Lyapunov function is known. In this lecture, I will discuss this process, including recent results.

Deterministic and stochastic analysis of eco-epidemic models, focusing on fear, refuge, and selective predation dynamics

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Schedule: December 17 12:30-13:00 Capital Suite 9

Samares Pal
University of Kalyani
India

Co-Author(s): Sasanka Shekhar Maity

Abstract:
In this investigation, we delve into the dynamics of an eco-epidemic model, considering the intertwined influences of fear, refuge-seeking behavior, and alternative food sources for predators with selective predation. We extend our model to incorporate the impact of fluctuating environmental noise on system dynamics. The deterministic model undergoes thorough scrutiny to ensure the positivity and boundedness of solutions, with equilibria derived and their stability properties meticulously examined. Furthermore, we explore the potential for Hopf bifurcation within the system dynamics. In the stochastic counterpart, we prioritize discussions on the existence of a globally positive solution. Through simulations, we unveil the stabilizing effect of the fear factor on susceptible prey reproduction, juxtaposed against the destabilizing roles of prey refuge behavior and disease prevalence intensity. Notably, when disease prevalence intensity is too low, the infection can be eradicated from the eco-system. Our deterministic analysis reveals a complex interplay of factors: the system destabilizes initially but then stabilizes as the fear factor suppressing disease prevalence intensifies, or as predators exhibit a stronger preference for infected prey over susceptible ones, or as predators are provided with more alternative food sources.

Assessing the impact of the Wolbachia-based control of malaria

Schedule: December 17 17:30-18:00 Capital Suite 9

Zhuolin Qu
University of Texas at San Antonio
USA

Co-Author(s): Zhuolin Qu and Lauren M. Childs

Abstract:
Malaria remains a significant infectious disease globally, causing hundreds of thousands of deaths each year. Traditional control methods, such as disease surveillance and mosquito control, along with the development of malaria vaccines, have made strides in reducing the disease`s impact, but new control methods are urgently needed. Wolbachia is a natural bacterium that can infect mosquitoes and reduce their ability to transmit diseases. While initially used to control dengue fever, recent research explored its potential for malaria control. In this study, we develop and analyze a novel mathematical model to assess the potential use of Wolbachia-based strategies for malaria control. The model describes the complex Wolbachia transmission dynamics among mosquitoes and incorporates key features of malaria transmission in humans with dynamical immunity feedback. We derive the basic reproduction number of the malaria disease transmission, which depends on the prevalence of Wolbachia in mosquitoes. Our findings reveal bifurcations in both Wolbachia transmission among mosquitoes and malaria transmission in humans, suggesting the potential for malaria elimination through Wolbachia-based interventions. The sensitivity analysis identifies the important parameters for the basic reproduction number and for malaria reduction and elimination. We further numerically explore the integration of Wolbachia and other malaria control.

Asymptotic stability for non-autonomous linear delay differential equations representing birth-death dynamics

Schedule: December 17 15:15-15:45 Capital Suite 9

Gergely Rost
University of Szeged / HCEMM
Hungary

Abstract:
We consider the fundamental non-autonomous linear scalar delay differential equation

$$\dot{x}(t) = -a(t)x(t) + b(t)x(t-\tau),$$

with non-negative time-varying coefficients, representing the birth-death process of a population with maturation delay. We review all previous results for this equation, then we prove a completely new asymptotic stability result for the zero solution. We construct a specific class of examples showing that our conditions for population extinction are indeed complement all previous theorems in the literature.

Spatial movement with temporally distributed memory

Schedule: December 17 13:30-14:00 Capital Suite 9

Junping Shi
College of William & Mary
USA

Co-Author(s): Junping Shi, Qingyan Shi

Abstract:
A reaction-diffusion population model with Dirichlet boundary condition and a directed movement oriented by a temporally distributed delay is proposed to describe the lasting memory of animals moving over space. The temporal kernel of the memory is taken to be the Gamma distribution function, in particular the weak kernel in which the animals can immediately acquire knowledge and memory decays over time and the strong kernel by which we assume that animals` memory undergoes learning and memory decay stages. It is shown that the population stabilizes to a positive steady state and aggregates in the interior of the territory when the delay kernel is the weak type; and in the strong kernel case, oscillatory patterns can arise and vanish when the mean delay value increases via two Hopf bifurcations, thus a stability switch phenomenon occurs and spatial-temporal patterns emerge for intermediate value of delays.

Lyapunov Functions for Large-Scale Dynamical Systems

Schedule: December 18 8:00-8:30 Capital Suite 9

Zhisheng Shuai
University of Central Florida
USA

Abstract:
This presentation revisits Lyapunov functions and their applications in large-scale dynamical systems, such as heterogeneous population models. We highlight recent advancements and ongoing challenges in establishing the global stability of both disease-free and endemic equilibria in infectious disease models. Noteworthy among recent advancements are work on discrete-time epidemiological models, offering promising insights that may steer future directions.

An evolutionary epidemic model to study the impact of tolerance on disease-induced recoveries

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Schedule: December 17 19:00-19:30 Capital Suite 9

Sabrina Streipert
University of Pittsburgh
USA

Abstract:
Recoveries of populations that have suffered severe disease-induced declines are being observed across disparate taxa. Yet, we lack theoretical understanding of the drivers and dynamics of recovery in host populations. Motivated by diseaseinduced declines and nascent recoveries in amphibians, we developed a model to ask: how does the rapid evolution of different host defense strategies affect the transient recovery trajectories of hosts following pathogen invasion and disease-induced declines? Our model, based on a moment closure approximation, provided key insights into the transient effects of different defense mechanisms. Furthermore, populations evolving tolerance recovered on average four times slower than populations evolving resistance. This motivated the long-term study of a tolerance evolving host species. We found that in the presence of a trade-off, where a higher tolerance comes at the expense of a lower reproductive rate, the set of pandemic equilibria increases in richness to contain equilibria where different tolerance classes are present, contrasting the results obtained in the absence of such trade-off.

Bifurcation Analysis for an OSN Model with Two Delays

Schedule: December 17 15:45-16:15 Capital Suite 9

Liancheng Wang
Kennesaw State University
USA

Co-Author(s): Min Wang

Abstract:
In this research, we introduce and analyze a mathematical model for online social networks, incorporating two distinct delays. These delays represent the time it takes for active users within the network to begin disengaging, either with or without contacting non-users of online social platforms. We focus particularly on the user prevailing equilibrium (UPE), denoted as P^*, and explore the role of delays as parameters in triggering Hopf bifurcations. In doing so, we find the conditions under which Hopf bifurcations occur, then establish stable regions based on the two delays. Furthermore, we delineate the boundaries of stability regions wherein bifurcations transpire as the delays cross these thresholds. We present numerical simulations to illustrate and validate our theoretical findings. Through this interdisciplinary approach, we aim to deepen our understanding of the dynamics inherent in online social networks.

Mathematical modeling of COVID-19

Schedule: December 18 9:30-10:00 Capital Suite 9

Xueying Wang
Washington State University
USA

Abstract:
COVID-19 has presented unprecedented global public health challenges. This talk will discuss some mathematical modeling works for COVID-19, divided into two parts. The first part introduces a multiscale modeling framework that integrates both within-host and between-host dynamics of COVID-19. It explores various transmission routes (human-to-human and environment-to-human) and scales (population and individual). The analysis reveals complex dynamics and underscores the environment`s critical role in transmission. While antiviral treatments can delay outbreaks, they cannot prevent them, highlighting the need for environmental control measures in addition to human-to-human interventions like social distancing and mask-wearing. The second part focuses on a multi-strain model that investigates how asymptomatic or pre-symptomatic infections impact strain transmission and control strategies. Our findings indicate that Omicron variants are more transmissible but less fatal than earlier strains. We also show that implementing mask mandates before the peak can reduce and delay it, with the timing of lifting mandates affecting subsequent waves.

Threshold dynamics of an age-structured HIV model

Schedule: December 17 14:45-15:15 Capital Suite 9

Yuan Yuan
Memorial University of Newfoundland, St. John`s
Canada

Co-Author(s): Hu, Dandan

Abstract:
We incorporate both virus-to-cell and cell-to-cell transmissions into an age-structured withinhost virus infec8on model with cytotoxic T lymphocyte immune response. We have established local stability of feasible steady states, by analyzing the characteristic equations, and discussed the global threshold dynamics by using Lyapunov functionals and LaSalle invariance principle.

Modeling the Dynamics of Legionnaires` Disease

Schedule: December 17 18:30-19:00 Capital Suite 9

Lihong Zhao
Kennesaw State University
USA

Abstract:
Some diseases have transmission pathways which rely on interaction with an environmental reservoir. One such disease is Legionnaires` disease (LD), an atypical pneumonia caused by the inhalation of bacteria of the genus Legionella suspended in aerosolized water. In 2018, there were nearly 10,000 LD cases reported by health departments in the United States. True incidence should be higher as LD is likely underdiagnosed. We develop and analyze an ODE-based model to examine the various factors that may have contributed to the increase in LD outbreaks.

Special Session 95 : Nonlinear analysis and elliptic boundary value problems

Introduction: This special session will cover novel topics and results concerning nonlinear elliptic boundary value problems, with an emphasis on smooth and nonsmooth variational methods, topological methods and the topological degree

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Existence and multiplicity of solutions for different Sturm-Liouville problems

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Schedule: December 17 18:00-18:30 Capital Suite 14

Eleonora Amoroso
University of Messina
Italy

Abstract:
In this talk, we present some existence and multiplicity results for Sturm-Liouville problems with either Dirichlet or periodic boundary conditions. Moreover, the problems are parameter-dependent and we provide intervals of parameters for which the problems admit one or multiple solutions. In addition, we offer a link between pure and applied mathematics since the problems considered are used to describe power converters (Dirichlet conditions) or the behavior of a neuron (period conditions). This research is partially supported by PNRR-MAD-2022-12376692 ``AN ARTIFICIAL INTELLIGENCE APPROACH FOR RISK ASSESSMENT AND PREVENTION OF LOW BACK PAIN: TOWARDS PRECISION SPINE CARE`` (XAI-CARE) - CUP: J43C22001510001.

Maximal and minimal weak solutions for elliptic coupled systems with non-linearity on the boundary

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Schedule: December 17 8:00-8:30 Capital Suite 14

Shalmali Bandyopadhyay
The University of Tennessee at Martin
USA

Co-Author(s): Nsoki Mavinga, Thomas Lewis

Abstract:
We analyze weak solutions for a coupled system of elliptic equations with quasimonotone nonlinearity on the boundary. We also formulate a finite difference method to approximate the PDE solutions. We establish the existence of maximal and minimal weak solutions in between ordered pairs of weak sub and supersolutions as well as the existence of maximal and minimal finite difference approximations in between ordered pairs of discrete sub and supersolutions. The analysis employs monotone iteration methods to construct the maximal and minimal solutions when the nonlinearity is monotone. We explore existence, nonexistence, uniqueness and nonuniqueness properties of positive solutions by analyzing particular examples with numerical simulations. When the nonlinearities do not satisfy the monotonicity condition, we prove the existence of weak maximal and minimal solutions using Zorn`s lemma and a version of Kato`s inequality for systems up to the boundary.

Multiplicity of Solutions for a Class of Critical Exponent Problems in the Hyperbolic Space

Schedule: December 17 9:00-9:30   Capital Suite 14

Mousomi Bhakta
Indian Institute of Science Education and Research Pune (IISER Pune)
India

Co-Author(s): Debdip Ganguly, Diksha Gupta, Alok Kumar Sahoo

Abstract:
In this talk I will discuss the multiplicity of positive solutions to problems of the type

$$-\Delta_{\mathbb{B}^N} u - \lambda u = a(x)|u|^{2^*-2}u + f(x) \quad \text{in } \mathbb{B}^N, \quad u \in H^1(\mathbb{B}^N),$$

where $\mathbb{B}^N$ denotes the ball model of the hyperbolic space of dimension $N \geq 4$, $2^* = \frac{2N}{N-2}$ $\frac{N(N-2)}{4} < \lambda < \frac{(N-1)^2}{4}$ and $f \in H^{-1}(\mathbb{B}^N)$ ($f \not\equiv 0$) is a non-negative functional in the dual space of $H^1(\mathbb{B}^N)$. The potential $a \in L^\infty(\mathbb{B}^N)$ is assumed to be strictly positive, such that $\lim_{d(x,0)\to\infty} a(x) = 1$, where $d(x,0)$ denotes the geodesic distance. In the profile decomposition of the functional associated with the above equation, concentration occurs along two different profiles, namely, hyperbolic bubbles and localized Aubin-Talenti bubbles. Using the decomposition result, we derive various energy estimates involving the interacting hyperbolic bubbles and hyperbolic bubbles with localized Aubin-Talenti bubbles. Finally, combining these estimates with topological and variational arguments, we establish a multiplicity of positive solutions in the cases: $a \geq 1$ and $a < 1$ separately.

Homogenization of a variable exponent problem

Schedule: December 17 12:30-13:00   Capital Suite 14

Maria-Magdalena Boureanu
University of Craiova, Romania
Romania

Co-Author(s): Renata Bunoiu; Claudia Timofte

Abstract:
We are concerned with periodic strongly oscillating variable exponent problems involving Leray-Lions type operators. We first show that the problem under study is uniquely solvable and we establish \emph{a priori} estimates. Using a suitable convergence setting, we then provide the homogenization result. This talk is based on a joint work with Renata Bunoiu and Claudia Timofte.

Existence results for a borderline case of a class of p-Laplacian problems

Schedule: December 17 15:15-15:45 Capital Suite 14

Anna Maria Candela
Universita' degli Studi di Bari Aldo Moro
Italy

Abstract:
Let us consider the class of asymptotically ``$p(s+1)$-linear`` p-Laplacian problems

$$\left\{ -\mathrm{div} \left[\left(A_0(x) + A(x)|u|^{ps}\right) |\nabla u|^{p-2} \nabla u \right] + s\, A(x)|u|^{ps-2} u\, |\nabla u|^p \quad = \; \mu |u|^{p(s+1)-2} u + g(x,u) \quad \text{in} \right.$$

where Ω is a bounded domain in $\mathbb{R}^N$, $N \geq 2$, $1 < p < N$, $s > 1/p$, both the coefficients $A_0(x)$ and $A(x)$ are in L^∞ from 0, $\mu \in \mathbb{R}$, and the ``perturbation`` term $g(x,t)$ grows as $|t|^{r-1}$ with $1 \leq r < p(s+1)$ and is such that $g(x,t$ $t \to 0$. Under good hypotheses on $g(x,t)$, suitable thresholds for the parameters μ and ν exist so that the exister nontrivial weak solution of the given problem is proved if either ν is large enough with μ small enough or ν is sı with μ large enough.

Joint work with Kanishka Perera and Addolorata Salvatore.

Partially supported by MUR PRIN 2022 PNRR Research Project P2022YFAJH, Linear and Nonlinear PDEs: New Di Applications.

Dissipative gradient nonlinearities prevent blow-up in a class of Keller--Segel mod

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Schedule: December 17 13:30-14:00 Capital Suite 14

Alessandro Columbu
Universit\`a degli Studi di Cagliari
Italy

Co-Author(s): Tongxing Li; Daniel Acosta Soba; Giuseppe Viglialoro;

Abstract:
We examine a class of attraction-repulsion chemotaxis models, which are defined by nonlinearities in the diffusion of cell density, chemosensitivity, and the production rates of chemoattractants and chemorepellents. Additionally, the model includes a logistic term that also depends on the gradient of the biological distribution. In this presentation, we will establish a condition for their boundedness.

Global existence and blow-up lower bounds in a class of tumor-immune cell interactions chemotaxis systems

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Schedule: December 17 17:30-18:00 Capital Suite 14

Rafael Diaz Fuentes
University of Cagliari
Italy

Co-Author(s): S. Gnanasekaran, A. Columbu, N. Nithyadevi

Abstract:
This talk describes the properties of classical solutions to a particular class of chemotaxis systems consisting of three partial differential equations that are either fully parabolic or comprises one parabolic equation along with two others that are elliptic. The primary goal of our investigation is to explore the global existence and potential blow-up of such solutions within bounded domains of $\mathbb{R}^n$, $n \geq 3$, subject to homogeneous Neumann boundary conditions. We establish the global-in-time existence and uniform boundedness of the solutions under smallness conditions imposed on the initial data. Furthermore, we present estimates for the blow-up time of unbounded solutions in three-dimensional space, which are corroborated by numerical simulations.

Nonlocal degenerate variable exponent elliptic problem: existence and multiplicity of solutions

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Schedule: December 17 9:30-10:00 Capital Suite 14

Giuseppe Failla
University of Palermo
Italy

Co-Author(s): Pasquale Candito, Roberto Livrea

Abstract:
In this talk, we will present some recent results on nonlocal $p(x)$ Carrier`s equation with Dirichlet boundary value conditions. One of the main novelties is the possibility of having a sign-changing function in the nonlocal term. To obtain our results, we combine sub-super solution, variational, and truncation techniques. Finally, multiplicity of solutions is obtained via a one-dimensional fixed-point problem.

Dissipation through combinations of nonlocal and gradient nonlinearities in chemotaxis models

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Schedule: December 17 8:30-9:00 Capital Suite 14

Silvia Frassu
University of Cagliari
Italy

Co-Author(s): Rafael D\`iaz Fuentes, Giuseppe Viglialoro

Abstract:
This talk concerns with a class of chemotaxis models in which external sources, comprising nonlocal and gradient-dependent damping reactions, influence the motion of a cell density attracted by a chemical signal. The mechanism of the two densities is studied in bounded and impenetrable regions. In particular, it is seen that no gathering effect for the cells can appear in time provided that the damping impacts are sufficiently strong.

Variational methods for nonlinear differential problems with discontinuous reaction terms

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Schedule: December 17 13:00-13:30 Capital Suite 14

Valeria Morabito
University of Messina
Italy

Abstract:
In this talk, we present existence results for a class of nonlinear differential problems with a discontinuous reaction term and explore their link to differential inclusions. The discontinuity of the reaction term necessitates an appropriate framework that can address the nonsmooth behavior of the nonlinearity. To achieve this, our approach is based on variational methods from nonsmooth analysis, specifically focusing on Clarke`s theory of locally Lipschitz functionals.

Mixed finite element methods for fourth order obstacle problems in linearised elasticity

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Schedule: December 17 15:45-16:15 Capital Suite 14

Paolo Piersanti
The Chinese University of Hong Kong Shenzhen
Peoples Rep of China

Co-Author(s): Tianyu Sun

Abstract:
This talk is devoted to the study of a novel mixed Finite Element Method for approximating the solutions of fourth order variational problems subjected to a constraint. The first problem we consider consists in establishing the convergence of the error of the numerical approximation of the solution of a biharmonic obstacle problem. The contents of this section are meant to generalise the approach originally proposed by Ciarlet \& Raviart, and then complemented by Ciarlet \& Glowinski. The second problem we consider amounts to studying a two-dimensional variational problem for linearly elastic shallow shells subjected to remaining confined in a prescribed half-space and we show that if the middle surface of the linearly elastic shallow shell under consideration is flat, the symmetry constraint required for formulating the constrained mixed variational problem announced in the second part of the paper is not required, and the solution can thus be approximated by solely resorting to Courant triangles.

Existence of multiple solutions for specific classes of nonlinear anisotropic problems

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Schedule: December 17 18:30-19:00 Capital Suite 14

Angela Sciammetta
University of Palermo
Italy

Abstract:
In this talk, we explore several results concerning the existence and multiplicity of solutions to anisotropic Laplacian problems with Dirichlet boundary conditions. Our findings include two nontrivial weak solutions, proven both with and without relying on the Ambrosetti-Rabinowitz condition. Moreover, we point out the existence of three solutions for a particular type of anisotropic Laplacian problem.

On the existence of solutions of degenerate Dirichlet problems with unbounded coefficient

Schedule: December 17 14:00-14:30 Capital Suite 14

Elisabetta Tornatore
University of Palermo
Italy

Co-Author(s): G. Bonanno, A. Chinn\`i, B. Di Bella, D. Motreanu

Abstract:
This talk is devoted to the study of the existence of solutions of degenerate Dirichlet problems with unbounded coefficient in the principal part. We analyze degenerate problems with convection term and intrinsic operator and degenerate problem with variable exponent. The results presented are part of the research carried out within project PRIN2022-Nonlinear differential problems with applications to real phenomena(20022ZXZTN2).

Multiple critical point results to Sturm-Liouville-type differential problems with highly discontinuous reaction term

Schedule: December 17 16:15-16:45 Capital Suite 14

Bruno Vassallo
University of Palermo
Italy

Co-Author(s): Roberto Livrea

Abstract:
We consider Sturm-Liouville-type differential problems dependent on a parameter with various boundary conditions. The reaction term f belongs to a class of almost everywhere continuous functions and the set of the points of discontinuity of f may also be uncountable. Combining variational methods with critical point theorems for non-differentiable functions, weak solutions to the problems are established provided the parameter belongs to an explicit interval.

Singular Kirchhoff problems with unbalanced-growth operators

Schedule: December 17 17:00-17:30 Capital Suite 14

Patrick Winkert
University of Technology Berlin
Germany

Co-Author(s): Umberto Guarnotta

Abstract:
In this talk, we present existence results for Kirchhoff problems with singular and super-linear reaction terms. The operator is given in a general form, possibly non-homogeneous and with unbalanced growth. Under general assumptions, we prove the existence of two solutions with different energy sign by using the fibering map and the Nehari manifold. Our hypotheses cover the double phase operator and the logarithmic double phase operator as special cases. This is a joint work with Umberto Guarnotta (Ancona).

Special Session 96 : Evolutionary Equations Systems

Introduction: The focus of this session is to give an update on recent developments concerning ordinary and partial differential equations obtained by exploiting different methods of the nonlinear analysis such as critical point theory, fixed point theorems, set-valued analysis, semigroup theory and so on. Evolutionary equations systems model a huge variety of real world models in all fields of Science, Technology and Environmental Sciences. This session will bring together researchers working on nonlinear differential equations, as well as their applications mainly focused on population dynamics, fluido-dynamics modeling, transport and diffusion problems. It will provide an opportunity to identify future directions of research, open questions and encourage interdisciplinary collaborations.

Weakly convex and generalized subharmonic functions related to a C_0-semigroup

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Schedule: December 18 9:00-9:30 Capital Suite 5

Ana Maria Acu
Lucian Blaga University of Sibiu
Romania

Co-Author(s): Ioan Rasa, Georgian Chivu

Abstract:
Let K be a convex compact subset of $R^p, p \geq 1$, having nonempty interior. Starting with a suitable positive linear projection T defined on $C(K)$, Altomare and Rasa defined in [1] the weakly T-convex functions. Using T, a C_0-semigroup of operators on C(K) was constructed and the generalized A-subharmonic functions were defined, where A is the infinitesimal generator of the semigroup. It was proved that if a function is weakly T-convex, then it is generalized A-subharmonic. The authors of [1] conjectured that the converse is also true, but as far as we know this is still an open problem. We present some results related to the conjecture. Namely, starting with the conjecture, we prove that a suitable stronger hypothesis entails a stronger conclusion. [1] F. Altomare, I. Rasa, Feller semigroups, Bernstein type operators and generalized convexity associated with positive projections, New Developments in Approximation Theory, Internat. Ser. Numer. Math. vol.132, Birkhauser, Basel, 1999, 9-32.

Regularity results on 3D viscous Tropical Climate Models

Schedule: December 19 9:00-9:30 Capital Suite 5

Diego Berti
University of Turin
Italy

Abstract:
We consider the Tropical Climate Model (TCM) in three spatial dimensions within the framework of mathematical fluid dynamics. The TCM consists of a coupled system of diffusion equations for two modes of wind velocity and the temperature. Similar to other well-known 3D systems in fluid dynamics, such as the Navier-Stokes equations, the global-in-time well-posedness of the 3D TCM remains an open problem. In collaboration with L. Bisconti (University of Florence, Italy) and Davide Catania (eCampus, Italy), we present new results on the analysis of regularized versions of the 3D TCM, particularly when nonlinear dampings are introduced.

Singular traveling waves in parabolic operators with a divergence-shaped flow operator.

Schedule: December 18 14:45-15:15 Capital Suite 5

Juan Campos
Universidad de Granada
Spain

Abstract:
We are going to analyze the traveling waves problem of

$$u_t = (a(u, u_x))_x + f(u), \qquad (t, x) \in \mathbb{R}^2,$$

where $a(u, u_x)$ is an increasing function in the second component and f is of Fisher type. The main problem is to make sense of the singular solution to provide information on the speed of propagation of the evolution of a compact supported initial data.

Chaos for degenerate parabolic equations

Schedule: December 18 8:30-9:00 Capital Suite 5

Anna Maria Candela
Universita' degli Studi di Bari Aldo Moro
Italy

Abstract:
The Nobel Prize winning Black-Scholes equation for stock options and the heat equation are both model equations of the generalized problem

$$\frac{\partial u}{\partial t} = P_2(A_a)u,$$

where $P_2(z) = \alpha z^2 + \beta z + \gamma$ is a quadratic polynomial with $\alpha > 0$ and $A_a = x^a \frac{\partial}{\partial x}$ is an operator for functions on $[0, \infty) \times [0, \infty)$ with $0 \leq a \leq 1$. For each operator A_a the corresponding degenerate parabolic equation is governed by a semigroup of operators which is chaotic on a suitable class of Banach spaces; thus, we unify, simplify and significantly extend earlier results obtained by H. Emamirad, G. R. Goldstein and J. A. Goldstein for the Black-Scholes equation ($a = 1$) and the heat equation ($a = 0$). \smallskip \noindent Joint work with G. Ruiz Goldstein, J. A. Goldstein and S. Romanelli. \medskip \noindent Supported by MUR-PNRR project code CN00000013 `\emph{National Centre for HPC, Big Data and Quantum Computing}` - Spoke 10 `\emph{Quantum Computing}`.

Parabolic logistic equation with harvesting involving the fractional Laplacian

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Schedule: December 18 13:00-13:30 Capital Suite 5

Maya Chhetri
The University of North Carolina at Greensboro
USA

Co-Author(s): P. Girg, E. Hollifield and L. Kotrla

Abstract:
This talk will focus on a class of parabolic problems governed by the fractional Laplacian, subject to zero Dirichlet conditions on the exterior of a bounded domain. We will discuss the existence and uniqueness of solutions for these problems. Additionally, we apply our results to logistic growth models with constant yield harvesting by constructing an ordered pair of sub- and supersolutions for the associated elliptic equation.

Impulsive and Dirichlet problems driven by second order differential inclusions.

Schedule: December 19 14:00-14:30 Capital Suite 5

Giulia Duricchi
Universita` degli Studi di Firenze
Italy

Co-Author(s): Tiziana Cardinali

Abstract:
In recent joint papers with Tiziana Cardinali we investigate in Banach spaces the existence of impulsive mild solutions for a problem driven by the following semilinear second order differential inclusion $x''(t) \in Ax(t) + F(t, x(t), x'(t)),$ a.e. $t \in [0, \infty) \setminus \{t_k\}_k$ and the existence of strong solutions for a Dirichlet problem governed by the following Duffing differential inclusion $-x''(t) - r(t)x(t) \in F(t, x(t)),\ t \in [0, a]$ To establish the first goal, we show the existence of mild solutions on a bounded interval. Then, by using a glueing method, we achieve the existence of impulsive mild solutions on $[0, \infty)$. While to study the Duffing Dirichlet problem, we apply a fixed point result to an appropriate solution operator. All results are proved without strong compactness assumptions. Finally, thanks to these findings, the controllability for problems driven by ordinary/partial differential equations is obtained.

Well-posedness and stability for a class of evolution systems

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Schedule: December 18 14:00-14:30 Capital Suite 5

Yassine El Gantouh
School of Mathematical Sciences, Zhejiang Normal University
Peoples Rep of China

Co-Author(s): Yassine El Gantouh

Abstract:
In many PDEs models some constraints need to be imposed when considering concrete applications. This is for instance the case of evolutionary systems (such as heat conduction, transportation networks, population dynamic, etc.) where realistic models must incorporate the consideration that the state should adhere to some positivity constraints to ensure their physical relevance. In this talk, we discuss the positivity property of linear evolution systems. We present criteria for well-posedness, positivity and stability of a class of infinite-dimensional systems. These criteria are based on an inverse estimate with respect to the Hille-Yosida Theorem. This unifies previous results available in the literature and that were established separately so far. As for illustration, we exhibit the feasibility of these criteria through a structured population model with (unbounded) delay in the birth process.

Some remarks on Melnikov chaos for smooth and piecewise smooth systems

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Schedule: December 18 15:45-16:15 Capital Suite 5

Matteo franca
Bologna University
Italy

Co-Author(s): Calamai A., Pospisil M.

Abstract:
It is well known that a smooth autonomous system which has a homoclinic trajectory (i.e. a trajectory converging to a critical point as $t \to \pm\infty$) and subject to a small periodic forcing may exhibit a chaotic pattern. A motivating example in this context is given by a forced inverted pendulum.\ Melnikov theory provides a computable sufficient condition for the existence of a transversal intersection between stable and unstable manifolds: in a smooth context this is enough to guarantee the persistence of the homoclinic and the insurgence of chaos.\ In this talk we show that in piecewise smooth system with a transversal homoclinic point a generic geometrical obstruction forbids chaotic phenomena which are replaced by new bifurcation scenarios. Further, if this obstruction is removed, chaos may arise again. Piecewise smooth system are motivated by the study of dry friction, state dependent switches, or impacts. In fact we will also show some results new in a smooth context, concerning multiplicity, position and size of the Cantor set Σ of initial conditions from which chaos emanates. In particular we will see that, even if the perturbation is $O(\varepsilon)$, we may find infinitely many distinct Cantor set Σ located in the same $O(\varepsilon^{\nu})$ neighborhood of the critical point, each corresponding to a different pattern, and where $\nu > 1$ is as large as we wish.

Delay evolution equations with nonlocal multivalued initial conditions

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Schedule: December 19 14:30-15:00 Capital Suite 5

Giovanni Giliberti
University of Modena and Reggio Emilia (Unimore)
Italy

Abstract:
We consider the nonlinear delay differential evolution equation in a Banach space X { $x`(t) = Ax(t) + f(t, x_t)$
generates a C_0-semigroup of contractions and the function x_t, defined by $x_t(s) = x(t+s)$ for $s \in [-r, 0]$, is the c
nonlocal, multivalued, Cauchy condition defined by the multimap $g : C([-r, T], X) \multimap C([-r, 0], X)$, whether the
suitable degree argument. We then apply our results to a transport equation in the form

$$\Bigg\{ u_t(t, y) + a \cdot \nabla u(t, y) = \Phi \left(\int_{\mathbb{R}^n} |u(t, \xi)|^p d\xi \right) \cdot h \left(\int_{t-r}^{t} \int_{\mathbb{R}^n} |u(s, \xi)|^p \, \mathrm{d}\xi \, \mathrm{d}s \right) \cdot \ell(t, u(t, y)) \qquad [0, T] \times \mathbb{R}^n \; u(t, y) \in \Bigg\{$$

where $a \in \mathbb{R}^n$, the functions Φ, h: $\mathbb{R} \to \mathbb{R}$ are continuous and bounded and the map $\ell : [0, T] \times \mathbb{R} \to \mathbb{R}$ satisfies s
function $u_0 : [-r, 0] \times \mathbb{R}^n \to \mathbb{R}$, the fixed instants 0

On multiplicative time-dependent perturbations of semigroup

Schedule: December 18 9:30-10:00 Capital Suite 5

Erica Ipocoana
Freie Universit\"{a}t Berlin
Germany

Co-Author(s): Valentina Taddei

Abstract:
In this work we aim to investigate a second order PDE modelling a vibrating string. Our strategy consists in transforming the PDE problem into a semilinear second order ODE in a suitable infinite dimensional space. Since the tension coefficient of the PDE may vary with time, the linear operator of the ODE depends on time. We therefore provide sufficient conditions guaranteeing that a suitable family of unbounded linear operators generates a fundamental system.

Estimates for the minimum time function

Schedule: December 19 13:30-14:00 Capital Suite 5

Alina I Lazu
"Gheorghe Asachi" Technical University of Iasi
Romania

Co-Author(s): Ovidiu Carja

Abstract:
For the semilinear control system $y'(t) = Ay(t) + f(y(t)) + Bu(t)$, where $B : U \to X$ is a linear continuous operator, X and U two Hilbert spaces, $A : D(A) \subseteq X \to X$ the generator of a C_0-semigroup, $f : X \to X$ a given function and u the control, we study the null controllability problem and we provide estimates for the minimum time function around the target, using viability results.

Boundary value problems for integro-differential and singular higher order differential equations

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Schedule: December 18 12:30-13:00 Capital Suite 5

Cristina Marcelli
Marche Politechical University
Italy

Co-Author(s): F. Anceschi - A. Calamai - F. Papalini

Abstract:
The talk concerns some recent results about third-order strongly nonlinear differential equations of the type

$$(\Phi(k(t)u''(t)))' = f(t, u(t), u'(t), u''(t)), \quad \text{a.e. on } [0, T]$$

where Φ is a strictly increasing homeomorphism and the nonnegative function k may vanish on a set of measure zero. By using the upper and lower solutions method, existence results for boundary value problems, associated to the above equation, are proved. Moreover, second-order integro-differential equations of the type

$$(\Phi(k(t)v'(t)))' = f(t, \int_0^t v(\tau)\, d\tau,\ v(t),\ v'(t)), \quad \text{a.e. on } [0, T]$$

are also considered, for which existence results for various types of boundary conditions, including periodic, Sturm-Liouville and Neumann-type conditions, are provided.

Weak Solutions of Nonlinear Elliptic Problems with Growth up to Critical Exponents

Schedule: December 19 8:30-9:00   Capital Suite 5

Nsoki Mavinga
Swarthmore College
USA

Co-Author(s): Nsoki Mavinga, Timothy Myers, Marius Nkashama

Abstract:
We will present some recent results on the existence of weak minimal and maximal solutions between an ordered pair of sub- and super-solutions for semilinear elliptic equations with nonlinearities in the differential equation and on the boundary. No monotonicity conditions are imposed on the nonlinearities. Unlike previous results in this setting, we allow the growth in the nonlinearities in the domain and on the boundary to go all the way to the critical Sobolev exponents in the appropriate Lebesgue spaces (in duality). The approach makes careful use of pseudomonotone coercive operators, the axiom of choice through Zorn`s lemma and a Kato`s inequality up to the boundary along with appropriate estimates.

A convergence criterion for elliptic quasivariational inequalities

Schedule: December 19 8:00-8:30   Capital Suite 5

Anna Ochal
Jagiellonian University
Poland

Co-Author(s): Mircea Sofonea (France) and Domingo Tarzia (Argentina)

Abstract:
The aim of this talk is to present a convergence result concerning an elliptic quasivariational inequality in a reflexive Banach space. Considering a sequence of unconstrained variational-hemivariational inequalities, we show that a sequence of their unique solutions converges to the solution of the quasivariational inequality. We introduce also a new well-posedness concept and show that it extends the classical Tykhonov and Levitin-Polyak well-posedness concepts for quasivariational inequalities.

On the justification of Koiter`s model for thermoelastic shells

Schedule: December 18 16:15-16:45   Capital Suite 5

Paolo Piersanti
The Chinese University of Hong Kong Shenzhen
Peoples Rep of China

Abstract:
In this talk, we justify the time-dependent version of Koiter`s model when the displacement is coupled with a temperature distribution via the neumann-Duhamel law. By menas of a rigorous asymptotic analysis, we describe how the modes of deformation interact with the temperature distribution.

On the regularity of the solutions to some evolutionary equations of p-Laplacian type

Schedule: December 18 18:00-18:30 Capital Suite 5

Maria Michaela MM Porzio
Sapienza Universit\`a di Roma
Italy

Abstract:
In this talk we describe the influence of the initial data and the forcing terms on the regularity of the solutions to a class of evolution equations including the heat equation, linear and semilinear parabolic equations, together with the nonlinear p-Laplacian equation. We focus our study mainly on the regularity (in terms of belonging to appropriate Lebesgue spaces) of the gradient of the solutions.

Blow-up and Global Solutions for Parabolic Equations with Critical Nonlinearities

Schedule: December 18 13:30-14:00 Capital Suite 5

Federica Sani
University of Modena and Reggio Emilia
Italy

Abstract:
In this talk, we analyze the asymptotic behaviour of solutions to the Cauchy problem associated with a class of parabolic equations with critical nonlinearities. We focus on initial data in the energy space $H^1(\mathbb{R}^N)$ and consider nonlinearities that exhibit critical growth in this energy space. We exploit variational techniques to show that the transition between blow-up in finite time and global existence is determined by the sign of suitable Nehari or Pohozaev functional, at least for low energies solutions.

Regularity for strongly coupled systems

Schedule: December 18 17:30-18:00 Capital Suite 5

Rafayel Teymurazyan
King Abdullah University of Science and Technology (KAUST) and University of Coimbra
Saudi Arabia

Abstract:
We will present recent advances in the study of nonlinear systems. The main challenge in dealing with those systems is the lack of comparison principle and of the classical Perron`s method. Nevertheless, we discover a chain reaction, exploiting the properties of an equation along the system and obtaining higher sharp regularity across the free boundary. Additionally, we prove geometric measure estimates and obtain coincidence of the free boundaries. Furthermore, we derive free boundary regularly results. These results are new, even for linear systems.

On a second order periodic system with multivalued perturbation

Schedule: December 19 13:00-13:30 Capital Suite 5

Calogero Vetro
University of Palermo
Italy

Abstract:
We consider the existence problem for the following second order periodic system:
$\{ m(u'(t))' \in F(u(t)) + G(t, u(t), u`(t)) \quad \text{for a.a. } t \in [0, t_{\max}],\ u(0) = u(t_{\max}) = 0,\ u'(0) = u'(t_{\max}) = 0,$
where $m : \mathbb{R}^N \to \mathbb{R}^N$ is a monotone-type map, including as special case the p-Laplacian operator $m(y) := |y|^{p-2}y$ with $p \in (1, +\infty)$. In the reaction, we have the combined effects of a maximal monotone multivalued map $F : D(F) \subseteq \mathbb{R}^N \to 2^{\mathbb{R}^N}$ and a graph measurable multivalued map $G : [0, t_{\max}] \times \mathbb{R}^N \times \mathbb{R}^N \to 2^{\mathbb{R}^N} \setminus \{\emptyset\}$. We develop a topological approach based on the theory of monotone-type nonlinear operators (see [1]) and multivalued analysis (see [2]). The starting point of the study is a joint work with N. S. Papageorgiou (see [3]). We discuss the cases when G has convex values and non-convex values, respectively, by imposing different hypotheses on the data.

[1] L. Gasi\`nski and N. S. Papageorgiou, \textit{Nonlinear Analysi}s. Ser. Math. Anal. Appl., vol. 9. CRC Press Boca Raton, 2006.

[2] S. Hu and N. S. Papageorgiou, \textit{Handbook of Multivalued Analysis}. Vol. I: Theory. Kluwer Academic, Dordrecht, 1997.

[3] N. S. Papageorgiou and C. Vetro, Existence and relaxation results for second order multivalued systems, \textit{Acta Appl. Math.}, 173 (2021), Paper No. 5, 36 pp.

Basic considerations about chemotactic models in penetrable habitats

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Schedule: December 18 15:15-15:45 Capital Suite 5

Giuseppe Viglialoro
Universit \\`a degli Studi di Cagliari
Italy

Co-Author(s): Silvia Frassu, Yuya Tanaka

Abstract:
The term chemotaxis describes the phenomenon by which cell bodies, bacteria, and other organisms (unicellular or multicellular) direct their movements in response to the presence of specific chemicals in their habitat. The simplest mathematical formulation of this phenomenon involves two unknowns that obey as many differential coupled equations. Since the advent of such a model (Keller and Segel, 1970), the results obtained are numerous. Nevertheless, the common denominator of such studies focuses on the assumption that the habitat is impenetrable. In this talk, we will discuss the phenomenon of chemotaxis in situations where the environment is, on the contrary, penetrable. This is a joint project with Silvia Frassu and Yuya Tanaka.

Some evolution problems modeling the interaction between acoustic waves and non-locally reacting surfaces

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Schedule: December 18 17:00-17:30 Capital Suite 5

Enzo Vitillaro
Universit\\`a degli Studi di Perugia
Italy

Abstract:
We deal with three families of evolutions problems modeling the interaction between acoustic waves and non-locally reacting surfaces. One family is constituted by problems derived in a Lagrangian framework, another family by problems derived in the Eulerian framework. In the talk, we show that they are equivalent with one between the two variants of the acoustic wave equation with acoustic boundary condition, which constitute the third family of problems. The results are connected with those in the talk given by the author in SS15, and are contained in two papers by the author, the first one in J. Evol. Eqs. (2024), the second one still in preparation. This work has been funded by the European Union - NextGenerationEU within the framework of PNRR Mission 4 - Component 2 - Investment 1.1 under the Italian Ministry of University and Research (MUR) program PRIN2022 - 2022BCFHN2 - Advanced theoretical aspects in PDEs and their applications - CUP: J53D23003700006

Special Session 97 : New Advances in Structured Signal Recovery

Introduction: Numerous signal recovery challenges, such as matrix/tensor recovery and phase retrieval, capitalize on the inherent low-dimensional structure of signals, such as sparsity within a frame and low-rank matrices. These problems find significant applications in image processing and various data science domains. This special session will showcase the latest breakthroughs in this field, employing tools from algebra geometry, frame theory, matrix theory, approximation theory, optimization and beyond.

Weighted Riemannian Optimization for Phase Retrieval

Schedule: December 16 14:45-15:15 Capital Suite 21 C

Jian-Feng Cai
The Hong Kong University of Science and Technology
Hong Kong

Co-Author(s): Jiayi Li, Huiping Li

Abstract:
We investigate the problem of generalized phase retrieval, which entails reconstructing a signal from its phaseless samples. We demonstrate that several well-known phase retrieval algorithms actually solve the least-squares fitting of lifted linear equations within the manifold of rank-1 matrices, using different Riemannian metrics on the manifold. However, these metrics only permit a stable and distinctly non-isometric embedding of rank-1 matrices, leading to linear convergence with a notably slow rate. To accelerate the convergence, we introduce a new metric on the rank-1 matrix manifold that enables an almost isometric embedding of these matrices. We propose a Riemannian gradient descent (RGD) algorithm, named Weighted RGD (WRGD), with this new metric to solve the phase retrieval problem. Due to the near isometric nature of this metric, we demonstrate that our WRGD, initialized via the spectral method, achieves linear convergence to the target signal at an enhanced rate.

A Generalized Matrix Separation Problem

Schedule: December 16 15:15-15:45 Capital Suite 21 C

Xuemei Chen
University of North Carolina Wilmington
USA

Abstract:
The problem of separating a known matrix into its low rank and sparse components have found numerous applications in imaging, multimedia processing, statistical modeling, etc. In this talk we will explore this problem in a more complicated setting where the sparse component has been masked by a linear transformation. This problem was motivated by an electrodermal activity signal decomposition problem, but we believe it has a wider appeal.

Conjugate Phase Retrieval in Shift-invariant Spaces

Schedule: December 16 18:30-19:00 Capital Suite 21 C

Cheng Cheng
SUN YAT-SEN University
Peoples Rep of China

Abstract:
Conjugate phase retrieval considers the recovery of a function, up to a unimodular constant and conjugation, from its phaseless measurements. In this talk, I will introduce some results on conjugate phase retrieval in shift-invariant spaces. We first consider the conjugate phase retrieval in a shift-invariant space generated by a Gaussian, and show that a function in the shift-invariant space generated by Gaussian can be uniquely determined, up to a unimodular constant and conjugation, from its phaseless Hermite samples on a discrete set.

Exponential type bases in L^2(\mu) with phase funtions

Schedule: December 16 17:00-17:30 Capital Suite 21 C

Xiaoye Fu
Central China Normal University
Peoples Rep of China

Co-Author(s): Ting Zhou

Abstract:
Given a finite Borel measure μ on $\mathbb{R}^d$, we give a characterization on the existence of a phase function φ such that $L^2(\mu)$ admits an orthogonal basis/a frame/a Riesz basis of exponential type $E(\Lambda, \varphi) = \{e^{2\pi i \langle \lambda, \varphi(x) \rangle} : \lambda \in \Lambda\}$, according to the type of μ: discrete, singularly and absolutely continuous. We show that if μ is an infinite discrete measure or a finite discrete measure with non-equal probability weights, then $L^2(\mu)$ can not admit any $E(\Lambda, \varphi)$ as an orthogonal basis. We also prove that $L^2(\mu)$ can admit some $E(\Lambda, \varphi)$ as an orthogonal basis if μ is one of the following four types (i) a self-affine measure generated by an equal probability IFS with no-overlap condition; (ii) the Lebesgue measure restricted on a bounded open set ; (iii) a positive and finite absolutely continuous measure with respect to Lebesgue measure on $\mathbb{R}$; (iv) a finite discrete measure with equal probability weights. Particularly, for the product of two finite Borel measures $\mu \subseteq \mathbb{R}^m$ and $\nu \subseteq \mathbb{R}^n$, we study the relationship on the existence of orthogonal bases in the form of $E(\Lambda, \varphi)$ between in $L^2(\mu \times \nu)$ and in $L^2(\mu)$ and $L^2(\nu)$ according to whether Λ or φ has a product structure (i.e. $\Lambda = \Lambda_1 \times \Lambda_2$ or $\varphi = \varphi_1 \times \varphi_2$) or not.

Learning Operators with Stochastic Gradient Descent in General Hilbert Spaces

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Schedule: December 16 18:00-18:30 Capital Suite 21 C

Shi Lei
Fudan University
Peoples Rep of China

Abstract:
This talk investigates leveraging stochastic gradient descent (SGD) to learn operators between general Hilbert spaces. We propose weak and strong regularity conditions for the target operator to depict its intrinsic structure and complexity. Under these conditions, we establish upper bounds for convergence rates of the SGD algorithm and conduct a minimax lower bound analysis, further illustrating that our convergence analysis and regularity conditions quantitatively characterize the tractability of solving operator learning problems using the SGD algorithm. It is crucial to highlight that our convergence analysis is still valid for nonlinear operator learning. We show that the SGD estimator will converge to the best linear approximation of the nonlinear target operator. Moreover, applying our analysis to operator learning problems based on vector-valued and real-valued reproducing kernel Hilbert spaces yields new convergence results, thereby refining the conclusions of existing literature.

Sparse Recovery using Expanders via Hard Thresholding Algorithm

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Schedule: December 16 19:00-19:30 Capital Suite 21 C

Peng Li
Lanzhou University
Peoples Rep of China

Abstract:
Expanders play an important role in binary sensors, network measurement, and distributed storage, etc. Via expanders measurements, we propose the expander normalized heavy ball hard thresholding algorithm (ENHB-HT) based on the expander iterative hard thresholding (E-IHT) algorithm. We provide a convergence analysis of ENHB-HT, and it turns out that ENHB-HT can recover an s-sparse signal if the binary sparse measurement matrix A satisfies some mild conditions. Numerical experiments are simulated to support our two main theorems which describe the convergence rate and the accuracy of the proposed algorithm. Simulations are also performed to compare the performance of ENHB-HT and several existing algorithms under different types of noise, the empirical results demonstrate that our algorithm outperforms a few existing ones in the presence of outliers.

Uniqueness of STFT Phase Retrieval for wide band functions

Schedule: December 16 17:30-18:00 Capital Suite 21 C

Kasso Okoudjou
Tufts University
USA

Co-Author(s): Shuang Guan and Kasso Okoudjou

Abstract:
We consider the phase retrieval problem for the short-time Fourier transform (STFT). We establish new results on the reconstruction of wide-band signals up to a global phase factor from only the magnitude of their measurements in the time-frequency domain. The proof of our main result relies on the factorization of functions in the Hardy space on the unit disk, the fractional short-time Fourier transform, and an identity theorem for holomorphic functions.

Leave-One-Out Analysis for Nonconvex Robust Matrix Completion with General Thresholding Functions

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Schedule: December 16 15:45-16:15 Capital Suite 21 C

Ke Wei
Fudan University
Peoples Rep of China

Co-Author(s): Tianming Wang

Abstract:
We study the problem of robust matrix completion (RMC), where the partially observed entries of an underlying low-rank matrix is corrupted by sparse noise. Existing analysis of the non-convex methods for this problem either requires the explicit but empirically redundant regularization in the algorithm or requires sample splitting in the analysis. In this paper, we consider a simple yet efficient nonconvex method which alternates between a projected gradient step for the low-rank part and a thresholding step for the sparse noise part. Inspired by leave-one out analysis for low rank matrix completion, it is established that the method can achieve linear convergence for a general class of thresholding functions, including for example soft-thresholding and SCAD. To the best of our knowledge, this is the first leave-one-out analysis on a nonconvex method for RMC. Additionally, when applying our result to low rank matrix completion, it improves the sampling complexity of existing result for the singular value projection method.

Sparse Phase Retrieval under Fourier-based Measurements

Schedule: December 16 16:15-16:45 Capital Suite 21 C

Yu Xia
Hangzhou Normal University
Peoples Rep of China

Abstract:
We consider the sparse phase retrieval problem, that is, recovering an unknown s-sparse signal from the intensity-only measurements. Specically, we focus on the problem of recovering x from the observations that are convoluted with some specfic kernel, it can also be considered as masked Fourier measurements. This model is motivated by real-world applications in optics and communications. If the convolutional kernel is generated by a random Gaussian vector and the number of subsampled measurements is on the order of $s \cdot polylog(n)$, one can recover x up to a global phase. Here we discuss the behavior of sparse phase retrieval under more realistic measurements, as opposed to independent Gaussian measurements.

Special Session 99 : Recent Advances in Mathematical Physics: A focus on (many-body) quantum systems and spectral theory.

Introduction: Mathematical Physics remains an active area of research that combines tools from mathematical analysis to further understand certain physical phenomena. This proposed special session to spotlight recent advances within the field, with a particular emphasis on the following key areas: (a) Quantum Many-Body Systems: quantum propagation velocity, Adiabatic dynamics, Entanglement, correlations, and the study of spectral gaps. (b) Disordered, Periodic, and Quasi-Periodic Quantum Systems: Localization/delocalization, quantum propagation, and spectral analysis. (c) Quantum Walks: Transport and spectral properties. By inviting researchers from diverse geographical locations, this special session aims to facilitate vibrant discussions and foster new collaborations. Held in the central location of the UAE, it provides a conducive environment for exchange and exploration, nurturing the growth of interdisciplinary research in mathematical physics.

Mathematics of Moire materials

Schedule: December 16 13:00-13:30 Capital Suite 21 B

Simon Becker
ETH Zurich
Switzerland

Abstract:
I will review recent advancements in the field of twistronics. Twistronics investigates how varying the angle between layers of two-dimensional materials can significantly alter their electrical properties. Notably, twisted bilayer graphene exhibits a broad spectrum of different strongly correlated phases of matter, ranging from non-conductive to superconductive, depending on the specific twist angle between its layers. These remarkable effects are observed at particular angles known as magic angles.

Ground States of Spin Boson Models and Long Range Order in 1D Ising Models

Schedule: December 16 17:30-18:00 Capital Suite 21 B

Benjamin Hinrichs
Paderborn University
Germany

Abstract:
The spin boson model describes a two-state quantum system (the spin) which is linearly coupled to a bosonic quantum field. Using a Feynman--Kac formula, the vacuum expectation of the semigroup generated by the Hamiltonian of the model can be described by a one-dimensional Ising model. In this talk, we discuss how the existence of ground states in the spin boson model can be investigated by studying the long-range behavior of the Ising correlation function. This especially includes the recent proof for a phase transition of the spin boson model with respect to the strength of the spin-field coupling.

Super-critical entanglement in strongly interacting simple models

Schedule: December 16 15:15-15:45 Capital Suite 21 B

Ramis Movassagh
Google Quantum AI
USA

Co-Author(s): Varun Menon, Andi Gu

Abstract:
We discuss recent developments on classes of simple quantum models in one-dimension that have surprising properties. These models have a rich combinatorial ground state structure in terms of Motzkin walks and Brownian excursions, have a local interaction, and unique ground states. They are surprising in that they are not describable by conformal field theories in the limit, and have exponentially more amount of entanglement entropy than even quantum critical systems. We introduce these models and present recent work on their spontaneous U(1) symmetry breaking, correlation functions, and new analytical work on their t-deformations.

LTQO and spectral gap stability for the AKLT model on the hexagonal lattice

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Schedule: December 16 14:00-14:30 Capital Suite 21 B

Bruno Nachtergaele
University of California, Davis
USA

Co-Author(s): Thomas Jackson (UC Davis) and Amanda Young (UIUC)

Abstract:
Local Topological Quantum Order (LTQO) is a crucial ingredient in proofs of stability of the spectral gap above the ground state of frustration free quantum lattice systems. LTQO has been proved to hold quite generally in one space dimension. It is also known in higher dimensions for many commuting Hamiltonians. In this work we prove LTQO for the AKLT model on the hexagonal lattice, adding one item to a rather short list of results that apply to non-commuting Hamiltonians in two or more dimensions.

Atypical spectra and dynamics of non-locally finite crystals

Schedule: December 16 17:00-17:30 Capital Suite 21 B

Mostafa Sabri
New York University Abu Dhabi
United Arab Emirates

Co-Author(s): Joachim Kerner, Olaf Post, Mattias Taufer

Abstract:
In this talk, we investigate the spectral theory of periodic graphs which are not locally finite but carry non-negative, symmetric and summable edge weights. These periodic graphs are shown to have rather intriguing behaviour. We construct a periodic graph whose Laplacian has purely singular continuous spectrum. We prove that motion remains ballistic along at least one layer under quite general assumptions. We construct a graph whose Laplacian has purely absolutely continuous spectrum, exhibits ballistic transport, yet fails to satisfy a dispersive estimate. This answers negatively an open question in this regard, in our setting. Concerning the point spectrum, we construct a graph with a partly flat band whose eigenvectors must have infinite support, in contrast to the locally finite case. We believe the present class of graphs can serve as a playground to better understand exotic spectra and dynamics in the future.

Entanglement entropy in the ground state of non-interacting massless Dirac fermions in dimension one

Schedule: December 16 15:45-16:15 Capital Suite 21 B

Wolfgang Spitzer
FernUniversitaet in Hagen
Germany

Co-Author(s): Fabrizio Ferro, Paul Pfeiffer

Abstract:
We present a novel proof of a formula of Casini and Huerta for the entanglement entropy of the ground state of non-interacting massless Dirac fermions in dimension one localized to (a union of) intervals and generalize it to the case of R\`enyi entropies. At first, we prove that these entropies are well-defined for non-intersecting intervals. This is accomplished by an inequality of Alexander V.~Sobolev. Then we compute this entropy using a trace formula for Wiener--Hopf operators by Harold Widom. For intersecting intervals, we discuss an extended entropy formula of Casini and Huerta and support this with a proof for polynomial test functions.

Quantum-inspired framework for computational fluid dynamics

Schedule: December 16 18:00-18:30 Capital Suite 21 B

Egor Tiunov
Technology Innovation Institute, Abu Dhabi, UAE
United Arab Emirates

Co-Author(s): Raghavendra Dheeraj Peddinti, Stefano Pisoni, Alessandro Marini, Philippe Lott, Henrique Argentieri, Leandro Aolita

Abstract:
Computational fluid dynamics is both a thriving research field and a key tool for advanced industry applications. However, the simulation of turbulent flows in complex geometries is a compute-power intensive task due to the vast vector dimensions required by discretized meshes. We present a complete and self-consistent full-stack method to solve incompressible fluids with memory and run time scaling logarithmically in the mesh size. Our framework is based on matrix-product states, a compressed representation of quantum states. It is complete in that it solves for flows around immersed objects of arbitrary geometries, with non-trivial boundary conditions, and self-consistent in that it can retrieve the solution directly from the compressed encoding, i.e. without passing through the expensive dense-vector representation. This framework lays the foundation for a generation of more efficient solvers of real-life fluid problems.

A weak limit theorem for quantum walks in 1-dimension

Schedule: December 16 14:45-15:15 Capital Suite 21 B

Kazuyuki Wada
Hokkaido University of Education
Japan

Co-Author(s): Masaya Maeda, Akito Suzuki

Abstract:
We consider the weak limit theorem for discrete-time quantum walks corresponding to the central limit theorem for classical random walks. The first result of this theorem was derived by Konno. After that, Suzuki extended this result to short-range cases. The next step is whether we can extend this result to long-range cases. In this talk, we will report some results in this direction.

Exponential tail estimates for quantum lattice dynamics

Schedule: December 16 16:15-16:45 Capital Suite 21 B

Albert H. Werner
QMATH - University of Copenhagen
Denmark

Co-Author(s): Christopher Cedzich, Alain Joye, Reinhard F Werner

Abstract:
We consider the quantum dynamics of a particle on a lattice for large times. Assuming translation invariance, and either discrete or continuous time parameter, the distribution of the ballistically scaled position Q(t)/t converges weakly to a distribution that is compactly supported in velocity space, essentially the distribution of group velocity in the initial state. We show that the total probability of velocities strictly outside the support of the asymptotic measure goes to zero exponentially with , and we provide a simple method to estimate the exponential rate uniformly in the initial state. Near the boundary of the allowed region the rate function goes to zero like the power 3/2 of the distance to the boundary.

Propagation bounds for long-range interacting bosons

Schedule: December 16 13:30-14:00 Capital Suite 21 B

Jingxuan Zhang
Tsinghua University
Peoples Rep of China

Co-Author(s): M. Lemm; C. Rubiliani; I. M. Sigal

Abstract:
We study propagation properties of nonequilibrium lattice models with long-range bosonic interactions. We prove (A) microscopic particle transport bounds and (B) Lieb-Robinson bounds, which are all thermodynamically stable. For both (A) and (B), we require Bose-Hubbard type Hamiltonians with hopping matrix decaying as $|x-y|^{-\alpha}$, $\alpha > d+2$ and initial state with uniformly bounded density from above. For (B), we further assume initially no particle lies in the region separating the supports of the probing observables. The proofs are based on a combination of commutator method originated in scattering theory and novel monotonicity estimate for certain adiabatic observables that track the spacetime localization of evolving states.

Special Session 100 : Roots and trends in number theory

Introduction: We will invites speakers of different ages on number theory subjects in variey directions, either related with some classical number theory problems or related with some new trend problems.

A new generalization of Fermat`s Last Theorem

Schedule: December 16 19:00-19:30 Capital Suite 3

Tianxin Cai
Zhejiang University
Peoples Rep of China

Abstract:
There are several generalizations of Fermat`s Last Theorem, such as Bill`s conjecture, Fermat-Catalan1 conjecture. In this talk, we will present a new generalization of Fermat`s Last Theorem, it remains unproved even under the strong abc conjecture or by using the inter-universal Teichmuller theory of Mochizuki Shinichi, and meanwhile we raise some new idea on additive and multiplicative number theory.

Improvements on exponential sums related to Piatetski-Shapiro primes

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Schedule: December 17 8:00-8:30 Capital Suite 3

Zhenyu Guo
Xi`an Jiaotong University
Peoples Rep of China

Co-Author(s): Lingyu Guo, Li Lu

Abstract:
Many problems in number theory are highly related to the bound of the following exponential sum

$$\sum_{h\sim H}\left|\sum_{n\sim x}\Lambda(n)\backslash\mathrm{e}(hn^{\gamma}+\alpha n)\right|\ll x^{1-\epsilon}$$

We give a new estimation of the type I bound to improve the admissible range of γ to $\frac{580}{663} < \gamma

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Semi-Regular Continued Fractions with Fast-Growing Partial Quotients

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Schedule: December 17 8:30-9:00 Capital Suite 3

Aiken Kazin
SDU University
Kazakhstan

Co-Author(s): Shirali Kadyrov, Farukh Mashurov

Abstract:
In number theory, continued fractions are essential tools because they provide distinct representations of real numbers and provide information about their characteristics. Regular continued fractions have been examined in great detail, but less research has been carried out on their semi-regular continued fractions, which are produced from the sequences of alternating plus and minus ones. In this talk, attention is paid to the structure and features of semi-regular continued fractions through the lens of dimension theory. A key result is established concerning the Hausdorff dimension of number sets with partial quotients that increase more rapidly than a specified rate. Additionally, numerical analyses are conducted to highlight the distinctions between regular and semi-regular continued fractions, offering insights into potential future directions in this area.

Binary sequence family with both small cross-correlation and large family complexity

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Schedule: December 17 9:30-10:00 Capital Suite 3

Huaning Liu
Northwest University
Peoples Rep of China

Co-Author(s): Huaning LIU and Xi LIU

Abstract:
Ahlswede, Khachatrian, Mauduit and S\`{a}rk\{o}zy introduced the notion of family complexity, Gyarmati, Mauduit and S\`{a}rk\{o}zy introduced the cross-correlation measure for families of binary sequences. It is a challenging problem to find families of binary sequences with both small cross-correlation measure and large family complexity. In this talk we present a family of binary sequences with both small cross-correlation measure and large family complexity by using the properties of character sums and primitive normal elements in finite fields.

Random matrices and L-functions

Schedule: December 17 9:00-9:30 Capital Suite 3

Sheng-Chi Liu
Washington State University
USA

Abstract:
Since the work of Montgomery and Odlyzko, there has been a significant body of literature on the similarities in the behavior of zeros of L-functions and the eigenvalues of random matrices. A major breakthrough came with the work of Katz and Sarnak, who demonstrated that while many random matrix ensembles share the same n-level correlations, there is another statistic, the n-level density, for which each ensemble has a different outcome. Moreover, most of the contribution to this statistic comes from the zeros near or at the central point, making it an ideal quantity for investigating the arithmetic of families. In this talk, we will discuss some new developments regarding the low-lying zeros of L-functions.

On the first sign change of Fourier coefficients of cusp forms

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Schedule: December 16 17:00-17:30 Capital Suite 3

Yingnan Wang
Shenzhen University
Peoples Rep of China

Abstract:
In the talk, we will survey some recent progress on the first sign-change of Fourier coefficients of cusp forms and present a variant of the current widely used method initiated by Choie and Kohnen in the study of the location of the first sign-change of the Fourier coefficients of a holomorphic cusp form when all the coefficients are real. This variant of Choie and Kohnen`s method applies to more cases including integral weight cusp forms on congruence subgroups of any levels as well as half-integral weight cusp forms. This is a joint work with Guohua Chen and Yuk-Kam Lau.

Rational points on elliptic curves and BSD conjecture

Schedule: December 16 17:30-18:00 Capital Suite 3

Shuai Zhai
Shandong University
Peoples Rep of China

Abstract:
It is widely recognised that there is a deep connection between the analytical and algebraic aspects of elliptic curves, namely the Birch and Swinnerton-Dyer conjecture, which is one of the Millennium Prize Problems. In this talk, I will present a few classical Diophantine problems, with connections to elliptic curves and the Birch and Swinnerton-Dyer conjecture.

On a sum involving the sum-of-divisors function

Schedule: December 16 18:00-18:30 Capital Suite 3

Feng Zhao
North China University of Water Resources and Electric Power
Peoples Rep of China

Co-Author(s): Jie Wu

Abstract:
Let $\sigma(n)$ be the sum of all divisors of n and let $[t]$ be the integral part of t. In this paper, we shall prove that

$$\sum_{n\leq x}\sigma\Big(\Big[\frac{x}{n}\Big]\Big)=\frac{\pi^2}{6}x\log x+O(x(\log x)^{2/3}(\log_2 x)^{4/3})$$

for $x\to\infty$, and that the error term of this asymptotic formula is $\Omega(x)$.

The classification and representations of positive definite ternary quadratic forms of level 4N

Schedule: December 16 18:30-19:00 Capital Suite 3

Haigang Zhou
School of Mathematical Sciences, Tongji University
Peoples Rep of China

Co-Author(s): Yifan Luo

Abstract:
Classifications and representations are two main topics in the theory of quadratic forms. In this talk, we consider these topics of ternary quadratic forms. For a given squarefree integer N, firstly we give the classification of positive definite ternary quadratic forms of level 4N explicitly. Secondly, we give the weighted sum of representations over each class in every genus of ternary quadratic forms of level 4N by using quaternion algebras and Jacobi forms. The formulas are involved with modified Hurwitz class number. As a corollary, we get a formula for the class number of ternary quadratic forms of level 4N. As applications, we give an explicit base of Eisenstein series space of modular forms of weight 3/2 of level 4N, and give new proofs of some interesting identities involving representation number of ternary quadratic forms.

Special Session 103 : Elliptic, parabolic problems and functional inequalities

Introduction: This session is focused on the most recent progress in elliptic and parabolic partial differential equations. Existence, uniqueness and the study of some qualitative and quantitative properties (as regularity, symmetry, and asymptotic behavior) of solutions of such kinds of equations are current and relevant topics in PDE' s theory and applications. The aim of this special session is to contribute to creating scientific relationships between researchers who deal with these topics, even with different approaches.

On the Laplace equation with non local dynamical boundary conditions

Schedule: December 19 14:00-14:30 Capital Suite 10

Raffaela Capitanelli
Sapienza University of Roma
Italy

Abstract:
In this talk I will present some results on the Laplace equation with non local dynamic boundary conditions, where the non locality is due to the presence of a time fractional derivative. In particular, a representation formula for the solution of the the Laplace equation with non local dynamic boundary conditions of reactive-diffusive type will be given. These results are obtained in collaboration with M. D` Ovidio.

Materials with memory: regular, singular and ageing problems in integrodifferential equations arising in viscoelasticity

Schedule: December 19 15:15-15:45 Capital Suite 10

Sandra Carillo
Sapienza University of Rome
Italy

Abstract:
The name Materials with memory is given to those materials whose mechanical or thermodynamical behaviour crucially depends on time not only through the present time, but also its history. We aim to provide an overview on various models of viscoelastic materials. Specifically, based on the well known classical model, different generalisations are introduced. The mechanical response of a viscoelastic material depends on time not only through the present time, but also via its deformation history. Hence, a viscoelastic material is termed a material with memory. Accordingly, under the mathematical viewpoint, such a behaviour is modelled via the introduction of, in the evolution equations, an integral term. In viscoelasticity, such a term whose kernel represents the relaxation modulus is the key quantity to describe the behaviour of the material of in- terest. Different aspects are taken into account via suitable modifications of the kernel, which represents the relaxation modulus, such as weak regularity or unbounded kernels at the initial t=0 time and, in addition, effects of ageing i.e. effects of degradation of the material response due to the age of the material itself, are considered.

Functional dissipativity of partial differential operators

Schedule: December 19 8:00-8:30 Capital Suite 10

Alberto Cialdea
University of Basilicata
Italy

Co-Author(s): Vladimir Maz` ya

Abstract:
In this talk I will present some recent results obtained with Vladimir Maz`ya concerning functional dissipativity of some partial differential operators. This is a new concept of dissipativity which extends the notion of L^p-dissipativity. It turns out that the class of operators whose principal part is strictly L^p-dissipative coincides with the class of the so-called p-elliptic operators, which has recently been considered by several authors. I will focus in particular on systems in which different notions of ellipticity arise.

Elliptic problems with W^{1,1}_0- solutions

Schedule: December 19 8:30-9:00 Capital Suite 10

Giuseppa Rita Cirmi
University of Catania
Italy

Abstract:
We consider some nonlinear Dirichlet problems with nonregular data and we study the existence of distributional solutions belonging to the space W^{1,1}_0.The talk concerns some joint papers with L.Boccardo e S. D`Asero.

Asymptotics for inverse problems in irregular domains

Schedule: December 19 16:15-16:45 Capital Suite 10

Simone Creo
Sapienza University of Rome
Italy

Abstract:
In this talk we consider inverse problems in an irregular domain Ω and in suitable approximating domains Ω_n, for $n \in \mathbb{N}$, respectively. After proving well-posedness results, we prove that the solutions of the approximating problems converge in a suitable sense to the solution of the problem on Ω via Mosco convergence. We also present some applications.\ These results are obtained in collaboration with M. R. Lancia, G. Mola and S. Romanelli.

Existence of bounded solutions for a class of fourth-order elliptic equations

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Schedule: December 18 18:00-18:30 Capital Suite 10

Salvatore D`Asero
Diaprtimento di Matematica e Informatica - Catania University
Italy

Abstract:
In this talk we study a class of fourth-order elliptic equations whose principal part satisfies a strengthened coercivity condition. We show that bounded solutions exist when the principal part has degenerate coercivity, or when a lower-order term is added, or when both cases are present. These results are also obtained in collaboration with G. R. Cirmi and S. Leonardi.

Symmetrization results for general nonlocal linear elliptic and parabolic problems

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Schedule: December 19 14:30-15:00 Capital Suite 10

Vincenzo Ferone
Universit\`a di Napoli Federico II
Italy

Abstract:
We discuss a Talenti-type symmetrization result in the form of mass concentration (\emph{i.e.} integral comparison) for very general linear nonlocal elliptic problems, equipped with homogeneous Dirichlet boundary conditions. In this framework, the relevant concentration comparison for the classical fractional Laplacian can be reviewed as a special case of our main result, thus generalizing previous results obtained in collaboration with B. Volzone. Also a Cauchy-Dirichlet nonlocal linear parabolic problem is considered.

Non autonomous fractional equations in extension domains: results and open problems

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Schedule: December 19 15:45-16:15 Capital Suite 10

Maria Rosaria Lancia
Sapienza University of Rome
Italy

Co-Author(s): S.Creo

Abstract:
In this talk I consider non autonomous fractional semilinear equations with Venttsel-type boundary conditions in irregular domains, possibly with fractal boundaries. Well posedness and regularity results for the mild solution of the associated semilinear abstract Cauchy problem via an evolution family $U(t,s)$ will be discussed as well as ultracontractivity properties of the evolution family. Some open problems will be discussed too.

These results are in collaboration with Simone Creo.

Generic configurations in 2D strongly competing systems

Schedule: December 19 13:30-14:00 Capital Suite 10

Flavia Lanzara
Mathematics Department, Sapienza University, Rome
Italy

Co-Author(s): E. Montefusco, V. Nesi, E. Spadaro

Abstract:
We study some qualitative properties of the solutions to a segregation limit problem in planar domains. The main goal is to show that, generically, the limit configuration of N interacting populations consists of a partition of the domain whose singular points are $N-2$ triple points, meaning that at most three populations meet at any point on the free boundary. To achieve this, we relate the solutions of the problem to a particular class of harmonic maps in singular spaces, which can be seen as the real part of certain holomorphic functions.The genericity result is obtained by perturbation arguments. This is a joint work with E. Montefusco, V. Nesi and E. Spadaro (Mathematics Department, Sapienza University, Rome, Italy).

Existence and uniqueness results for elliptic equations with general growth in the gradient

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Schedule: December 18 17:00-17:30 Capital Suite 10

Anna Mercaldo
University of Naples Federico II
Italy

Abstract:
Existence and uniqueness results are established for solutions to homogeneous Dirichlet problems concerning second-order elliptic equations, in divergence form, with principal part a Leray-Lions type operator and a first order term which grows as a $q-$power of the gradient. The case of elliptic operators having a zero order term is also considered. Under suitable summability assumptions and smallness on the datum and on the coefficients of the elliptic operators, existence and uniqueness results are presented depending on several ranges of values of the power q of the gradient term. The talk is based on joint papers with A.Alvino and V.Ferone.

On a class of non-coercive elliptic and parabolic equations

Schedule: December 19 16:45-17:15 Capital Suite 10

Gioconda G. Moscariello
University of Naples Federico II
Italy

Abstract:
We present existence and regularity results to convection-diffusion elliptic and parabolic equations with singular coefficients in the convective term. Our operator is not coercive and the coefficients in the lower order term belong to a borderline Marcinkiewicz space. The obstacle problems for this class of equations is also addressed. In the parabolic setting, the obstacle function has irregular time-dependence.

A stability result for the first Robin-Neumann eigenvalue: A double perturbation approach

Schedule: December 19 13:00-13:30 Capital Suite 10

Gloria Paoli
University of Napoli Federico II
Italy

Co-Author(s): Simone Cito, Gianpaolo Piscitelli

Abstract:
We consider the eigenvalue problem for the Laplace operator associated to an holed domain with Robin boundary condition on the external boundary and Neumann boundary condition on the internal one. Since the spherical shell is the only maximizer for the first Robin-Neumann eigenvalue in the class of domains with fixed outer perimeter and volume, we want to establish a quantitative version of the afore-mentioned isoperimetric inequality. This is a joint work with Simone Cito and Gianpaolo Piscitelli

The influence of singular potentials on the solutions to some parabolic problems

Schedule: December 19 17:30-18:00 Capital Suite 10

Maria Michaela MM Porzio
Sapienza Universit\` a di Roma
Italy

Abstract:
In this talk we investigate a class of parabolic problems with irregular initial data and lower order terms singular with respect the solution. We show that, even if the initial datum is not bounded but only in $L^1(\Omega)$, there exists a solution that istanttly becomes bounded. Moreover, we discuss the behavior in time of this solution.

Isoperimetric sets for weighted twisted eigenvalues

Schedule: December 18 17:30-18:00 Capital Suite 10

Maria Rosaria M Posteraro
Universita di Napoli Federico II
Italy

Co-Author(s): Brandolini B. ,Henrot A. , Mercaldo A.

Abstract:
We present an isoperimetric inequality for the first twisted eigenvalue $\lambda_{1,\gamma}^T(\Omega)$ of a weighted operator, defined as the minimum of the usual Rayleigh quotient when the trial functions belong to the weighted Sobolev space $H_0^1(\Omega, d\gamma)$ and have weighted mean value equal to zero in Ω. We are interested in positive measures $d\gamma = \gamma(x)dx$ for which we are able to identify the optimal sets, namely, the sets that minimize $\lambda_{1,\gamma}^T(\Omega)$ among sets of given weighted measure. In the cases under consideration, the optimal sets are given by two identical and disjoint copies of the isoperimetric sets (for the weighted perimeter with respect to the weighted measure).

Existence of minimizers of Cheeger\` s functional among convex sets

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Schedule: December 19 9:00-9:30 Capital Suite 10

Giorgio Saracco
Universit\\\`{a} di Firenze
Italy

Co-Author(s): Aldo Pratelli

Abstract:
Given any open, bounded set $\Omega \subset \mathbb{R}^N$, Cheeger inequality states that %

$$\mathcal{J}_{1,p}[\Omega] := \frac{\lambda_p(\Omega)}{h(\Omega)^p} \geq \frac{1}{p^p},$$

% where $h(\Omega)$ denotes the Cheeger constant of Ω and $\lambda_{1,p}(\Omega)$ the first Dirichlet eigenvalue of the p-Laplacian. A natural question is whether the shape functional $\mathcal{J}_{1,p}[\,\cdot\,]$ admits minimizers in some suitable class of sets. Denoting with $\mathcal{K}_N$ the class of \emph{convex} subsets of $\mathbb{R}^N$, Parini proved that the shape functional $\mathcal{J}_{1,2}[\,\cdot\,]$ admits minimizers in $\mathcal{K}_2$. Recently Briani, Buttazzo and Prinari proved existence in $\mathcal{K}_2$ for the more general shape functional $\mathcal{J}_{1,p}[\,\cdot\,]$, and conjectured existence of minimizers in $\mathcal{K}_N$ to hold true regardless of the dimension N. Together with Aldo Pratelli, we prove this conjecture. Our proof exploits a criterion proved by Ftouhi paired with some cylindrical estimate on the Cheeger constant of $(N+1)$-dimensional cylinders $\Omega \times [0, L]$ in terms of the Cheeger constant of the cross-section Ω.

Special Session 104 : Recent Developments in High-Order Numerical Methods for Multiscale/Multiphysics Partial Differential Equations

Introduction: Mathematical models represented by partial differential equations serve as indispensable tools across mathematical, scientific, and engineering domains. The pursuit of robust, efficient, highly accurate, and structure-preserving numerical algorithms remains a formidable challenge in simulating the multiscale/multiphysics features inherent in these models. The objective of this special session is to convene researchers and computational scientists to present and discuss recent advancements in the design, analysis, and implementation of numerical algorithms tailored for challenging partial differential equations. These equations encompass a diverse range of complexities, including hyperbolic equations, time-dependent equations, and coupled systems. The applications span a broad spectrum, encompassing fluid dynamics, flow and transport phenomena in porous media, magneto-hydrodynamics, material science, semiconductor device simulation, oceanography, and beyond.

Discontinuous Galerkin approximation of the stationary Boussinesq system with a Navier-type boundary condition

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Schedule: December 19 15:15-15:45 Capital Suite 2

Afaf Bouharguane
University of Bordeaux
France

Co-Author(s): Nour Seloula

Abstract:
In this talk, we introduce and analyze a discontinuous Galerkin method for approximating the solutions of the stationary Boussinesq system, which models non-isothermal fluid flow. The model consists of incompressible Navier-Stokes equations, which describe the velocity and pressure of the fluid, coupled with an advection-diffusion equation for the temperature. We impose a Navier-type boundary condition on the velocity and a Dirichlet boundary condition on the temperature. The proposed numerical scheme combines an interior penalty discontinuous Galerkin method with an upwind approach for the Boussinesq system. We prove existence and uniqueness results for the discrete scheme under a certain regularity assumption of the domain. A priori error estimates in terms of natural energy norms for the velocity, pressure, and temperature are also derived. We conclude with some numerical experiments.

Well-balanced positivity-preserving high-order discontinuous Galerkin methods for Euler equations with gravitation

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Schedule: December 19 16:15-16:45 Capital Suite 2

Jie Du
East China Normal University
Peoples Rep of China

Abstract:
We develop high order discontinuous Galerkin (DG) methods with Lax-Friedrich fluxes for Euler equations under gravitational fields. Such problems may yield steady-state solutions and the density and pressure are positive. There were plenty of previous works developing either well-balanced (WB) schemes to preserve the steady states or positivity-preserving (PP) schemes to get positive density and pressure. However, it is rather difficult to construct WB PP schemes with Lax-Friedrich fluxes, due to the penalty term in the flux. In fact, for general PP DG methods, the penalty coefficient must be sufficiently large, while the WB scheme requires that to be zero. This contradiction can hardly be fixed following the original design of the PP technique. In this talk, we reformulate the source term such that it balances with the flux term when the steady state has reached. To obtain positive numerical density and pressure, we choose a special penalty coefficient in the Lax-Friedrich flux, which is zero at the steady state. The technique works for general steady-state solutions with zero velocities. Numerical experiments are given to show the performance of the proposed methods.

Compact difference finite element method for high-dimensional convection-diffusion equations

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Schedule: December 19 13:00-13:30 Capital Suite 2

Xinlong feng
xinjiang university
Peoples Rep of China

Abstract:
In this work, a difference finite element (DFE) method is proposed for solving 3D steady convection-diffusion equations that can maximize good applicability and efficiency of both FDM and FEM. The essence of this method lies in employing the centered difference discretization in the z-direction and the FE discretization based on the P_1 conforming elements in the (x, y) plane. This allows us to solve PDEs on complex cylindrical domains at lower computational costs compared to applying 3D FEM. We derive the stability estimates for the DFE solution and establish the explicit dependence of H_1 error bounds on the diffusivity, convection field modulus, and mesh size. Moreover, a compact DFE method is presented for the similar problems. Finally, we provide numerical examples to verify the theoretical predictions and showcase the accuracy of the considered method.

Solve electromagnetic interface problems on unfitted meshes

Schedule: December 19 17:30-18:00 Capital Suite 2

Ruchi Guo
Sichuan University
Peoples Rep of China

Co-Author(s): Long Chen, Shuhao Can

Abstract:
Electromagnetic interface problems widely appear in a lot of engineering applications, such as electric actuators, invasive detection techniques and integrated circuit, which are typically described by Maxwell equations with discontinuous coefficients. Conventional finite element methods require a body-fitted mesh to solve interface problems, but generating a high-quality mesh for complex interface geometry is usually very expensive. Instead, using unfitted mesh finite element methods can circumvent mesh generation procedure, which greatly improves the computational efficiency. However, the low regularity of Maxwell equations makes its computation very sensitive to the conformity of the approximation spaces. This very property poses challenges on unfitted mesh finite element methods, as most of them resort to non-conforming spaces. In this talk, we will present our recent progress including several methods for this topic.

Modelling of compressible multi-component two-phase flow with multi-component Navier boundary condition

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Schedule: December 19 8:30-9:00 Capital Suite 2

Qiaolin He
Sichuan University
Peoples Rep of China

Co-Author(s): Junkai Wang

Abstract:
In this work, we derive a dimensionless model for compressible multi-component two-phase flows with Peng-Robinson equation of state (EoS), incorporated with the multi-component Navier boundary condition (MNBC). We propose three linearly decoupled and energy-stable numerical schemes for this model. These schemes are developed based on the Lagrange multiplier approach for bulk Helmholtz free energy and surface free energy. One of them is based on a component-wise approach, which requires solving a sequence of linear, separate mass balance equations and leads to an original discrete energy that unconditionally dissipates. Another numerical scheme is based on a component-separate approach, which requires solving a sequence of linear, separate mass balance equations but leads to a modified discrete energy dissipating under certain conditions. Numerical results are presented to verify the effectiveness of the proposed methods.

Stabilized numerical simulations for the transport equation in a fluid

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Schedule: December 19 14:30-15:00 Capital Suite 2

Seulip Lee
Tufts University
USA

Co-Author(s): Shuhao Cao, Long Chen

Abstract:
This talk presents stabilized numerical simulations for the transport equation in a fluid while applying polygonal discretization. A convection-dominated problem explains convective and molecular transport along a given fluid velocity with a small diffusive effect, where classical numerical methods may yield spurious oscillations on numerical solutions and fail to provide accurate simulations. The edge-averaged finite element (EAFE) scheme is a stable discretization for the convection-dominated problem, and its stability is mathematically verified by the discrete maximum principle (DMP). We aim to generalize the edge-averaged stabilization to a polygonal discretization called the virtual element method. Hence, the edge-averaged virtual element (EAVE) methods produce stable and accurate numerical simulations on polygonal meshes and have less computational complexity than other stabilized schemes on polygons. We also show numerical experiments with numerical solutions with sharp boundary layers.

A new type of simplified inverse Lax-Wendroff boundary treatment for hyperbolic conservation law

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Schedule: December 19 18:30-19:00 Capital Suite 2

Shihao Liu
KTH Royal Institute of Technology
Sweden

Co-Author(s): Tingting Li, Ziqiang Cheng, Yan Jiang, Chiwang Shu, Mengping Zhang

Abstract:
We design a new kind of high order inverse Lax-Wendroff (ILW) boundary treatment for solving hyperbolic conservation laws with finite difference method on a Cartesian mesh. This new ILW method decomposes the construction of ghost point values near inflow boundary into two steps: interpolation and extrapolation. First, we impose values of some artificial auxiliary points through a polynomial interpolating the interior points near the boundary. Then, we will construct a Hermite extrapolation based on those auxiliary point values and the spatial derivatives at boundary obtained via the ILW procedure. This polynomial will give us the approximation to the ghost point value. By an appropriate selection of those artificial auxiliary points, high-order accuracy and stable results can be achieved. Moreover, theoretical analysis indicates that comparing with the original ILW method, especially for higher order accuracy, the new proposed one would require fewer terms using the relatively complicated ILW procedure and thus improve computational efficiency on the premise of maintaining accuracy and stability. We perform numerical experiments on several benchmarks, including one- and two-dimensional scalar equations and systems. The robustness and efficiency of the proposed scheme is numerically verified.

Explicit Runge-Kutta methods for quadratic optimization via gradient flow equations

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Schedule: December 19 19:00-19:30 Capital Suite 2

Tuo Liu
King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): Tuo Liu, David Ketcheson

Abstract:
This talk focuses on analyzing and developing accelerated optimization methods for the class of smooth and strongly convex functions. We derive a family of optimal gradient-based methods (named OERKD) for quadratic programming by building a mapping between continuous dynamics and discrete updates of optimization algorithms. Optimality of convergent rates is proved by analysis of explicit Runge-Kutta methods on the gradient flow equation with linear stability conditions. Experiments demonstrate the effectiveness of the proposed algorithm even on classical nonlinear problems. A noteworthy byproduct is proving the asymptotic equivalence between OERKD and Polyak`s heavy ball method, which subtly bridges two primary integration schemes.

Efficient and Parallel Solution of High-order Continuous Time Galerkin for Dissipative and Wave Propagation Problems

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Schedule: December 19 18:00-18:30 Capital Suite 2

Yong Liu
Academy of Mathematics and Systems Science, CAS
Peoples Rep of China

Co-Author(s): Zhiming Chen

Abstract:
In this talk, I will propose efficient and parallel algorithms for the implementation of the high-order continuous time Galerkin method for dissipative and wave propagation problems. By using Legendre polynomials as shape functions, we obtain a special structure of the stiffness matrix that allows us to extend the diagonal Pad\`e approximation to solve ordinary differential equations with source terms. The unconditional stability, hp error estimates, and hp superconvergence at the nodes of the continuous time Galerkin method are proved. Numerical examples will be shown to confirm our theoretical results.

A moment-based Hermite WENO scheme with unified stencils for hyperbolic conservation laws

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Schedule: December 19 8:00-8:30 Capital Suite 2

Jianxian QIU
Xiamen University
Peoples Rep of China

Co-Author(s): Chuan Fan, Zhuang Zhao

Abstract:
In this presentation, we introduce a fifth-order moment-based Hermite weighted essentially non-oscillatory scheme with unified stencils (termed as HWENO-U) for hyperbolic conservation laws. The main idea of the HWENO-U scheme is to modify the first-order moment by a HWENO limiter only in the time discretizations using the same information of spatial reconstructions, in which the limiter not only overcomes spurious oscillations well, but also ensures the stability of the fully-discrete scheme. For the HWENO reconstructions, a new scale-invariant nonlinear weight is designed by incorporating only the integral average values of the solution, which keeps all properties of the original one while is more robust for simulating challenging problems with sharp scale variations. Compared with previous HWENO schemes, the advantages of the HWENO-U scheme are: (1) a simpler implemented process involving only a single HWENO reconstruction applied throughout the entire procedures without any modifications for the governing equations; (2) increased efficiency by utilizing the same candidate stencils, reconstructed polynomials, and linear and nonlinear weights in both the HWENO limiter and spatial reconstructions; (3) reduced problem-specific dependencies and improved rationality, as the nonlinear weights are identical for the function u and its non-zero multiple ζu. Besides, the proposed scheme retains the advantages of previous HWENO schemes, including compact reconstructed stencils and the utilization of artificial linear weights. Extensive benchmarks are carried out to validate the accuracy, efficiency, resolution, and robustness of the proposed scheme.

A local discontinuous Galerkin method for the Novikov equation

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Schedule: December 19 16:45-17:15 Capital Suite 2

Qi Tao
Beijing University of Technology
Peoples Rep of China

Abstract:
In this talk, we present a local discontinuous Galerkin method for the Novikov equation that contains cubic nonlinear high-order derivatives. Flux correction techniques are used to ensure the stability of the numerical scheme. The H^1-norm stability of the general solution and the error estimate for smooth solutions without using any priori assumptions are presented. Numerical examples demonstrate the accuracy and capability of the LDG method for solving the Novikov equation.

Optimal L2 error estimates of unconditionally stable FE schemes for the Cahn-Hilliard-Navier-Stokes system

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Schedule: December 19 13:30-14:00 Capital Suite 2

Jilu Wang
Harbin Institute of Technology (Shenzhen)
Peoples Rep of China

Abstract:
The paper is concerned with the analysis of a popular convex-splitting finite element method for the Cahn-Hilliard-Navier-Stokes system, which has been widely used in practice. Since the method is based on a combined approximation to multiple variables involved in the system, the approximation to one of the variables may seriously affect the accuracy for others. Optimal-order error analysis for such combined approximations is challenging. The previous works failed to present optimal error analysis in L^2-norm due to the weakness of the traditional approach. Here we first present an optimal error estimate in L^2-norm for the convex-splitting FEMs. We also show that optimal error estimates in the traditional (interpolation) sense may not always hold for all components in the coupled system due to the nature of the pollution/influence from lower-order approximations. Our analysis is based on two newly introduced elliptic quasi-projections and the superconvergence of negative norm estimates for the corresponding projection errors. Numerical examples are also presented to illustrate our theoretical results. More important is that our approach can be extended to many other FEMs and other strongly coupled phase field models to obtain optimal error estimates.

A penalty free weak Galerkin finite element method on quadrilateral meshes

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Schedule: December 19 14:00-14:30 Capital Suite 2

Ruishu Wang
Jilin University
Peoples Rep of China

Co-Author(s): Jiangguo Liu; Zhuoran Wang

Abstract:
The weak Galerkin finite element methods are non-standard finite element methods. The newly defined weak functions are considered as the approximate functions, which have two parts, inner and boundary, on each element. Weak derivatives are correspondingly defined. Appropriate spaces should be used when no penalty term is employed. We use the Arbogast-Correa element to define the weak gradient and obtain a penalty-free weak Galerkin scheme, which is then employed to solve problems related to Stokes flow, linear elasticity, and poroelasticity.

The Finite volume element method with global conservation law

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Schedule: December 19 9:00-9:30 Capital Suite 2

Xiang Wang
Jilin University
Peoples Rep of China

Co-Author(s): Xinyuan Zhang

Abstract:
Conservation laws are fundamental physical properties that are expected to be preserved in numerical discretizations. We propose a two-layered dual strategy for the finite volume element method (FVEM), which possesses the conservation laws in both flux form and equation form. In particular, for problems with Dirichlet boundary conditions, the proposed schemes preserves conservation laws on all triangles, whereas conservation properties may be lost on boundary dual elements by existing vertex-centered finite volume element schemes. Theoretically, we carry out the optimal L^2 analysis with reducing the regularity requirement from $u \in H^{k+2}$ to $u \in H^{k+1}$. While, as a comparison, all existing L^2 results for high-order $(k >= 2)$ finite volume element schemes require $u \in H^{k+2}$ in the analysis.

Recent Advances in High-Order Bound-Preserving Schemes and Theory

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Schedule: December 19 15:45-16:15 Capital Suite 2

Kailiang Wu
Southern University of Science and Technology
Peoples Rep of China

Abstract:
Solutions to many partial differential equations (PDEs) are subject to certain bounds or constraints. For instance, in fluid dynamics, density and pressure must remain positive, while in relativistic cases, fluid velocity must not exceed the speed of light. Developing bound-preserving numerical methods that uphold these intrinsic constraints is crucial. Recently, significant attention has been given to design provably bound-preserving schemes, though challenges remain, particularly for systems with nonlinear constraints. In this talk, I will present our recent efforts in developing high-order bound-preserving schemes and theories: 1. Geometric Quasilinearization (GQL): Drawing on key insights from geometry, we propose a novel and general framework called geometric quasilinearization. GQL offers an effective approach for addressing bound-preserving problems with nonlinear constraints by transforming these constraints into linear ones through the introduction of auxiliary variables. We establish the fundamental principles and general theory of GQL using the geometric properties of convex regions and present three effective methods for constructing GQL. 2. Optimal Cell Average Decomposition (OCAD): Utilizing convex geometry and symmetric group theory, we develop the optimal cell average decomposition theory, which provides a foundation for constructing more efficient bound-preserving schemes. We demonstrate that the classic Zhang-Shu CAD is optimal in one dimension but generally not in multiple dimensions, thereby addressing their conjecture proposed in 2010. We apply the GQL and OCAD approaches to various PDEs, showcasing their effectiveness and advantages through diverse and challenging examples and applications, including magnetohydrodynamics (MHD), relativistic hydrodynamics, and the ten-moment Gaussian closure system.

Special Session 105 : Nonlinear Differential Problems on Flat and Curved Structures: Variational and Topological Methods

Introduction: The session focuses on the qualitative analysis of nonlinear differential problems on Euclidean and non-Euclidean spaces. In particular, the main purpose is to give an update on recent developments concerning ordinary and partial differential equations, variational-hemivariational inequalities, difference and algebraic systems obtained by exploiting different methods of the nonlinear analysis such as critical point theory, fixed point theorems, topological degree, Morse theory, set-valued analysis, optimal mass transportation, etc.

Nonlinear differential equations in the whole space

Schedule: December 17 9:00-9:30 Capital Suite 8

Eleonora Amoroso
University of Messina
Italy

Abstract:
In this talk, we present some existence and multiplicity results for nonlinear elliptic equations involving the p-Laplacian operator and which are defined in the whole space. As a special case, the existence of two non-zero solutions, one with negative energy and other with positive one, for equations having combined effects of concave and convex nonlinearities is obtained. The approach is based on variational methods and critical point theory. This is a joint work with G. Bonanno and K. Perera.

Multiple Solutions for Nonlinear Elliptic Differential Inclusions

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Schedule: December 16 12:30-13:00 Capital Suite 8

Gabriele Bonanno
University of Messina
Italy

Abstract:
A multiplicity result for elliptic differential inclusions is presented. The approach is based on variational methods and a theorem on the existence of two generalized nonzero critical points is applied. Finally, differential equations with discontinuous nonlinearities are studied.

A Variant Prescribed Curvature Flow on Closed Surfaces with Negative Euler Characteristic

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Schedule: December 17 8:00-8:30 Capital Suite 8

Franziska Borer
Technical University of Berlin
Germany

Co-Author(s): Peter Elbau, Tobias Weth

Abstract:
Let $(M, \bar{g})$ be a two-dimensional, smooth, closed, connected, oriented Riemann manifold endowed with a smooth background metric $\bar{g}$. A classical problem raised by Kazdan and Warner is the question which smooth functions $f : M \to \mathbb{R}$ arise as the Gauss curvature K_g of a conformal metric $g(x) = \mathrm{e}^{2u(x)}\bar{g}(x)$ on M and to characterise the set of all such metrics. In this talk, we give an overview on several results concerning prescribed Gauss curvature problems depending on the given function f as well as the Euler characteristic $\chi(M)$ of the manifold M, and consider everything in the flow context. Finally we will see, that in the case where the characteristic $\chi(M)$ is negative and f is sign-changing, we have to introduce a new kind of prescribed Gauss curvature flow to solve the problem. This is a joint work with Peter Elbau and Tobias Weth.

Two positive solutions for parametric singular p-Laplacian type problems

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Schedule: December 16 15:15-15:45 Capital Suite 8

Pasquale Candito
Mediterranean University of Reggio Calabria
Italy

Abstract:
The aim of this talk is to discuss some recent results about the existence of at least two positive solutions for parametric singular p-Laplacian type problems.

Existence and regularity results for a class of singular parabolic problems with L1 data

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Schedule: December 16 14:00-14:30 Capital Suite 8

Ida de Bonis
Sapienza University of Rome
Italy

Co-Author(s): Maria Michaela Porzio

Abstract:
In this paper we prove existence and regularity results for a class of parabolic problems with irregular initial data and lower order terms singular with respect to the solution. We prove that, even if the initial datum is not bounded but only in $L^1(\Omega)$, there exists a solution that `instantly` becomes bounded.

Tumor-inmune cell interactions by a chemotaxis system with logistic source

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Schedule: December 17 12:30-13:00 Capital Suite 8

Rafael Diaz Fuentes
University of Cagliari
Italy

Abstract:
This talk presents an extension of a previously studied class of chemotaxis systems, in which a source term of logistic type is introduced into one of the three parabolic partial differential equations. The source term of logistic type is given by the expression $u^k(1-u)$. This choice generalizes some models previously described in literature. We study some properties of the classical solutions for the superquadratic and quadratic degradation rate, i.e., $k>1$ and $k=1$ respectively. Under suitable assumptions on the initial data and the coefficients of the system, the global-in-time existence of the classical solutions and their uniform boundedness are proved in bounded domains of $\mathbb{R}^n$, $n \geq 3$.

Existence results for nonlinear differential problems and applications to neural networks

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Schedule: December 17 14:00-14:30 Capital Suite 8

Giuseppina D`Agui
University of Messina
Italy

Abstract:
This talk concerns results on the existence of positive solutions to boundary value problems for ordinary differential equations. In particular, we show the existence of a periodic weak solution to a nonlinear parametric differential problem using variational methods. The core approach is based on critical point theorems, with particular emphasis on a recently developed non-zero local minimum theorem. The results presented are part of the research carried out within the project: PNRR-MAD-2022-12376692-PNRR-Missione 6 - Componente 2 Investimento 2.1 Valorizzazione e Potenziamento della Ricerca Biomedica del SSN

Tumbling Downhill along a Given Curve

Schedule: December 16 13:30-14:00 Capital Suite 8

Jean-Pierre Eckmann
University of Geneva
Switzerland

Co-Author(s): Y. Sobolev and T. Tlusty

Abstract:
A cylinder will roll down an inclined plane in a straight line. A cone will wiggle along a circle on that plane and then will stop rolling. We ask the inverse question: For which curves drawn on the inclined plane R^2 can one chisel a shape that will roll downhill following precisely this prescribed curve and its translationally repeated copies? This is a nice, and easy to understand problem, but the solution is quite interesting. (After a Nature paper, Solid-body trajectoids shaped to roll along desired pathways, August 2023, and Notices AMS, Vol 71, 2024)

Ordered solutions for degenerate Kirchhoff problems

Schedule: December 16 14:45-15:15 Capital Suite 8

Francesca Faraci
University of Catania
Italy

Co-Author(s): K.Silva

Abstract:
In this talk we study a parametrized Kirchhoff type equation with two degeneracy points. The existence of two $H_0^1(\Omega)$-norm ordered solutions is established for small value of the parameter via a careful analysis of the fiber maps associated to the energy functional. As a consequence we show existence of multiple or even infinitely many solutions to degenerate Kirchhoff equations. Some applications are given. Based on the paper: F. Faraci, K. Silva, Ordered solutions for degenerate Kirchhoff problems, submitted.

Singular (N,q)-Lapacian equation on Riemannian manifolds.

Schedule: December 16 18:30-19:00 Capital Suite 8

Csaba Farkas
Sapientia Hungarian University of Transylvania
Romania

Abstract:
n this talk, we aim to investigate the existence of solutions for a singular elliptic equation of (N,q)-Laplacian type on a non-compact, complete N-dimensional Riemannian manifold with nonnegative Ricci curvature and Euclidean volume growth. The nonlinearity appearing in the problem exhibits exponential critical growth in the Moser-Trudinger sense. By combining variational arguments with a Lions-type compactness principle, we guarantee the existence of a non-zero, isometry-invariant solution for such problems.

Riccati pairs: an alternative approach to Hardy inequalities

Schedule: December 16 19:00-19:30 Capital Suite 8

Sandor Kajanto
Babes-Bolyai University, Cluj-Napoca
Romania

Abstract:
Riccati pairs allow us to establish Hardy inequalities on Riemannian manifolds by solving corresponding Riccati-type ordinary differential inequalities. This method relies solely on simple convexity arguments, the divergence theorem, and the Laplace comparison theorem. Moreover, it is symmetrization-free, making it broadly applicable: inequalities formulated on model space forms extend naturally to general manifolds with lower sectional curvature.

Sharp Sobolev inequalities on noncompact Riemannian manifolds

Schedule: December 16 17:30-18:00 Capital Suite 8

Alexandru Kristaly
Babes-Bolyai University
Romania

Abstract:
In their seminal work, Cordero-Erausquin, Nazaret and Villani [Adv. Math., 2004] proved sharp Sobolev inequalities in Euclidean spaces via Optimal Transport, raising the question whether their approach is powerful enough to produce sharp Sobolev inequalities also on Riemannian manifolds. By using L^1-optimal transport approach, the compact case has been successfully treated by Cavalletti and Mondino [Geom. Topol., 2017], even on metric measure spaces verifying the synthetic lower Ricci curvature bound. In the present talk we affirmatively answer the above question for noncompact Riemannian manifolds with non-negative Ricci curvature; namely, by using Optimal Transport theory with quadratic distance cost, sharp L^p-Sobolev and L^p-logarithmic Sobolev inequalities (both for $p > 1$ and $p = 1$) are established, where the sharp constants contain the asymptotic volume ratio arising from precise asymptotic properties of the Talentian and Gaussian bubbles, respectively. Talk based on [A]. [A] Krist\`aly Alexandru, Sharp Sobolev inequalities on noncompact Riemannian manifolds with $Ric \geq 0$ via optimal transport theory. Calc. Var. Partial Differential Equations 63 (2024), no. 8, Paper No. 200.

On some properties of solutions to a class of parabolic system

Schedule: December 17 13:30-14:00 Capital Suite 8

Monica Marras
University of Cagliari
Italy

Co-Author(s): Y. Chiyo, T. Yokota, S. Vernier-Piro

Abstract:
We are interested in qualitative properties as blow-up phenomena, decay in time, boundedness, global existence for solutions of some classes of parabolic systems. In particular, we study a new class of Keller Segel models, which presents a limited flux and an optimal transport of cells density according to chemical signal density.

Sharp Morrey-Sobolev inequalities on Finsler manifolds with nonnegative Ricci curvature

Schedule: December 16 17:00-17:30 Capital Suite 8

Agnes Mester
University of Bern
Switzerland

Co-Author(s): Alexandru Kristaly, Ildiko I. Mezei

Abstract:
We present sharp Morrey-Sobolev inequalities (i.e., in the case $p > n$) on n-dimensional Finsler manifolds having nonnegative n-Ricci curvature. For this purpose, we elaborate suitable anisotropic symmetrization arguments by applying the sharp isoperimetric inequality available on these spaces. We also provide a Hardy-type inequality within the same geometric setting. As application, by using variational arguments, we guarantee the existence & multiplicity of solutions for certain elliptic PDEs involving the Finsler-Laplace operator. Our results are also new in the Riemannian setting. Talk based on Kristaly A, Mester A, Mezei I. I, Sharp Morrey-Sobolev inequalities and eigenvalue problems on Riemannian- Finsler manifolds with nonnegative Ricci curvature, Commun. Contemp. Math, 25 (2023), no. 10, Paper No. 2250063.

Nonsmooth analysis for boundary value problems with discontinuous nonlinearities

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Schedule: December 16 16:15-16:45 Capital Suite 8

Valeria Morabito
University of Messina
Italy

Abstract:
In this talk, we investigate the existence of solutions for boundary value problems governed by nonlinear differential equations with discontinuous nonlinearities, employing nonsmooth techniques from variational analysis. Specifically, we focus on Clarke`s theory for locally Lipschitz functionals, which provides a framework for analyzing functionals that exhibit nonsmooth behavior, extending classical variational methods to non-smooth setting.

Sharp inequalities on Riemannian manifolds with Euclidean volume growth

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Schedule: December 16 18:00-18:30 Capital Suite 8

Carlo Morpurgo
University of Missouri
USA

Co-Author(s): Luigi Fontana, Liuyu Qin

Abstract:
In this talk, I will discuss recent results on Moser-Trudinger inequalities on complete Riemannian manifolds with nonnegative Ricci curvature and large volume growth. These inequalities will feature different best constants under different norm conditions. The main tools involved in the proof are sharp asymptotic and global estimates for heat kernels and Green functions, combined with recent results on Adams inequalities on metric measure spaces, obtained in joint work with Liuyu Qin.

A study of the Kuramoto model for synchronization phenomena based on a degenerate partial differential equation

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Schedule: December 16 13:00-13:30 Capital Suite 8

Sergio Polidoro
Dipartimento FIM - Universit\`{a} di Modena e Reggio Emilia
Italy

Co-Author(s): Giulio Pecorella, Cecilia Vernia

Abstract:
We consider a semilinear integro-differential equation that arises when introducing inertial effects in the Kuramoto model. Based on the known theory of degenerate Kolmogorov operators, existence, uniqueness and regularity results for the relevant Cauchy problem are discussed. Moreover, a stable numerical operator, which is consistent with the degenerate Kolmogorov operator, is provided in order to produce numerical solutions. Numerical experiments show how the synchronization phenomena depend on the parameters of the Kuramoto model with inertia.

Nonlinear sampling Durrmeyer operators in functional spaces

Schedule: December 17 9:30-10:00 Capital Suite 8

Arianna Travaglini
University of Florence
Italy

Co-Author(s): Gianluca Vinti

Abstract:
Among sampling type operators, the Generalized Durrmeyer-Sampling type series represents a generalization of both the Generalized and Kantorovich Sampling operators. The talk is focused on some recent approximation results for the Nonlinear version of Durrmeyer-Sampling type operators. \ For what concerns the space of continuous functions, a pointwise and uniform convergence theorem is provided. Moreover, approximation results for the nonlinear sampling Durrmeyer operators in the general setting of Orlicz spaces are also discussed. This results also ensures convergence in notable specific cases, such as in L^p-spaces, Zygmund spaces, and exponential spaces. Moreover, by considering the case of functions that are not necessarily continuous, these findings prove especially valuable in practical applications, where most real-world signals, such as digital images, are not mathematically represented by continuous functions.

Discrete and semi-discrete sampling type operators and applications to image segmentation

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Schedule: December 17 8:30-9:00 Capital Suite 8

Gianluca Vinti
Department of Mathematics and Informatics, University of Perugia
Italy

Abstract:
In this talk, I will present some convergence results for discrete and semi-discrete operators of sampling type and I will show their applications to digital image processing. In particular, I will use a family of the above operators to solve a medical problem concerning the segmentation of the patent lumen of the aortic vessel. The above problem will be discussed showing two approaches: a deterministic one, that exploits results of approximation theory and one based on artificial intelligence methods through the use of convolutional neural networks. Finally, I will compare them each other by the numerical estimation of some similarity indexes.

Special Session 106 : Data-Driven Multiscale Modeling and Model Reduction Techniques in Biomedicine: Bridging Scales and Complexity

Introduction: Background: Biomedical research is increasingly dealing with complex data sets and biological systems that operate across multiple scales, from molecular to organismal. Data-driven multiscale modeling and model reduction methods offer powerful tools to integrate heterogeneous data types, reduce complexity, and provide insights into the underlying mechanisms of health and disease. These approaches are critical for the development of personalized medicine, efficient drug discovery, and the design of novel therapeutic interventions. Themes: Foundations and Innovations in Multiscale Modeling: Presentations on the latest theoretical developments, computational frameworks, and algorithms for multiscale modeling in biomedicine. This theme will cover both data-driven and mechanistic approaches to bridging scales in biological systems. Advances in Multiscale Analysis and Model Reduction Techniques: Focus on the development and application of multiscale modeling and model reduction techniques to address the complexity of biomedical systems, facilitate computational efficiency, and extract meaningful insights. Data-Driven Modeling in Biomedicine: Exploration of how applied mathematicians and computational scientists are leveraging big data, from genomic sequences to clinical trials, to inform and refine biomedical models. Bridging Theory and Practice: Case studies demonstrating the successful translation of theoretical models into practical applications in diagnostics, drug development, and personalized medicine.

Data-Driven Models for Extended Reality Solutions in General Anesthesia Management.

Schedule: December 17 13:30-14:00 Capital Suite 11 A

Ghada Ben Othman
Ghent University
Belgium

Co-Author(s): Ghada BEN OTHMAN, Clara Mihaela IONESCU

Abstract:

This presentation introduces an extension to system theory as a novel framework for modeling clinical data under significant uncertainty and poor identifiability conditions, common challenges in medical systems. These challenges arise from ethical, safety, and regulatory constraints, limiting the persistent drug-related excitation of the human body. Moreover, the drug-dose effect relationship is complicated by substantial inter- and intra-patient variability. The absence of suitable instrumentation for direct measurement, relying instead on inferences and surrogate metrics, adds further complexity. The efficacy of our approach was examined in clinical data from patients monitored during the induction phase of target-controlled intravenous anesthesia. The proposed method delivered models with physiological explainable parameters and suitable for closed-loop control of anesthesia. A notable advantage of this approach is its robustness in the face of uncertainty. The work is the first piece of the puzzle towards Extended Reality solutions encompassing virtual, augmented, and mixed reality in general anesthesia management.

Mechanisms of cancer invasion and progression: insights from agent-based models

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Schedule: December 16 17:00-17:30 Capital Suite 11 A

Andreas Deutsch
Centre for Interdisciplinary Digital Sciences, Dresden University of Technology
Germany

Abstract:

Cancer invasion may be viewed as collective phenomenon emerging in populations of normal and malignant cells. As such it can be studied with agent-based models, e.g. cellular automata. I will provide examples of such models to analyze breast and glioma invasion as well as the emergence of phenotypic heterogeneity due to cellular interactions in growing tumors. Furthermore, I will present models which shed light on cancer progression.

COVID-19 in Greece: the dynamics of the 4th, 5th and 6th waves

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Schedule: December 17 12:30-13:00 Capital Suite 11 A

Dimitris A Goussis
Khalifa University
United Arab Emirates

Abstract:
The results of an alternative methodology for making predictions about the COVID-19 pandemic are presented. The methodology is based on the Computational Singular Perturbation method, which delivers algorithmically singular perturbation analysis results for complex multiscale systems. Instead of focusing on the various population profiles (subjected to instabilities introduced by the fitting process), this methodology focuses on the time scale that characterizes the intensity and duration of the outbreak phase. The analysis leads to the conclusion that the prediction of the inflection point in the profile of the active cases is much more robust and accurate than the prediction of the. Since the inflection point precedes the peak, this methodology can serve as an early warning of the peak. In addition, CSP diagnostics are shown to provide significant information regarding the paths between the various populations (healthy, exposed, infected, etc) that contribute the most to the outbreak phase. The accuracy of the new methodology in analyzing pandemic outbreaks is demonstrated for the 4th, 5th and 6th outbreak waves of COVID-19 in Greece.

How to make clinical predictions when we do not know everything? Synergies between dynamic modelling and AI

Schedule: December 16 18:00-18:30 Capital Suite 11 A

Haralampos Hatzikirou
Khalifa University
United Arab Emirates

Abstract:
In clinical practice, a plethora of examinations is conducted to assess the state of a certain pathology. These span from blood sample analysis, clinical imaging (e.g. CT, MRI) and biopsy sampling are among the most important diagnostic and prognostic tools. Such medical data correspond to snapshots in time of the patient`s state, since current standard of care (SoC) is not based on emergent technologies of real-time measurements, such as liquid biopsies or biosensors. Moreover, clinical data refer to different biological scales since imaging, such as MRI, typically provides an organ level picture of a disease (macroscopic), biopsies represent cellular patterns at a tissue (mesoscopic) level and -omics, FACS or molecular markers allow for sub-cellular insights. Finally, the biophysical mechanisms that regulate phenomena in all these scales are not completely known. Therefore, current clinical care faces the following challenges: (C1) data collection is sparse in time since it relies on patient`s clinical presentation, (C2) we lack the knowledge/uncertainty of the mechanisms involved in regulating these data variables across different scales (structural uncertainty), and (C3) medical data are multiscale. Therefore, integrating these data to predict the future of a disease and propose an appropriate treatment is a formidable task. I propose to harness the ability of mechanistic models to integrating the existing biological knowledge and deal with the emerging dynamics. At the same time complete the missing knowledge by using data intensive techniques. Here I will present (i) a Bayesian regression framework of combining models and machine learning to predict tumor growth and (ii) model-driven classification method to assess the graft loss risk in kidney transplantation patients.

Spatio-temporal Dynamics of MMK4 Function for JNK Pathway from Analog to Digital Converter in Response to Stress Intensities

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Schedule: December 17 14:00-14:30 Capital Suite 11 A

Nuha Loling Othman
Osaka University
Japan

Co-Author(s): Hisashi Moriizumi, Mutsuhiro Takekawa, Takashi Suzuki

Abstract:
Spatio-temporal regulation of mitogen-activated protein kinase (MAPK) signaling is essential for mammalian cells` growth, differentiation, and survival. There are three mitogens involved in response to proliferation, apoptosis, and cytokine production, which are called ERK, p38, and c-JUN N-terminal kinases (JNK). MAPK pathway cascade is a central signal transduction pathway activated by growth factors in response to stimuli by phosphorylating and activating mitogen-activated protein kinase kinase kinase (MAPKKK) - mitogen-activated protein kinase kinase (MAPKK) - MAPK in a stepwise and continuous manner, transmitting signals from upstream to downstream. The activation of MAPK which activates several nuclear targets such as mitogen-activated protein kinase kinase 4 (MKK4) which binds to JNK leads to their translocation from cytoplasm to nucleus. MKK4 is a member of MAPKK family, phosphorylates, and activates JNK in response to cellular stresses and proinflammatory cytokines. JNK which also belongs to the family of mitogen-activated protein kinase (MAPK) has been implicated in the apoptotic response of cancer cells exposed to stress while JNK is required to induce apoptosis. Here, we model the relation of MAPK pathway response to stress intensities for apoptosis in programmed cell death in cancer.

Modelling Post-Operative Glioblastoma Relapse

Schedule: December 16 18:30-19:00 Capital Suite 11 A

Andrei Macarie
University of Dundee
Scotland

Abstract:
In this work we aim to explore oedema infiltration and predict relapse patterns of GBM. To address this, we propose a novel multiscale mathematical modelling framework to simulate and predict tumour growth, oedema infiltration, and treatment response under various conditions. Simulation results obtained by exploring a large space of post-operatory residual oedema cell distributions led us to formulate the hypothesis that a higher concentration of tumour cells remaining near the surgical cavity edge led to slower and more localized tumour growth. Based on this simulations-inspired hypothesis we explore the ways of reconstructing the personalised initial tumour distribution within the oedema from existing MRI patient data in an inverse problem approach, with the ultimate goal of achieving prediction abilities for our modelling framework. The prediction abilities acquired by our framework through this inverse problem approach are promising, which for instance enabled us to achieve realistic prediction (i.e., match MRI data) of 881 days post-treatment GBM relapse evolution [4]. While further analytical investigations are ongoing, this innovative approach holds promise for reconstructing tumor relapses from readily available clinical data, offering new insights into GBM progression and treatment response.

Data-Driven Identification of Regions for Model Reduction in Multiscale Biomedical Data

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Schedule: December 17 13:00-13:30 Capital Suite 11 A

Dimitris M Manias
Khalifa University
United Arab Emirates

Abstract:
The rapidly increasing volume and complexity of biomedical data, characterized by its multiscale and multidimensional nature, present significant opportunities and challenges for effective model development. Multiscale systems in biomedicine often exhibit complex dynamics that cannot be adequately captured by traditional modeling approaches, thereby necessitating novel data-driven model reduction techniques. Furthermore, the sparse, heterogeneous, and often incomplete nature of biomedical datasets adds layers of complexity, underscoring the need for advanced methodologies capable of extracting meaningful patterns and representing system dynamics across multiple scales. In this work, we present a systematic methodology for identifying regions within the data where reduced models can be effectively constructed, leveraging tools from the Computational Singular Perturbation (CSP) method. By segmenting the data and pinpointing distinct regions of dynamic behavior, our approach facilitates the construction of region-specific reduced models that accurately represent the local properties of the system. This strategy is particularly effective in addressing the inherent multiscale complexity of biological systems, allowing for the development of reduced models that are computationally efficient while retaining the critical features of the underlying dynamics. The proposed methodology employs data-driven techniques to approximate key components, such as the Jacobian matrix, which plays a vital role in identifying timescale separations and dominant subprocesses in the data. By integrating CSP tools, we ensure a systematic partitioning of the data into regions where different reduced models can be reliably constructed, thereby enhancing both the validity and applicability of these models. After identifying the correct data partitioning, we can apply existing numerical methods to reconstruct the corresponding governing equations of the reduced models. This structured approach bridges the gap between data sparsity, multiscale interactions, and model complexity, ultimately contributing to the development of accurate, patient-specific models in the biomedical domain.

Reinforcement learning informs optimal treatment strategies to limit antibiotic resistance

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Schedule: December 16 17:30-18:00 Capital Suite 11 A

Jacob G Scott
Cleveland clinic
USA

Abstract:
Antimicrobial resistance was estimated to be associated with 4.95 million deaths worldwide in 2019. It is possible to frame the antimicrobial resistance problem as a feedback-control problem. If we could optimize this feedback-control problem and translate our findings to the clinic, we could slow, prevent, or reverse the development of high-level drug resistance. Prior work on this topic has relied on systems where the exact dynamics and parameters were known a priori. In this study, we extend this work using a reinforcement learning (RL) approach capable of learning effective drug cycling policies in a system defined by empirically measured fitness landscapes. Crucially, we show that it is possible to learn effective drug cycling policies despite the problems of noisy, limited, or delayed measurement. Given access to a panel of 15 -lactam antibiotics with which to treat the simulated Escherichia coli population, we demonstrate that RL agents outperform two naive treatment paradigms at minimizing the population fitness over time. We also show that RL agents approach the performance of the optimal drug cycling policy. Even when stochastic noise is introduced to the measurements of population fitness, we show that RL agents are capable of maintaining evolving populations at lower growth rates compared to controls. We further tested our approach in arbitrary fitness landscapes of up to 1,024 genotypes. We show that minimization of population fitness using drug cycles is not limited by increasing genome size. Our work represents a proof-of-concept for using AI to control complex evolutionary processes.

Special Session 107 : Recent Advances in Data Assimilation with Machine Learning

Introduction: In recent years, machine learning has become one of the dominant methods for studying complex dynamical systems, especially for data assimilation and prediction. Machine learning has been widely used as a computationally efficient surrogate of complicated knowledge-based forecast models or applied to the role of a statistical correction for the knowledge-based models that mitigate the model error in the forecast step of data assimilation. It has also been exploited to optimize the tuning parameters in ensemble data assimilation, such as the inflation rate of the covariance matrix. On the other hand, machine learning has been applied more directly by building end-to-end learning schemes for the entire data assimilation pipeline. This special session will focus on topics that relate to both fundamental mathematical theories and numerical algorithms for data assimilation with the assistance of machine learning. The session serves as a venue for developing new ideas and advancing mathematical analysis of machine-learning-assisted data assimilation methods.

An Efficient Online Smoother and Sampling Algorithm for Partially Observed Nonlinear Dynamical Systems

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Schedule: December 20 15:30-16:00 Conference Hall B (B)

Marios Andreou
University of Wisconsin-Madison
USA

Co-Author(s): Nan Chen, Yingda Li

Abstract:
State estimation is a critical task in practice as it is the prerequisite for effective parameter estimation (PE), skillful prediction, optimal control, and the development of robust and complete datasets. Of essence is the probabilistic state estimation of the unobserved variables in high-dimensional complex nonlinear turbulent dynamical systems with intermittent instability, given a partially observed time series. Data assimilation (DA) through Bayesian inference combines the partial observations and the model-induced likelihood, potentially plagued by a small error in model structure or initial condition, to form the posterior distribution for optimal state estimation. In this work, an efficient algorithm with closed-form explicit expressions is developed for the optimal (in the mean-squared sense) online smoother and sampling of a rich class of nonlinear turbulent dynamical systems widely appearing in modeling natural phenomena like physics-constrained stochastic models (noisy Lorenz models, low-order models of Charney-DeVore flows, paradigm models for topographic mean flow interaction), stochastically coupled reaction-diffusion models in neuroscience and ecology (stochastically coupled FitzHugh-Nagumo models, stochastically coupled SIR epidemic models), multiscale models for geophysical flows (noisy Boussinesq equations, stochastically forced rotating shallow water equation), and to develop realistic systems for the Madden-Julian oscillation and Arctic sea ice. The conditional Gaussian nonlinear system framework is highly flexible since it encompasses the linear Kalman filter and the Rauch-Tung-Striebel smoother and facilitates studying extreme events, stochastic parameterisation, DA, and online PE. The method particularly handles systems with hidden intermittency and extreme events along with the associated highly non-Gaussian features, such as heavy tails in the probability density functions, by using a computationally effective and systematic method to determine the adaptive lag for the online procedure. A rigorous analysis of the performance of the framework will be illustrated through numerical simulations of high-dimensional Lagrangian DA and online model identification of highly intermittent time series via an expectation-maximization procedure.

A mechanism learning based method for data filling of physical fields

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Schedule: December 20 8:30-9:00 Conference Hall B (B)

Yu Chen
Shanghai University of Finance and Economics
Peoples Rep of China

Co-Author(s): Yu Chen, Jin Cheng, Xinyue Luo

Abstract:
This talk is concerned with an data filling method based on mechanism learning, from the perspective of inverse problems. The underlying data mechanism, characterized by temporal-spatial or cross-sectional linear differential equations, is identified from observations on the known area and then exploited to infer that on the missing part, which improves interpretability and generalizability. Attention is paid to incorporation of prior information as higher order mechanism. Method analysis and numerical examples demonstrate effectiveness, robustness and flexibility of the method and it performs well over mechanism/scientific data, such as oceanic and atmospheric fields.

Data-driven model selections of interacting particle dynamics via Gaussian processes with uncertainty quantification

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Schedule: December 20 8:00-8:30 Conference Hall B (B)

Jinchao Feng
Great Bay University
Peoples Rep of China

Co-Author(s): Charles Kulick, Yunxiang Ren, and Sui Tang

Abstract:
In this talk, I will introduce a data-driven method to identify a comprehensive second-order particle-based model, which integrates numerous advanced models for simulating aggregation and collective behaviors of agents with comparable sizes and shapes. The model is represented as a high-dimensional set of ordinary differential equations, parameterized by dual interaction kernels that evaluate the coordination of positions and velocities. We propose a Gaussian Process (GP)-based methodology for estimating the model parameters, employing two separate GP priors for the latent interaction kernels, which are calibrated against both dynamical and observational data. This approach yields a nonparametric model for interacting dynamical systems, incorporating uncertainty quantification. Additionally, we provide a theoretical analysis to elucidate our method and assess conditions necessary for kernel recovery. The efficacy of our approach is validated through applications to various prototype systems, emphasizing system order and interaction type selection.

A unified Bayesian inversion approach for a class of tumor growth models with different pressure laws

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Schedule: December 20 16:45-17:15 Conference Hall B (B)

Yu Feng
Great Bay University
Peoples Rep of China

Co-Author(s): Liu Liu, Zhennan Zhou

Abstract:
We use the Bayesian inversion approach to study the data assimilation problem for a family of tumor growth models described by porous-medium type equations. The models contain uncertain parameters and are indexed by a physical parameter m, which characterizes the constitutive relation between density and pressure. Based on these models, we employ the Bayesian inversion framework to infer parametric and nonparametric unknowns that affect tumor growth from noisy observations of tumor cell density. We establish the well-posedness and the stability theories for the Bayesian inversion problem and further prove the convergence of the posterior distribution in the so-called incompressible limit, $m \to \infty$. Since the posterior distribution across the index regime $m \in [2, \infty)$ can thus be treated in a unified manner, such theoretical results also guide the design of the numerical inference for the unknown. We propose a generic computational framework for such inverse problems, which consists of a typical sampling algorithm and an asymptotic preserving solver for the forward problem. With extensive numerical tests, we demonstrate that the proposed method achieves satisfactory accuracy in the Bayesian inference of the tumor growth models, which is uniform with respect to the constitutive relation.

Efficient Derivative-Free Bayesian Inference for Large-Scale Inverse Problems

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Schedule: December 20 14:30-15:00 Conference Hall B (B)

Daniel Zhengyu Huang
Peking University
Peoples Rep of China

Abstract:
We consider Bayesian inference for large-scale inverse problems, where computational challenges arise from the need for repeated evaluations of an expensive forward model, which is often given as a black box or is impractical to differentiate. We propose a framework, which is built on Kalman methodology and Fisher-Rao Gradient flow, to efficiently calibrate and provide uncertainty estimations of such models with noisy observation data.

A random reconstruction method in optical tomography

Schedule: December 20 9:00-9:30 Conference Hall B (B)

Yiwen Lin
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Min Tang, Li Wang

Abstract:
In this work, we address the inverse problem of radiative transfer equation (RTE) using the Random Ordinate Method (ROM) for the forward problem and the Stochastic Gradient Descent (SGD) based method for the inverse problem, aimed at efficiently reconstructing the absorption and scattering coefficients by minimizing the mismatch between computed and measured outgoing data. Since the Discrete Ordinates Method (DOM) for solving RTE is computationally intensive and suffers from the ray effect, we utilize ROM to mitigate the ray effect due to the low regularity of the solution in the velocity direction. ROM offers several advantages over DOM, including comparable computational costs, minimal changes to existing code, and ease of parallelization. The SGD algorithm requires low memory and computation, and advances fast. Numerical examples demonstrate the accuracy and efficiency of the proposed method

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An Asymptotic-Preserving Neural Network approach for the Boltzmann equation with uncertainties

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Schedule: December 20 16:15-16:45 Conference Hall B (B)

Liu Liu
Chinese University of Hong Kong
Peoples Rep of China

Co-Author(s): Zhenyi Zhu, Xueyu Zhu

Abstract:
In this talk, we develop the Asymptotic-Preserving Neural Networks (APNNs) approach to study the forward and inverse problem for the semiconductor Boltzmann equation. The goal of the neural network is to resolve the computational challenges of conventional numerical methods and multiple scales of the model. In a micro-macro decomposition framework, we design such an AP formulation of loss function. The convergence analysis of both the loss function and its neural network is shown, based on the hypocoercivity theory of the model equation. Our analysis also suits for the general collisional kinetic equation including the full Boltzmann. We will show a series of numerical tests for forward and inverse problems, also extend to uncertainty quantification problems, to demonstrate the efficiency and robustness of our approach.

Inverse Transfer and Coherence in Rotating Stratified Turbulence with Clouds and Phase Transitions

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Schedule: December 20 17:15-17:45 Conference Hall B (B)

Yingshuo Peng
Shanghai University of Finance and Economics
Peoples Rep of China

Co-Author(s): Yeyu Zhang, Leslie M. Smith

Abstract:
Inverse energy transfer to large-scale coherent structures in idealized geophysical flow models has been a key research focus for over four decades. Extensive knowledge exists regarding inverse transfer in rotating and stratified dry dynamics, characterized by the Rossby number and a single dry Froude number. This study includes water, phase changes, and rainfall in the dynamics, characterized by the Rossby number, two Froude numbers for unsaturated and saturated environments, and a rainfall speed. Using numerical computations with random forcing, inverse transfer of energy is examined in Boussinesq model, incorporating water vapor and liquid water in the limit of asymptotically-fast cloud microphysics. Total energy includes kinetic energy, buoyant potential energies from each phase, and latent moist energy at phase boundaries. The rotation and stratification terms are comparable, such that the evolution of evolution dry equations is dominated by inverse transfer of pseudo potential vorticity. Phase changes and latent heat exchange raise the potential-to-kinetic energy ratio and reduce overall energy transfer to large scales. However, upscale transfer persists, influenced by nonlinear waves near phase interfaces, resulting in coherent updrafts and downdrafts aligned with large-scale phase boundaries. The relationship between coherent updrafts/downdrafts and moist pseudo potential vorticity is also examined.

Reduced-Order Models for Data Assimilation of Multiscale Turbulent Systems

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Schedule: December 20 14:00-14:30 Conference Hall B (B)

Di Qi
Purdue University
USA

Co-Author(s): Jian-Guo Liu

Abstract:
The capability of using imperfect stochastic and statistical reduced-order models to capture key statistical features in multiscale nonlinear dynamical systems is investigated. A new efficient ensemble forecast algorithm is developed dealing with the nonlinear multiscale coupling mechanism as a characteristic feature in high-dimensional turbulent systems. To address challenges associated with closely coupled spatio-temporal scales in turbulent states and expensive large ensemble simulation for high-dimensional complex systems, we introduce efficient computational strategies using the so-called random batch method. It is demonstrated that crucial principal statistical quantities in the most important large scales can be captured efficiently with accuracy using the new reduced-order model in various dynamical regimes of the flow field with distinct statistical structures. Finally, the proposed model is applied for a wide range of problems in uncertainty quantification, data assimilation, and control.

An Efficient Multiscale Stochastic Reduced-Order Model and Nonlinear Filtering Scheme for Two-Dimensional Stratified Turbulence

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Schedule: December 20 15:00-15:30 Conference Hall B (B)

Yeyu Zhang
Shanghai University of Finance and Economics
Peoples Rep of China

Co-Author(s): Nan Chen, Changhong Mou

Abstract:
This work aims to design a systematic multiscale stochastic Reduced-Order Model (ROM) framework for complex systems such as Boussinesq systems, which exhibit chaotic or turbulent characteristics. Based on this framework, an efficient general multiscale stochastic data assimilation scheme is developed to provide accurate tools for inversion and prediction. The primary focus of ROM design is to restore large-scale dynamics as accurately as possible. A unique feature of the generated ROM is that it facilitates the construction of an efficient and accurate nonlinear data assimilation scheme, which provides solutions through closed-form analytical expressions. This analytically solvable data assimilation scheme significantly accelerates the computation of recovering unobserved states from partial observations (e.g., efficiently updating the posterior distribution of unobserved variables, such as temperature, based on measurable data like wind fields and vice versa) through closed-form solutions, thereby avoiding many potential numerical sampling issues. This work also presents the performance of various ROMs with different model errors and different data assimilation schemes in recovering unobserved variables in complex systems. While understanding model errors, it also analyzes how to balance the filter`s reliance on the model versus observations in different physical dynamical regimes, which exhibit distinct flow characteristics (i.e., more stable layered flow or more turbulent flow).

Special Session 108 : New Trends in Fractional Modelling with General Kernel

Introduction: Fractional Calculus has a history of 328 years. It generalizes the operations of differentiation and integration to non-integer orders. The literature models are commonly constructed using integer order derivative which may introduce large errors. One advantage of fractional calculus is in the minimization of this error using fractional derivatives while providing the involvement of the memory effect during the process is the other critical advantage. Many seminal works were developed in both theories and applied areas. Among many open problems of this very young and dynamic field, one is represented by finding the applications of the fractional operators with the general kernel. The problem is interesting because the general kernels may contain singular and non-singular operators. These classes of operators have different properties and should be treated very carefully from the modelling point of view. In this special session, many experts from different fields will interact and have the opportunity to discuss their works for further improvements on how to solve the field`s open problems.

New aspects of the generalized operators

Schedule: December 20 15:30-16:00 Capital Suite 9

DUMITRU BALEANU
Lebanese American University,Beirut,Lebanon
Lebanon

Abstract:
The fractional calculus is an extension of meaning and it is an important field of the applied mathematics. In my talk I will review the concept of the generalized fractional operators and their applications. Illustrative examples will be given.

Generalization of 1D-Asymmetric Harmonic Oscillator Model via Different Kernels

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Schedule: December 20 14:00-14:30 Capital Suite 9

Ozlem Defterli
Associate Professor Dr., Department of Mathematics, Faculty of Arts and Sciences, Cankaya University, Ankara
Turkey

Co-Author(s): Dumitru Baleanu,Amin Jajarmi, Ozlem Defterli, Noorhan Alshaikh, Jihad Asad

Abstract:
The fractional dynamics of a one-dimensional asymmetric harmonic oscillator model having quadratic nonlinearity is investigated within a generalized kernel. Using the principles of the calculus of variations, a system of two-coupled fractional differential equations with a nonlinear component is derived as fractional Euler-Lagrange equations of the corresponding system. The numerical solution to the system is evaluated and then simulated concerning various model parameter values, including mass, linear and quadratic nonlinear stiffness, and the order of the fractional derivative.

Coupled Dynamics Of Caputo Memory Effects And Time Delays In Fractional Physical Models

Schedule: December 20 14:30-15:00   Capital Suite 9

Imad A Jaradat
Abdullah Al-Salem University
Kuwait

Co-Author(s): NA

Abstract:
This work explores the impact of spatiotemporal memory effects, governed by Caputo derivatives, and proportional time delays on the dynamics of fractional physical models. Using a novel transformation method, these models are reformulated into recurrence relations that result in the derivation of convergent series solutions of the Cauchy product type. The results demonstrate that these parameters significantly influence the system`s evolution over time and show a continuous transition from stationary to dynamic states, with the Caputo derivative orders functioning as homotopy parameters in a topological context. Additionally, a detailed graphical analysis highlights the parallel roles of time delays and fractional temporal derivatives, further supporting the view of Caputo derivatives as indicators of memory effects.

The treatment of conformable electromagnetic theory of Maxwell as a singular system

Schedule: December 20 15:00-15:30   Capital Suite 9

Eqab M. Rabei
Al al-Bayt university
Jordan

Co-Author(s): Mohamed Ghaleb Al-Masaeed and Dumitru Baleanu

Abstract:
documentclass{article} \usepackage{graphicx} % Required for inserting images \title{The treatment of conformable electromagnetic theory of Maxwell as a singular system } \author{Eqab.M.Rabei[1,2], Mohamed Ghaleb Al-Masaeed [3,4], Dumitru Baleanu[5] $^1 $ScienceDepartment, FacultyofScience, JerashPrivateUniversity$ ^2 $PhysicsDepartment, FacultyofScience, Alal-BaytUniversity, P.O.Box130040, Mafraq25113, Jordan$[3] Ministry of Education, Jordan\ [4]Ministry of Education and Higher Education, Qatar^{5}Department of Mathematics, Cankaya University, Ankara, Turkey\eqabrabei@gmail.com\moh.almssaeed@gmail.com} \begin{document} \maketitle \begin{abstract} The study explores the conformable electromagnetic field theory. The concept of the conformable delta function is introduced. Subsequently, the conformable Maxwell`s equations are derived. \ \textit{Keywords:}conformable derivative; Singular systems; constrained system; Dirac theory ; Lagrangian formulations; Hamiltonian formulations. \end{abstract} \end{document}

Special Session 109 : Differential, Difference, and Integral Equations: Techniques and Applications

Introduction: Due to the numerous applications in the STEM fields, the theory of differential, difference, and integral equations has attracted the attention of researchers from related fields. This Special Session is devoted to the broad research areas involving Boundary Value Problems (BVPs) of Nonlinear Differential, Difference, and Integral Equations. The study of nonlinear BVPs for Ordinary Differential Equations (ODEs), Partial Differential Equations (PEDs), Fractional Differential Equations (FDEs), and their integral and discrete counterparts in the form of Difference Equations has a long history and wide applications in Sciences, Engineering, social activities, and natural phenomenon. Especially, BVPs for fractional-order differential equations have attracted more and more interests and achieved significant improvements recently partly due to their new applications in Finance, Physics, control theory, econometrics, signal processing and deep learning neural networks. We are interested in the most recent advancement of theory, techniques, and applications of Boundary Value Problems.

Existence and uniqueness of solutions for integral equations in b-metric and generalized b-metric spaces

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Schedule: December 19 13:00-13:30 Conference Hall B (D)

Wenying Feng
Trent University Durham GTA
Canada

Co-Author(s): Christopher Middlebrook and Wenying Feng

Abstract:
We study fixed point theorems of contractive mappings in b-metric space, cone b-metric space, and the newly introduced extended b-metric space. To generalize an existence and uniqueness result for the so-called Φ_s functions in the b-metric space to the extended b-metric space and the core b-metric space, we introduced the class of Φ_M functions and applied the H\older continuous condition in the extended b-metric space. The obtained results are applied to prove existence and uniqueness of solutions and positive solutions for nonlinear integral equations and fractional boundary value problems. Examples and numerical simulation are given to illustrate the applications.

Differentiation of Solutions of Caputo Boundary Value Problems with Respect to Boundary Data

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Schedule: December 19 8:30-9:00 Conference Hall B (D)

Jeffrey Lyons
The Citadel
USA

Co-Author(s): Jeffrey W. Lyons

Abstract:
Under suitable continuity and uniqueness conditions, solutions of an alpha order Caputo fractional boundary value problem are differentiated with respect to boundary values and boundary points. This extends well-known results for nth order boundary value problems. The approach used applies a standard algorithm to achieve the result and makes heavy use of recent results for differentiation of solutions of Caputo fractional initial value problems with respect to initial conditions and continuous dependence for Caputo fractional boundary value problems.

Asymptotic Analysis of Nonlinear Second Order Differential, Difference and Fractional Differential Equations in the Framework of Regular Variation

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Schedule: December 19 13:30-14:00 Conference Hall B (D)

Jelena Manojlovic
University of Nis, Faculty of Science and Mathematics, Department of Mathematics
Yugoslavia

Abstract:
We present a survey of results that have been obtained over the past years on asymptotic properties of positive solutions of second order nonlinear differential equations

$$y'' = q(t)\Phi_\gamma(y)\,,$$

difference equations

$$\Delta^2 y(n) = q(n)\Phi_\gamma(y(n+1))\,,\ \ n \in \mathbb{N}\,,$$

and Caputo fractional differential equations

$${}^C\mathcal{D}^{\alpha+1} y = q(t)\Phi_\gamma(y)\,,\ \ \alpha \in (0,1)\,,$$

where $\Phi_\gamma(u) = |u|^\gamma \operatorname{sgn} u$, $\gamma > 0$. Frequently, asymptotic analysis of these equations examines cases in which coefficients and/or solutions are close to power functions, in the sense that $q(t)$ is $= t^\varrho$ or $\sim t^\varrho$ or $o(t^\varrho)$ or $\mathcal{O}(t^\varrho)$ as $t \to \infty$. An objective is to emphasize how the concept of regular variation can be used to generalize these power behavior settings and, at the same time, provide quite accurate information about the behavior of solutions. Therefore, it will be shown with the application of theory of regular variation, that all positive increasing and all positive decreasing solutions of these equations are regularly varying, providing the coefficient q is regularly varying, as well as that the asymptotic behavior at infinity of these solutions can be determined explicitly. Another objective is to discuss some analogies and discrepancies between the continuous, discrete and fractional case.

Semi-linear impulsive higher-order coupled systems with generalized impulsive effects

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Schedule: December 19 14:30-15:00 Conference Hall B (D)

Feliz M Minhos
University of Evora
Portugal

Co-Author(s): Gracino Rodrigues

Abstract:

In this talk we present sufficient conditions for the solvability of a second-order coupled system, composed of two differential equations involving different Laplacians applied to fully discontinuous nonlinearities, two-point boundary conditions, and generalized impulsive effects. Applying the lower and upper solutions technique and Schauder`s fixed point theorem, it is obtained as an existence and localization theorem, based on local monotone properties on the nonlinearities and the impulsive functions. \bigskip \textbf{Acknowledgement} This research was supported by national funds through Funda\c{c}\~{a}o para a Ci\^{e}ncia e Tecnologia, FCT, under the project \newline https://doi.org/10.54499/UIDB/04674/2020.

On the effects of density-dependent emigration on ecological models with logistic and weak Allee type growth terms

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Schedule: December 19 9:00-9:30 Conference Hall B (D)

Ratnasingham Shivaji
University of North Carolina at Greensboro
USA

Co-Author(s): A. Acharya, N. Fonseka, J. Goddard, A. Henderson.

Abstract:

We analyze the structure of positive steady states for a population model designed to explore the effects of habitat fragmentation, density dependent emigration, and Allee effect growth. The steady state reaction diffusion equation is: $\begin{cases} -\Delta u = \lambda f(u);\ \Omega\ \frac{\partial u}{\partial \eta} + \gamma\sqrt{\lambda}g(u)u = 0;\ \partial\Omega \end{cases}$ where $f(s) = \frac{1}{a}s(1-s)(a+s)$ can represent either logistic-type growth ($a \geq 1$) or weak Allee affect growth ($a \in (0,1)$), $\lambda, \gamma > 0$ are parameters, Ω is a bounded domain in $\mathbb{R}^N$; $N > 1$ with smooth boundary $\partial\Omega$ or $\Omega = (0,1)$, $\frac{\partial u}{\partial \eta}$ is the outward normal derivative of u, and $g(u)$ is related to the relationship between density and emigration. In particular, we consider three forms of emigration: density independent emigration ($g = 1$), a negative density dependent emigration of the form $g(s) = \frac{1}{1+\beta s}$ and a positive density dependent emigration of the form $g(s) = 1 + \beta s$, where $\beta > 0$ is a parameter representing the interaction strength. We establish existence, nonexistence, and multiplicity results for ranges of λ depending on the choice of the function g. Our existence and multiplicity results are proved via the method of sub-super-solutions and study of certain eigenvalue problems. For the case $\Omega = (0,1)$, we also provide exact bifurcation diagrams for positive solutions for certain values of the parameters a, β and γ via a quadrature method and Mathematica computations. Our results shed light on the complex interactions of density dependent mechanisms on population dynamics in the presence of habitat fragmentation.

Finite-time blow-up in a three-dimensional chemotaxis-May--Nowak model

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Schedule: December 19 14:00-14:30 Conference Hall B (D)

Yuya Tanaka
Department of Mathematical Sciences, Kwansei Gakuin University
Japan

Co-Author(s): Mario Fuest

Abstract:
A chemotaxis-May--Nowak model was introduced as one of epidemic models (e.g. HIV infection) in 2013, and also results on boundedness and finite-time blow-up of solutions were obtained. Moreover, to consider more realistic situations, a modified model was proposed and investigated boundedness of solutions by Fuest (J. Math. Anal. Appl.; 2019; 472; 1729--1740). In this talk we give a result on finite-time blow-up of solutions for the parabolic--elliptic--parabolic version of this model. This is a joint work with Mario Fuest.

Special Session 110 : Evolution Equations with Applications to Control, Mathematical Modeling and Mechanics

Introduction: The session highlights recent developments in evolution problems, their mathematical analysis, optimal control, and real-world applications. The focus is on the theory and modeling of problems leading to partial differential equations, the well-posedness and properties of their solutions, control and optimization, numerical analysis, and their applications in mechanics and physics. The related topics include, but are not limited to, dynamical systems, fixed points, nonconvex and nonsmooth analysis, nonlinear inclusions, and numerical methods. The session welcomes all papers concerned with theoretical development of optimal controls, their computational complexities as well as their applications in all areas of Physical and Social Sciences.

Migrations in epidemiological context-a multiscale point of view

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Schedule: December 16 15:15-15:45 Capital Suite 14

Jacek Banasiak
Lodz University of Technology/University of Pretoria
Poland

Abstract:
Migrations have been a feature of human life since the dawn of humankind. Usually, they are due to external factors such as environmental changes, natural disasters, economic challenges, or wars. They are instrumental in spreading conditions such as epidemic status, prevalent in particular subpopulations, to the global level. Thus, migration models should be coupled with other processes affecting them. In this talk, we focus on metapopulation models coupling infections with migrations and consider cases when migrations occur either at a much lower or much faster rate than the other processes, leading to, respectively, regularly or singularly perturbed systems of differential equations. Using recent results on uniform-in-time asymptotics, we show how to reduce such models to simpler ones without losing salient features of the original dynamics.

Network models for infection dynamics

Schedule: December 16 15:45-16:15 Capital Suite 14

Adam Bloch
Institute of Mathematics, Lodz University of Technology
Poland

Co-Author(s): Jacek Banasiak, Katarzyna Szyma{\`n}ska-D{\k e}bowska

Abstract:
In the talk we present general framework for dynamical systems on networks represented by metric graphs and discuss first steps into application of these models to modelling of infection spread, also in the context of armed conflicts. The research is partially supported by the polish National Center of Science grant 2023/05/Y/ST6/00263 Modeling and Forecasting of Infection Spread in War and Post War Settings Using Epidemiological, Behavioral and Genomic Surveillance Data.

A priori estimates for anisotropic systems

Schedule: December 16 13:00-13:30 Capital Suite 14

Maria-Magdalena Boureanu
University of Craiova, Romania
Romania

Co-Author(s): Alejandro Velez-Santiago

Abstract:
We study anisotropic systems with variable exponents involving Leray-Lions type operators not only in the interior of the domain, but also on the boundary. To justify the study of such general systems, we provide multiple examples of operators satisfying our hypotheses. Our goal is to deduce the existence, the uniqueness, and the global regularity of the weak solution. All these results were recently obtained in a joint work with Alejandro V\`elez\,-\,Santiago.

Set-valued Young integrals and their properties

Schedule: December 16 13:30-14:00 Capital Suite 14

Mariusz Michta
University of Zielona Gora
Poland

Co-Author(s): Jerzy Motyl

Abstract:
In the talk we present new types of set-valued integrals which establish a generalization of a single-valued Young integral. In a single-valued case the Young integral has been used in a wide range of applications, in particular, one can consider stochastic integration and stochastic equations concerning non-semimartingale integrators such as the Mandelbrot fractional Brownian motion which has Holder continuous sample paths. Thus it seems reasonable to investigate Young-type integrals for multivalued functions and their applications to differential inclusions driven by such new types of integrals. In the presentation, we shall establish properties of different types of set-valued Young integrals for classes of set-valued functions being Holder continuous or with bounded p-variations. These properties are crucial in the studies of different types of Young differential inclusions.

References

1. M. Michta, J. Motyl, Selection properties and set-valued Young integrals of set-valued functions, Results Math. 75, 164 (2020).

2. M. Michta, J. Motyl, Set-valued functions of bounded generalized variation and set-valued Young integrals, J. Theor. Probab. 35 (2022), 528-549.

3. M. Michta, J. Motyl, Solution sets for Young differential inclusions, Qual. Theory Dyn. Syst. 22, 132 (2023).

4. M. Michta, J. Motyl, Properties of set-valued Young integrals and Young differential inclusions generated by sets of Holder functions, Nonlinear Differ. Equ. Appl. 31, article no 70 (2024).

Constrained quasi-variational-hemivariational inequalities with applictions

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Schedule: December 16 12:30-13:00 Capital Suite 14

Stanislaw Migorski
Jagiellonian University in Krakow, Faculty of Mathematics and Computer Science, Chair of Optimization and Control
Poland

Abstract:
In the talk a class of elliptic quasi-variational-hemivariational inequalities with constraints is examined. The existence of solutions and compactness of the solution set is proved. The upper semicontinuity property of the solution set with respect to a parameter appearing in the data is also established. Then, the results are applied to the stationary incompressible Navier-Stokes equation with mixed multivalued boundary conditions which model a generalized Newtonian fluid of Bingham-type. The corresponding boundary value problem involves a nonmonotone version of the slip condition of frictional type described by the Clarke subgradient law with a locally Lipschitz potential and an implicit obstacle constraint set. Finally, within the framework of optimal control, a double minimization problem for the fluid model is studied and the existence of its solution is established.

Solution sets of Young differential inclusions

Schedule: December 16 14:00-14:30 Capital Suite 14

Jerzy Motyl
University of Zielona Gora
Poland

Co-Author(s): Mariusz Michta

Abstract:
In the talk we investigate the problem of the existence and properties of solution sets of two types of differential inclusions with Aumann and Young set-valued integrals, presented in their integral form

$$x(t) - x(s) \in \int_s^t F(\tau, x(\tau))d\tau + \int_s^t cl_{\mathcal{C}}(\mathcal{H} \circ x)(\tau)dg(\tau), \ \ x(0) = x_0$$

and

$$x(t) - x(s) \in \int_s^t F(\tau, x(\tau))d\tau + \int_s^t G(\tau, x(\tau))dg(\tau), \ \ x(0) = x_0.$$

The existence of solutions, boundedness, compactness of the set of solutions and continuous dependence type results are considered. The obtained results are applied to some optimality problems driven by Young differential inclusions. The properties of optimal solutions and their reachable sets are discussed. These inclusions contain as a particular case set-valued stochastic inclusions with respect to fractional Brownian motion (fBm), and therefore, their properties are crucial for investigation the properties of solutions of (fBm) stochastic differential inclusions. The controlled cancer tumor growth model under the influence of drugs will be presented also.

References

[1] M. Michta, J. Motyl, Selection Properties and Set-Valued Young Integrals of Set-Valued Functions, Results Math. {\bf 75}, 164 (2020).

[2] M. Michta, J. Motyl, Set-Valued Functions of Bounded Generalized Variation and Set-Valued Young Integrals, J. Theor. Probab. {\bf 35}, 528--549 (2022).

[3] M. Michta, J. Motyl, Solution Sets for Young Differential Inclusions, Qual. Theory Dyn. Syst. {\bf 22}, 132 (2023).

[4] M. Michta, J. Motyl, Properties of set-valued Young integrals and Young differential inclusions generated by sets of H\older functions, Nonlinear Differ. Equ. Appl., Vol. 31, art. no. 70, 1--33, published online June 4, 2024 https://doi.org/10.1007/s00030-024-00963-2

Finite-time synchronization for fuzzy shunting inhibitory cellular neural networks

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Schedule: December 16 17:30-18:00 Capital Suite 14

Zhangir Nuriyev
Nazarbayev University
Kazakhstan

Co-Author(s): Alfarabi Issakhanov, Jurgen Kurths, Ardak Kashkynbayev

Abstract:
Finite-time synchronization (FTS) is a critical problem in the study of neural networks. The primary objective of this study was to construct feedback controllers for various models based on fuzzy shunting inhibitory cellular neural networks (FSICNNs) and find sufficient conditions for the solutions of those systems to reach synchronization in finite time. In particular, by imposing global assumptions of Lipschitz continuous and bounded activation functions, we prove the existence of FTS for three FSICNN models. In general, we consecutively explore models of regular delayed FSICNNs and then consider them in the presence of either inertial or diffusion terms. Using criteria derived by means of the maximum-value approach in its different forms, we give an upper bound of the time up to which synchronization is guaranteed to occur in all three FSICNN models. These results are supported by 2D and 3D computer simulations and two respective numerical examples for 2×2 and 2×3 cases, which show the behaviour of the solutions and errors under different initial conditions of FSICNNs in the presence and absence of designed controllers.

Time-dependent variational-hemivariational inequalities with applications

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Schedule: December 16 17:00-17:30 Capital Suite 14

Anna Ochal
Jagiellonian University
Poland

Co-Author(s): Anna Kulig (Jagiellonian University in Krakow, Poland)

Abstract:
In the talk a class of time-dependent variational-hemivariational inequalities is studied. The existence and uniqueness of a solution are proved. Then, the convergence result for a penalized form of the problem is provided. Finally, the results are applied to a quasistatic frictional contact problem for locking materials.The contact is modeled with friction and a nonsmooth multivalued interface law. The law involves unilateral constraints and subdifferential conditions.

Geometric Approach to Stability of Sets in Differential Inclusions with Maximally Monotone Operators

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Schedule: December 16 18:00-18:30 Capital Suite 14

Hassan Saoud
Gulf University for Science and Technology
Kuwait

Co-Author(s): Minh Dao, Michel Thera

Abstract:
Stability analysis of differential inclusions governed by maximally monotone operators presents significant challenges, especially when focusing on sets rather than isolated equilibria. Traditional methods often require explicit solutions or specific assumptions that may not be feasible. This talk addresses these issues by exploring pointwise asymptotic stability (PAS) and semistability. The approach involves splitting the operator into a convex upper-semicontinuous (CUSCO) mapping and a normal cone, simplifying the problem and allowing for a thorough examination of stability. By using nonsmooth Lyapunov pairs and proximal analysis, this method avoids many traditional assumptions, making the results more widely applicable. This framework extends stability analysis to a broader range of dynamic systems, even when explicit solutions are not available.

Modeling the spread of infection during war

Schedule: December 16 16:15-16:45 Capital Suite 14

Katarzyna Szymanska-Debowska
Institute of Mathematics Lodz University of Technology
Poland

Abstract:
We consider a deterministic model to study the impact of war on the dynamics of viral disease transmission. The starting point is the classical susceptible-infectious-recovered model, which can be enriched with additional classes, for example: contaminated environment, hospitalized persons, vaccinations, limited medical resources.

Divergence-Free Randomized Neural Networks for Solving Incompressible Magnetohydrodynamics Equations

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Schedule: December 16 14:45-15:15 Capital Suite 14

Fei Wang
Xi`an Jiaotong University
Peoples Rep of China

Co-Author(s): Yunlong Li

Abstract:
The incompressible magnetohydrodynamic (MHD) equations are extensively utilized in scientific and engineering fields, yet their strong nonlinearity and two divergence-free conditions pose significant challenges for conventional numerical methods. In this study, we introduce an automatically and precisely divergence-free approach based on Randomized Neural Networks. This method avoids solving nonconvex and nonlinear optimization problems during training, maintains divergence-free properties naturally, and operates as a space-time method. Our proposed approach, named divergence-free randomized neural networks with finite difference method (DF-RNN-FDM), linearizes equations through Picard or Newton iterations, discretizes the problem into a linear system at randomly sampled points across the domain and boundary using the finite difference scheme, and then solves it via a least-square method. We apply this method to solve NS equations, Maxwell equations, and MHD equations. The effectiveness of DF-RNN-FDM is demonstrated by comparison with conventional numerical methods and other neural network-based methods. Our approach achieves higher accuracy with fewer degrees of freedom, simplifies the training process, and precisely adheres to the divergence-free conditions.

Special Session 111 : Partial Differential Equations and Material Sciences

Introduction: The aim of this session is to facilitate academic exchanges and foster cooperation in the theory of partial differential equations and applied mathematics. By bringing together researchers from diverse backgrounds, we aim to promote the integration of cross-disciplinary research on partial differential equations and material sciences. Through this platform, we seek to enhance mutual understanding among peers and facilitate the sharing of scientific research and knowledge.

Bruun-Minkowski Inequalities in Some Variational Problems

Schedule: December 17 17:00-17:30 Conference Hall B (D)

Meiyue Jiang
School of Mathematical Sciences, Peking University
Peoples Rep of China

Co-Author(s): Meiyue Jiang

Abstract:
In this talk, motivated by the Brunn-Minkowski inequalities in convex geometry, we will discuss the Brunn-Minkowski type inequalities in variational problems related to some nonlinear elliptic equations.

Properties of ground states for two-component attractive Bose-Einstein condensates

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Schedule: December 17 18:00-18:30 Conference Hall B (D)

Xiaoyu Zeng
Wuhan University of Technology
Peoples Rep of China

Abstract:
In this talk, we study a system of two coupled time-independent Gross-Pitaevskii equations, which is used to model two-component Bose-Einstein condensates with attractive interactions. For a certain type of trapping potentials, especially for the degenerate ring-shaped potentials, we investigate the existence, concentration and local uniqueness of ground states.

Optimal higher derivative estimates for solutions of the Lam\` e system with closely spaced hard inclusions

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Schedule: December 17 18:30-19:00 Conference Hall B (D)

Peihao Zhang
Beijing Normal University
Peoples Rep of China

Co-Author(s): Hongjie Dong; Haigang Li; Huaijun Teng

Abstract:
We study the higher derivative estimates for the Lam\` e system with hard inclusions embedded in a bounded domain in $\mathbb{R}^d$. The stress in the narrow regions between two closely spaced hard inclusions significantly increases as ε, the distance between inclusions, approaches to 0. The stress is represented by the gradient of the solution. The novelty of this paper is that to fully characterize this singularity, we derive higher derivative estimates for solutions to the Lam\` e system with partially infinite coefficients. These upper bounds are shown to be sharp in dimensions two and three when the domain exhibits certain symmetry. To the best of our knowledge, this work is the first to quantify precisely this singular behavior of the higher derivatives for the Lam\` e system with hard inclusions.

Some results on Kirchhoff type elliptic equation on $\mathbb{R}^N$

Schedule: December 17 17:30-18:00 Conference Hall B (D)

Huan-Song Zhou
Wuhan University of Technology
Peoples Rep of China

Co-Author(s): H L Guo, X Y Zeng, Y M Zhang, L F Weng and X Zhang

Abstract:
We are concerned with certain nonlinear Schrodinger equations involving Kirchhoff type nonlocal term. The existence and concentration behavior of L^2-normalized solutions for the equations are discussed. Moreover, due to the presence of Kirchhoff type nonlocal term in the equations, it is well known that some strong growth conditions on the nonlinear terms of the equations are required when we seek a mountain pass solution (i.e., a solution obtained by using mountain pass theorem), in this talk we will show that there is a way to get a mountain pass solution for a Kirchhoff type elliptic equation under the usual growth condition on the nonlinear term. The work was supported by NSFC.

Special Session 112 : Controllability and Stabilization of Partial Differential Equations

Introduction: In recent years, important progresses have been made in the control theory of partial differential equations (PDEs). The aim of this special session is to share the most advanced developments and challenges in this filed. We hope to provide a platform for the experts and young researchers to present their latest research results and address key issues related to two fundamental topics (i.e. controllability and stabilization) of various types of PDEs. Some challenging open problems are expected to be discussed in this section.

Controllability for parabolic equations with large parameters.

Schedule: December 18 15:15-15:45 Capital Suite 11 B

Felipe W. Chaves-Silva
Federal University of Paraiba
Brazil

Co-Author(s): N. Carreno & M. G. Ferreira-Silva

Abstract:
We consider a parabolic equation perturbed by an anomalous diffusion term scaled by a large parameter. We study the cost of null controllability for the system as the parameter goes to infinity and, using spectral analysis, show that is possible to construct null controls that exhibit exponential decay with respect to the parameter. Additionally, we construct uniform controls for some nonlinear versions as well.

Null Controllability of Nonlinear Wave Equations

Schedule: December 18 14:00-14:30 Capital Suite 11 B

Yan Cui
Jinan University
Peoples Rep of China

Co-Author(s): Peng Lu, Yi Zhou

Abstract:
In this talk, we mainly introduce the controllability of several types of nonlinear wave equations. Firstly, by using the Galerkin method, we obtain the null controllability of a class of semilinear wave equations. Secondly, based on the Picard iteration method, we establish the local null controllability of a class of quasilinear equations. The talk is based on joint work with Peng Lu and Yi Zhou.

Feedback stabilization of entropy solutions to the p-system at a junction

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Schedule: December 18 17:30-18:00 Capital Suite 11 B

Nicola N De Nitti
EPFL
Switzerland

Co-Author(s): G. M. Coclite, M. Garavello, F. Marcellini.

Abstract:
We consider the p-system in Eulerian coordinates on a star-shaped network. Under suitable transmission conditions at the junction and dissipative boundary conditions in the exterior vertices, we show that the entropy solutions of the system are exponentially stabilizable. Our proof extends the strategy by Coron et al. (2017) and is based on a front-tracking algorithm used to construct approximate piecewise constant solutions whose BV norms are controlled through a suitable exponentially-weighted Glimm-type Lyapunov functional. This talk is based on a joint work with G. M. Coclite, M. Garavello, and F. Marcellini.

Minimal control time for the internal exact controllability of 1D linear hyperbolic balance laws

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Schedule: December 18 14:45-15:15 Capital Suite 11 B

Long Hu
Shandong University
Peoples Rep of China

Co-Author(s): Guillaume Olive

Abstract:
In this talk, we are concerned with the internal exact controllability of 1D linear hyperbolic balance laws when the number of controls is equal to the number of state variables. The controls are supported in space in an arbitrary nonempty open subset. The necessary and sufficient conditions will be proposed in order to characterize the minimal control time for such systems. This talk is based on a joint work with Guillaume Olive.

Disturbance rejection approaches of Korteweg-de Vries-Burgers equation under event-triggering mechanism

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Schedule: December 18 16:15-16:45 Capital Suite 11 B

Wen Kang
Beijing Institute of Technology
Peoples Rep of China

Co-Author(s): Wen Kang, Jing Zhang, Jun-Min Wang

Abstract:
In this talk, disturbance rejection approaches are suggested to stabilize Korteweg-de Vries-Burgers (KdVB) equation under the averaged measurements. Here two approaches-active disturbance rejection control (ADRC) and disturbance observer-based control (DOBC), are introduced to reject the external unknown disturbance actively. The main challenging issue is to design the effective extended state observer (ESO)/disturbance observer (DO) for KdVB equation respectively. As for ADRC strategy, the disturbance is rejected on the basis of an ESO. As for DOBC strategy, a DO is constructed to estimate the disturbance formulated by an exogenous system. Continuous-time and event-triggered anti-disturbance controllers are further presented for distributed stabilization of KdVB system. To significantly reduce the amount of control updates, an event-triggering mechanism is utilized and the Zeno behaviour is avoided. Sufficient stability conditions are established via Lyapunov functional method. The effectiveness of proposed approaches is verified by simulation results.

Null controllability of underactuated linear parabolic-transport system

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Schedule: December 18 12:30-13:00 Capital Suite 11 B

Pierre Lissy
Ecole nationales des ponts et chaussees
France

Co-Author(s): Armand Koenig

Abstract:
I will present controllability properties of mixed systems of linear parabolic-transport equations, with possibly nondiagonalizable diffusion matrix, on the 1D torus, coupled by constant coupling terms. The distributed control acts through a constant matrix, with possibly less controls than equations. In small time or for not regular enough initial data, these systems are never controllable, whereas in large time, null-controllability holds, for regular initial data, iff a spectral Kalman rank condition is verified.

Global controllability of the Boussinesq system by using a degenerate temperature control

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Schedule: December 18 13:00-13:30 Capital Suite 11 B

Vahagn Nersesyan
NYU Shanghai
Peoples Rep of China

Co-Author(s): Manuel Rissel

Abstract:
We will prove that the 2D incompressible Boussinesq system on the torus is globally approximately controllable via physically localized control appearing only in the temperature equation. In addition, our controls have an explicitly prescribed structure; even without such structural requirements, large data controllability results for Boussinesq flows driven merely by a physically localized temperature profile were so far unknown. The presented method exploits various connections between the model`s underlying transport-, coupling-, and scaling mechanisms. This is a joint work with Manuel Rissel (NYU Shanghai).

Second-Order Necessary Conditions for Stochastic Optimal Control Problems with Final Point Constraints

Schedule: December 18 13:30-14:00   Capital Suite 11 B

Haisen Zhang
School of Mathematical Science, Sichuan Normal University
Peoples Rep of China

Abstract:
We establish some second-order necessary conditions for optimal control problems of stochastic differential equations with final points constraints. Both the drift and the diffusion terms of the control systems can contain the control variable, and the control regions are allowed to be nonconvex. The classical variational analysis approach and the inverse mapping theorem are used to derive those second-order necessary conditions.

Stability Analysis of an Abstract System with Local Damping

Schedule: December 18 17:00-17:30   Capital Suite 11 B

Qiong Zhang
Beijing Institute of Technolog
Peoples Rep of China

Co-Author(s): Chenxi Deng, Otared Kavian

Abstract:
We consider an abstract system of the type $u_{tt} + Lu + Bu_t = 0$, where L is a self-adjoint operator on a Hilbert space and operator B represents the local damping. By establishing precise estimates on the resolvent, we prove polynomial decay of the corresponding semigroup. The results reveal that the rate of decay depends strongly on the concentration of eigenvalues of operator L and non-degeneration of operator B. Finally, several examples are given as application of our abstract results.

Output regulation for a 1-D wave equation with velocity recirculation and disturbances

Schedule: December 18 15:45-16:15   Capital Suite 11 B

Hua-Cheng Zhou
Central South University
Peoples Rep of China

Abstract:
In this talk, we consider the output regulation problem for a 1-D wave equation with velocity recirculation where the disturbances in all possible channels of the wave equation and the reference signal are generated from an unknown finite-dimensional exosystem. An adaptive error-based observer is proposed to effectively estimate all unknown frequencies, and based on this, a tracking-error-based feedback control is designed to regulate the output to the reference signal exponentially. This talk is based on a joint work with Fanggang Hu.

Special Session 113 : New Achievements in Nonlinear PDEs and Applications

Introduction: The purpose of this special session is to bring together researchers working in nonlinear PDEs related to variational problems, particularly those arising in Mathematical Physics, to present their recent advances. The main topics concern existence, multiplicity, and qualitative aspects of solutions of nonlinear partial differential equations and systems. Throughout the session, special emphasis will be placed on fostering collaboration between leading experts and emerging researchers.

Normalized solutions to the Born-Infeld and related problems

Schedule: December 16 17:30-18:00 Capital Suite 13

Laura Baldelli
University of Granada
Spain

Co-Author(s): Jaroslaw Mederski, Alessio Pomponio

Abstract:
It is well known that in the classical Maxwell electromagnetic theory the so called infinite energy problem appears: the energy of the electrostatic field generated by a point charge is infinite. In the early years of the last century, Born and Infeld proposed to solve such a problem by introducing a nonlinear modification of Maxwell`s theory. The aim of this talk is therefore to introduce the Born-Infeld equation and to present some recent existence results concerning normalized solutions for a large class of operators by means of variational methods.

Travelling waves for nonlinear Schrodinger equations

Schedule: December 16 18:00-18:30 Capital Suite 13

Bartosz Bieganowski
University of Warsaw
Poland

Co-Author(s): Laura Baldelli, Jaroslaw Mederski

Abstract:
We look for travelling wave solutions to the nonlinear Schrodinger equation with a subsonic speed, covering several physical models with Sobolev subcritical nonlinear effects. Our approach is based on a variant of Sobolev type inequality involving the momentum and we show existence of its minimizers solving the nonlinear Schrodinger equation.

Positive and nodal solutions for a quasi-linear equation depending on the gradient

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Schedule: December 16 18:30-19:00 Capital Suite 13

Francesca Faraci
University of Catania
Italy

Co-Author(s): D. Motreanu, D.Puglisi

Abstract:
In this talk we deal with a quasi-linear elliptic equation depending on a sublinear nonlinearity involving the gradient. Our aim is to combine variational techniques with fixed point theory in order to prove the existence of a positive solution.We prove also the existence of a nontrivial nodal solution employing the theory of invariant sets of descending flow together with sub-supersolution techniques, gradient regularity arguments, strong comparison principle for the p-Laplace operator. Based on the papers F. Faraci, D.Motreanu, D. Puglisi, Quasi-linear elliptic equations with dependence on the gradient, Calc. Var. Partial Differential Equations (2015) and F. Faraci, D. Puglisi, Nodal solutions of p-Laplacian equations depending on the gradient, Proc. Roy. Soc. Edinburgh A (2024).

ON A CLASS OF QUASILINEAR CRITICAL SCHR\H ODINGER EQUATIONS IN $\mathbb{R}^N$

Schedule: December 16 16:15-16:45 Capital Suite 13

Roberta Filippucci
University of Perugia
Italy

Co-Author(s): Laura Baldelli

Abstract:
In this talk, we present multiplicity results, obtained via variational tools, for solutions of generalized quasilinear Schr\H odinger potential free equations, also in the singular case, defined in the entire $\mathbb{R}^N$ and involving a nonlinearity which combines a power-type term at a critical level with a subcritical term, both with weights. The equation can be seen as models of several physical phenomena in plasma physics.

Poincare-Sobolev equations with the critical exponent and a potential in the hyperbolic space

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Schedule: December 16 15:45-16:15 Capital Suite 13

DEBDIP GANGULY
Indian Institute of Technology Delhi
India

Co-Author(s): Mousomi Bhakta, Diksha Gupta, A.K.Sahoo

Abstract:
In this talk, I will discuss the following Poincare-Sobolev-type equation $-\Delta_{\mathbb{H}}{}^{N} u - \lambda u = a(x)|u|^{p-1}\, u \;\; \text{in } \mathbb{B}^N, \quad u \in H^1(\mathbb{B}^N)$, where $\mathbb{B}^N$ denotes the hyperbolic space, 16 in the critical case, whereas in the subcritical case, we use the min-max procedure in the spirit of Bahri-Li in the hyperbolic space and using a series of new estimates involving interacting hyperbolic bubbles.

On a classification of steady solutions to two-dimensional Euler equations

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Schedule: December 16 14:45-15:15 Capital Suite 13

Changfeng Gui
University of Macau
Macau

Co-Author(s): Chunjing Xie, Huan Xu

Abstract:
In this talk, I shall provide a classification of steady solutions to two-dimensional incompressible Euler equations in terms of the set of flow angles. The first main result asserts that the set of flow angles of any bounded steady flow in the whole plane must be the whole circle unless the flow is a parallel shear flow. In an infinitely long horizontal strip or the upper half-plane supplemented with slip boundary conditions, besides the two types of flows appeared in the whole space case, there exists an additional class of steady flows for which the set of flow angles is either the upper or lower closed semicircles. This type of flows is proved to be the class of non-shear flows that have the least total curvature. As consequences, we obtain Liouville-type theorems for two-dimensional semilinear elliptic equations with only bounded and measurable nonlinearity, and the structural stability of shear flows whose all stagnation points are not inflection points, including Poiseuille flow as a special case. Our proof relies on the analysis of some quantities related to the curvature of the streamlines. This talk is based on a joint work with Chunjing Xie and Huan Xu.

On Calderon-Zygmund theory for the p-Laplacian

Schedule: December 16 17:00-17:30 Capital Suite 13

Armin Schikorra
University of Pittsburgh
USA

Abstract:
Calderon-Zygmund theory for the Laplace equation is among the most classical results in Harmonic Analysis. It was conjectured by Iwaniec in 1983 that an analogue theory holds for the p-Laplace. I will discuss how to disprove this conjecture.

Least energy sign-changing solution for degenerate Kirchhoff double phase problems

Schedule: December 16 19:00-19:30 Capital Suite 13

Patrick Winkert
University of Technology Berlin
Germany

Co-Author(s): \`{A}ngel Crespo-Blanco, Leszek Gasi\`{n}ski

Abstract:
In this talk, we present existence and multiplicity results for Kirchhoff Dirichlet equations of double phase type with right-hand sides that grow superlinearly and subcritically. We prove the existence of two constant sign solutions (one is positive, the other one negative) and of a sign-changing solution which turns out to be a least energy sign-changing solution. Our proofs are based on variational tools in combination with the quantitative deformation lemma and the Poincar\`{e}-Miranda existence theorem. This is a joint work with \`{A}ngel Crespo-Blanco (Berlin) and Leszek Gasi\`{n}ski (Krakow).

Special Session 114 : New developments in Analysis of Mathematical Fluid Dynamics

Introduction: This special session aims to present a platform for experts, researchers, together with creative collaborations to present their latest work in partial differential equations arising in fluid dynamics. It focuses on existence and uniqueness, long-time behaviors, stability and instability, free boundary problems, etc for incompressible and compressible Navier-Stokes equations, and related physical models. We hope that this session can cast on a lasting impact on the future of the field and the research impact of the session topics will be significant for all our participants.

Stability of Stationary Solutions to the Nonisentropic Euler--Poisson System in a Perturbed Half Space

Schedule: December 19 8:00-8:30 Capital Suite 6

Mingjie LI
Minzu University of China
Peoples Rep of China

Co-Author(s): Masahiro Suzuki

Abstract:
The main concern of the talk is to mathematically investigate the formation of a plasma sheath near the surface of nonplanar walls. We study the existence and asymptotic stability of stationary solutions for the nonisentropic Euler-Poisson equations in a domain of which boundary is drawn by a graph, by employing a space weighted energy method. Moreover, the convergence rate of the solution toward the stationary solution is obtained, provided that the initial perturbation belongs to the weighted Sobolev space. Because the domain is the perturbed half space, we first show the time-global solvability of the nonisentropic Euler-Poisson equations, then construct stationary solutions by using the time-global solutions. This is a joint work with Professor Masahiro Suzuki.

Asymptotic stability for n-dimensional magnetohydrodynamic equations

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Schedule: December 19 8:30-9:00 Capital Suite 6

Jitao Liu
Beijing University of Technology
Peoples Rep of China

Abstract:
This talk is concerned with the stability theory of n-dimensional incompressible and compressible magnetohydrodynamic ({\it MHD for short}) equations with only kinematic viscosity or magnetic diffusion in the periodic domain {{\mathbb{T}}^n}. I will present some new results on the asymptotic stability and sharp decay estimates of this system when the magnetic field close to an equilibrium state satisfying the Diophantine condition. In the present works, by exploiting and effectively utilizing the structure of perturbation system, a new dissipative mechanism is found out and applied so that we can sharply improve the spaces of existing works, where the decay estimates and asymptotic stability of solutions are taking place. Some key ideas of our method will be discussed. This talk is based on joint works with Quansen Jiu and Yaowei Xie.

Vanishing viscosity limits for the free boundary problem of compressible flows

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Schedule: December 19 9:00-9:30 Capital Suite 6

Yu Mei
Northwestern Polytechnical University
Peoples Rep of China

Abstract:
In this talk, we present some results of vanishing viscosity limits for the free boundary problem of compressible isentropic flows. For the free boundary compressible Navier-Stokes equations of Newtonian fluids with or without surface tension, we established the uniform regularities of solutions in Sobolev conormal and Lipschitz spaces, and justified the vanishing viscosity and surface tension limits by a strong convergence argument. On the other hand, for the free boundary compressible viscoelastic equations of neo-Hookean fluids with or without surface tension, we obtained the uniform Sobolev regularities of solutions and proved the vanishing viscosity limits in Sobolev spaces, which indicates the stabilizing effect of elasticity.

Stability and large-time behavior of nD tropical climate model with zero thermal dissipation

Schedule: December 19 13:00-13:30 Capital Suite 6

Dongjuan Niu
Capital Normal University
Peoples Rep of China

Co-Author(s): Wu, Huiru; Tang, Houzhi

Abstract:
In this talk, we are concerned with stability problem and large- time behavior of 2D and 3D tropical climate model with zero thermal dissipation under small initial data. Specifically, the first one focuses on the global well-posedness and large-time behavior of solutions of the system with the dissipation and part damping in the whole space. The second one investigates the stability problem and the optimal decay rate of 3D tropical climate model with zero thermal dissipation under small initial data. The third one works on the stability near Couette flow to the system with the dissipation and damping in the strip domain.

Isothermal Limit of Entropy Solutions of the Euler Equations for Isentropic Gas Dynamics

Schedule: December 19 13:30-14:00 Capital Suite 6

Tianyi Wang
Wuhan University of Technology
Peoples Rep of China

Abstract:
In this talk, we want to present the isothermal limit of entropy solutions in L^∞, containing the vacuum states, of the Euler equations for isentropic gas dynamics. First, We want to start with the explicit asymptotic analysis of the Riemann solutions containing the vacuum states. Then, we want to show the entropy solutions in L^∞ of the isentropic Euler equations converge strongly to the corresponding entropy solutions of the isothermal Euler equations, when the adiabatic exponent $\gamma \to 1$. This is achieved by combining careful entropy analysis and refined kinetic formulation with compensated compactness argument to obtain the required uniform estimates for the limit. The entropy analysis involves careful estimates for the relation between the corresponding entropy pairs for the isentropic and isothermal Euler equations when the adiabatic exponent $\gamma \to 1$. The kinetic formulation for the entropy solutions of the isentropic Euler equations with the uniformly bounded initial data is refined, so that the total variation of the dissipation measures in the formulation is locally uniformly bounded with respect to $\gamma > 1$. This is the joint work with Gui-Qiang G. Chen, and Fei-Min Huang.

Time-periodical solution to compressible Euler Equation

Schedule: December 19 14:00-14:30 Capital Suite 6

Huimin Yu
Shandong Normal University
Peoples Rep of China

Co-Author(s): Peng Qu and Xiaomin Zhang

Abstract:
In this talk, we will discuss some recent work on the time-periodical solutions of compressible Euler equations with damping or geometric effects. We will focus on the solutions triggered by time periodic boundary conditions. Firstly, the steady states are analyzed. Then, the existence, stability and uniqueness of the supersonic/subsonic temporal periodic solutions around the steady states are given. Finally, the time periodic transonic shock will be discussed.

Incompressible limit of viscous vortex sheets with large data

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Schedule: December 19 14:30-15:00 Capital Suite 6

Qian Yuan
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Qian Yuan, Wenbin Zhao

Abstract:
In this talk, we shall discuss the incompressible limit of vortex sheets for the Navier-Stokes equations with ill-prepared initial data. The results are valid for all time and in addition, there are not any smallness assumptions on the background vortex sheets, as well as some components of the initial perturbations.

Special Session 115 : Computational Techniques Using Fast Fourier Transformation (FFT) for Partial Differential Equations

Introduction: This session explores the application of Fast Fourier Transforms (FFTs) in solving Partial Differential Equations (PDEs). We will examine recent advancements in FFTs, share research findings, and foster collaboration in enhancing PDE solutions. Topics include theoretical underpinnings, practical applications, efficient parallel computations, and computational approaches. Participants will gain valuable insights into the practical use of FFTs in PDE solutions and their broader implications for computational PDE techniques in mathematical modeling.

Advancements in FFT Techniques: A Focus on My Publications

Schedule: December 20 15:30-16:00 Capital Suite 12 A

Samar Aseeri
King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): Benson Muite & David Keyes

Abstract:
This presentation will focus on my publications related to Fast Fourier Transforms (FFTs) and their applications in solving Partial Differential Equations (PDEs). I will discuss significant advancements in parallel FFT techniques and benchmarking practices, showcasing how these contributions enhance the efficiency and accuracy of complex PDE solutions. By sharing insights from my research, I aim to foster collaboration and knowledge exchange among participants. Attendees will gain a deeper understanding of the implications of FFT methodologies in computational techniques and mathematical modeling.

Utilizing Network Delays for Modeling Physical Propagation in HPC

Schedule: December 20 15:00-15:30 Capital Suite 12 A

Anando G Chatterjee
Indian Institute of Technology Kanpur
India

Abstract:
A common trend in high-performance computing (HPC) is the effort to minimize network delays to enhance performance. However, in compressible fluids, disturbances originating in one region propagate through the medium at the speed of sound, with other regions evolving independently until the disturbance reaches them. Similarly, in HPC environments, signals travel across the network at the speed of electromagnetic waves (i.e., the speed of light). In this work, we explore an approach that draws an analogy between these two systems by intentionally mapping the physical propagation delays to the network delays. This novel perspective seeks to align computation with communication delays, leveraging the inherent latency of the network rather than eliminating it, thus optimizing both system behavior and performance.

Spectral methods for nonlinear dispersive equations

Schedule: December 20 14:00-14:30 Capital Suite 12 A

Christian Klein
University of Burgundy
France

Co-Author(s): N. Stoilov

Abstract:
Nonlinear dispersive equations are omnipresent in applications in hydrodynamics, nonlinear optics, plasma physics,... but their mathematical description is challenging since they can have stable solitary waves, but also zones of rapid modulated oscillations called dispersive shock waves and even a blow-up, a loss of regularity in finite time. For the numerical description spectral methods are the preferred choice since they minimise the introduction of numerical dissipation which could suppress the dispersive effects to be studied. For smooth rapidly decreasing or periodic functions, FFT techniques are preferred. But we will also discuss spectral methods, for instance Chebyshev polynomials, for slowly decaying or piecewise smooth functions. Several examples are discussed, also for fractional derivatives.

Implementation of Parallel 3-D Real FFT with 2-D Decomposition on Manycore Clusters

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Schedule: December 20 14:30-15:00 Capital Suite 12 A

Daisuke Takahashi
University of Tsukuba
Japan

Co-Author(s): Daisuke Takahashi

Abstract:
In this talk, we propose an implementation of parallel three-dimensional real fast Fourier transforms (FFTs) with two-dimensional decomposition on manycore clusters. The proposed parallel three-dimensional FFT algorithm is based on the conjugate symmetry property for the discrete Fourier transform (DFT) and the multicolumn FFT algorithm. We show that a two-dimensional decomposition effectively improves performance by reducing the communication time for larger numbers of MPI processes. We also present a computation-communication overlap method that introduces a communication thread with OpenMP. Performance results of three-dimensional real FFTs on manycore clusters are reported.

Special Session 116 : Stochastic computing and structure preserving methods

Introduction: Stochastic computing has shown increasingly broad and profound cross-integration with other important branches within mathematics and other disciplines outside mathematics, resulting in a series of new methods and new research directions. This session focuses on numerical methods and simulations for stochastic (partial) differential equations, including but not limited to stochastic structure preserving methods, stochastic ergodic methods, convergence analysis, etc., and aims to provide participants with opportunities to showcase new achievements and exchange new ideas.

Exponential bounds for the density of the law of the solution of a SDE with locally Lipschitz coefficients

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Schedule: December 20 8:00-8:30 Capital Suite 6

Cristina Anton
MacEwan University
Canada

Abstract:
Under the uniform Hormander`s hypothesis we study smoothness and exponential bounds of the density of the law of the solution of a stochastic differential equation (SDE) with locally Lipschitz drift that satisfy a monotonicity condition. We obtain estimates for the Malliavin covariance matrix and its inverse, and to avoid non-integrability problems we use results about Malliavin differentiability based on the concepts of Ray Absolute Continuity and Stochastic Gateaux differentiability.

Diffusion model for generative learning

Schedule: December 20 8:30-9:00 Capital Suite 6

Yanzhao Cao
Auburn University
USA

Co-Author(s): Feng Bao, Guanan Zhang

Abstract:
Abstract: We present a supervised learning framework for training generative models for density estimation. Generative models, including generative adversarial networks, normalizing flows, and variational auto-encoders, are usually considered unsupervised learning models because labeled data are generally unavailable for training. Despite the success of the generative models, there are several issues with unsupervised training, e.g., the requirement of reversible architectures, vanishing gradients, and training instability. We utilize the score-based diffusion model to generate labeled data to enable supervised learning in generative models. Unlike existing diffusion models that train neural networks to learn the score function, we develop a training-free score estimation method. This approach uses mini-batch-based Monte Carlo estimators to directly approximate the score function at any spatial-temporal location in solving an ordinary differential equation (ODE) corresponding to the reverse-time stochastic differential equation (SDE). This approach can offer high accuracy and substantial time savings in neural network training. Both algorithm development and convergence analysis will be presented.

Superiority of stochastic symplectic methods via the law of iterated logarithm

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Schedule: December 20 9:00-9:30 Capital Suite 6

Xinyu Chen
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Chuchu Chen, Tonghe Dang, Jialin Hong

Abstract:
The superiority of stochastic symplectic methods over non-symplectic counterparts has been verified by plenty of numerical experiments, especially in capturing the asymptotic behaviour of the underlying solution process. This talk aims to theoretically investigate the superiority from the perspective of the law of iterated logarithm, taking the linear stochastic Hamiltonian system in Hilbert space as a test model. Based on the time-change theorem for martingales and the Borell--TIS inequality, we first prove that the upper limit of the exact solution with a specific scaling function almost surely equals some non-zero constant, thus confirming the validity of the law of iterated logarithm. Then, we prove that stochastic symplectic fully discrete methods asymptotically preserve the law of iterated logarithm, but non-symplectic ones do not. This reveals the good ability of stochastic symplectic methods in characterizing the almost sure asymptotic growth of the utmost fluctuation of the underlying solution process. Applications of our results to the linear stochastic oscillator and the linear stochastic Schr\{o}dinger equation are also presented.

A supervised learning scheme for computing Hamilton--Jacobi equation via density coupling

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Schedule: December 20 14:00-14:30 Capital Suite 6

Jianbo Cui
Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Shu Liu and Haomin Zhou

Abstract:
We propose a supervised learning scheme for the first order Hamilton--Jacobi PDEs in high dimensions. The scheme is designed by using the geometric structure of Wasserstein Hamiltonian flows via a density coupling strategy. It is equivalently posed as a regression problem using the Bregman divergence, which provides the loss function in learning while the data is generated through the particle formulation of Wasserstein Hamiltonian flow. We prove a posterior estimate on L1 residual of the proposed scheme based on the coupling density. Furthermore, the proposed scheme can be used to describe the behaviors of Hamilton--Jacobi PDEs beyond the singularity formations on the support of coupling density. Several numerical examples with different Hamiltonians are provided to support our findings.

Long-time strong convergence of one-step methods for McKean-Vlasov SDEs with non-globally Lipschitz continuous coefficients

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Schedule: December 20 14:30-15:00 Capital Suite 6

Siqing Gan
Central South University
Peoples Rep of China

Abstract:
This talk focuses on strong error analysis for long-time approximations of McKean-Vlasov SDEs with super linear growth coefficients. Under certain non-globally Lipschitz conditions, the propagation of chaos over infinite time is derived. The long-time mean-square convergence theorem is then established for general one-step methods. As applications of the obtained convergence theorem, the mean-square convergence rate of two numerical schemes such as the split-step backward Euler method and the projected Euler method is investigated. Numerical examples are finally provided to validate our theoretical findings.

Numerical approximation of the invariant measure for a class of stochastic damped wave equations

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Schedule: December 20 15:00-15:30 Capital Suite 6

Ziyi Lei
Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Charles-Edouard Brehier, Siqing Gan

Abstract:
We study a class of stochastic semilinear damped wave equations driven by additive Wiener noise. Owing to the damping term, under appropriate conditions on the nonlinearity, the solution admits a unique invariant distribution. We apply semi-discrete and fully-discrete methods in order to approximate this invariant distribution, using a spectral Galerkin method and an exponential Euler integrator for spatial and temporal discretization respectively. We prove that the considered numerical schemes also admit unique invariant distributions, and we prove error estimates between the approximate and exact invariant distributions, with identification of the orders of convergence. To the best of our knowledge, this is the first result in the literature concerning numerical approximation of invariant distributions for stochastic damped wave equations.

A second-order Langevin sampler preserving positive volume for isothermal-isobaric ensemble

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Schedule: December 20 15:30-16:00 Capital Suite 6

Lei Li
Shanghai Jiao Tong University
Peoples Rep of China

Abstract:
We propose a second-order Langevin sampler for the isothermal-isobaric ensemble (the NPT ensemble) for molecular simulations, preserving a positive volume for the simulation box throughout the simulation. The equations of motion are obtained by taking the cell mass to zero in the equations in our previous work. We show the well-posedness of the new system of equations. Choosing a suitable friction, the equation for the volume can be converted into an SDE with additive noise, based on which we design the second-order scheme.

Long-time weak convergence analysis of a semi-discrete scheme for stochastic Maxwell equations

Schedule: December 20 16:15-16:45 Capital Suite 6

Ge Liang
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Chuchu Chen, Jialin Hong

Abstract:
In this talk, we focus on investigating the weak convergence of the implicit Euler scheme for stochastic Maxwell equations on the infinite time horizon. Based on the properties of the Maxwell operator, we first analyze the regularities of transformed Kolmogorov equation associated to the stochastic Maxwell equations. Then by constructing an adapted continuous auxiliary process of the implicit Euler scheme, we prove that the long-time weak convergence order of the scheme is one, which is twice the strong convergence order. At last, we give some applications of the weak convergence result. This is a joint work with Prof. Chuchu Chen and Prof. Jialin Hong.

The stochastic scalar auxiliary variable approach for stochastic nonlinear Klein--Gordon equation

Schedule: December 20 16:45-17:15 Capital Suite 6

Liying Sun
Capital Normal University
Peoples Rep of China

Co-Author(s): Jianbo Cui, Jialin Hong, Liying Sun

Abstract:
In this talk, we propose and analyze energy-preserving numerical schemes for the stochastic nonlinear wave equation.These numerical schemes, called stochastic scalar auxiliary variable (SAV) schemes, are constructed by transforming the considered equation into a higher dimensional stochastic system with a stochastic SAV. We prove that they can be solved explicitly, and preserve the modiified energy evolution law and the regularity structure of the original system. These structure-preserving properties are the keys to overcoming the mutual effect of noise and nonlinearity. By providing new regularity estimates of the introduced SAV, we obtain the strong convergence rate of stochastic SAV schemes under Lipschitz conditions. Furthermore, based on the modified energy evolution laws, we derive the exponential moment bounds and sharp strong convergence rate of the proposed schemes for equation with a non-globally Lipschitz nonlinearity in the additive noise case. To the best of our knowledge, this is the first result on the construction and strong convergence of semi-implicit energy-preserving schemes for stochastic nonlinear wave equations.

Asymptotic error distribution for the Euler scheme of stochastic delay differential equation with locally Lipschitz coefficients

Schedule: December 20 17:15-17:45 Capital Suite 6

Fuke Wu
Huazhong University of Science and Technology
Peoples Rep of China

Co-Author(s): Huagui Liu, Ya Wang

Abstract:
This paper primarily concentrates on Euler schemes for stochastic delay differential equations (SDDEs) with locally Lipschitz coefficients. The convergence in probability and the weak limit process of the normalized error process are derived. Furthermore, this paper consider a specific degenerate stochastic system and obtain the associated weak limit process. In contrast to ``non-degenerate`` systems considered earlier, the normalized error parameter of such degenerate systems is n instead of \sqrt{n}. This caused some challenges, as there are additional terms in the weak limit process. These results are new even for stochastic differential equations without delay.

A new class of splitting methods that preserve ergodicity and exponential integrability for stochastic Langevin equation

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Schedule: December 20 17:45-18:15 Capital Suite 6

Fengshan Zhang
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Chuchu Chen, Tonghe Dang, Jialin Hong

Abstract:
In this talk, we propose a new class of splitting methods to solve the stochastic Langevin equation, which can simultaneously preserve the ergodicity and exponential integrability of the original equation. The central idea is to extract a stochastic subsystem that possesses the strict dissipation from the original equation, which is inspired by the inheritance of the Lyapunov structure for obtaining the ergodicity. We prove that the exponential moment of the numerical solution is bounded, thus validating the exponential integrability of the proposed methods. Further, we show that under moderate verifiable conditions, the methods have the first-order convergence in both strong and weak senses, and we present several concrete splitting schemes based on the methods. The splitting strategy of methods can be readily extended to construct conformal symplectic methods and high-order methods that preserve both the ergodicity and the exponential integrability, as demonstrated in numerical experiments. Our numerical experiments also show that the proposed methods have good performance in the long-time simulation. This work was completed in collaboration with Chuchu Chen, Tonghe Dang and Jialin Hong.

Strong Stability Preserving Multistep Schemes for FBSDEs

Schedule: December 20 18:15-18:45 Capital Suite 6

Weidong Zhao
Shandong University
Peoples Rep of China

Co-Author(s): Shuixin Fang, Tao Zhou

Abstract:
This talk concerns with strong stability preserving (SSP) multistep schemes for forward backward stochastic differential equations (FBSDEs). We first perform a comprehensive analysis on a general type of multistep schemes for FBSDEs, then we present new sufficient conditions on the coefficients such that the associated schemes are stable and enjoy certain order of consistency. Upon these results, we propose a practical way to design high-order SSPM schemes for FBSDEs. Some numerical experiments are carried out to show the merits of our SSP multist schemes.

Special Session 117 : Advances on nonlinear elliptic PDEs

Introduction: This special session aspires to present some recent trends and progress in the analysis of PDEs such as existence and nonexistence results as well as a priori estimates and qualitative properties of solutions, like symmetry, monotonicity, uniqueness, and regularity by exploiting different, variational and non-variational, methods of nonlinear analysis. Among the participants, who are experts in the PDEs field, we aim to build a profitable exchange of ideas, results and applications to various branches of applied sciences.

Nonlinear scalar field $(p1, p2)$-Laplacian equations in $\mathbb{R}^N$: existence and multiplicity

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Schedule: December 17 14:45-15:15 Capital Suite 12 B

Vincenzo Ambrosio
Universita' Politecnica delle Marche
Italy

Abstract:
In this talk, we focus on the following class of $(p1, p2)$-Laplacian problems:

$$\{ -\Delta_{p1} u - \Delta_{p2} u = g(u) \text{ in } \mathbb{R}^N, \; u \in W^{1,p1}(\mathbb{R}^N) \cap W^{1,p2}(\mathbb{R}^N),$$

where $N \geq 2$, 1<$p1$<$p2 \leq N$, Δ_{p_i} is the p_i-Laplacian operator for $i = 1, 2$, and $g : \mathbb{R} \to \mathbb{R}$ is a Berestycki-Lions type nonlinearity. Using appropriate variational arguments, we obtain the existence of a ground state solution. In particular, we provide three different approaches to deduce this result. Finally, we prove the existence of infinitely many radially symmetric solutions. Our results improve and complement those that have appeared in the literature for this class of problems.

Existence results for quasilinear Choquard equations in $\mathbb{R}^N$

Schedule: December 17 17:00-17:30 Capital Suite 12 B

Giuseppina Autuori
Universita` Politecnica delle Marche
Italy

Co-Author(s): Vincenzo Ambrosio, Teresa Isernia

Abstract:
In this talk I will present some existence results for quasilinear Choquard equations driven by the p-Laplacian operator including a C^1 nonlinearity G, in $\mathbb{R}^N$. Assuming \textit{Berestycki--Lions} type conditions on G, we prove the existence of ground state solutions $u \in W^{1,p}(\mathbb{R}^N)$ by means of variational methods. Moreover, we establish some qualitative properties of the solutions when G is even and non--decreasing. The talk is based on a joint work with Vincenzo Ambrosio and Teresa Isernia.

Fractional Schrodinger equations with mixed nonlinearities

Schedule: December 17 15:45-16:15 Capital Suite 12 B

Mousomi Bhakta
Indian Institute of Science Education and Research Pune (IISER Pune)
India

Co-Author(s): Paramananda Das, Debdip Ganguly

Abstract:
In this talk I will discuss fractional Schr\"odinger equations with a vanishing parameter, namely

$$(-\Delta)^s u + u = |u|^{p-2}u + \lambda |u|^{q-2}u \text{ in } \mathbb{R}^N, \quad u \in H^s(\mathbb{R}^N),$$

where $s \in (0,1)$, $N > 2s$, $2 < q < p \leq 2_s^* = \frac{2N}{N-2s}$ are fixed parameters and $\lambda > 0$ is a vanishing parameter. We investigate the asymptotic behavior of positive ground state solutions for λ small, when p is subcritical, or critical Sobolev exponent 2_s^*. For $p < 2_s^*$, the ground state solution asymptotically coincides with unique positive ground state solution of $(-\Delta)^s u + u = u^p$, whereas for $p = 2_s^*$ the asymptotic behavior of the solutions, after a rescaling, is given by the unique positive solution of the nonlocal critical Emden-Fowler type equation. Additionally, for $\lambda > 0$ small, we will discuss the uniqueness and nondegeneracy of the positive ground state solution using these asymptotic profiles of solutions.

Multiplicity of solutions to stronglu indefinite problems with sign-changing nonlinearities

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Schedule: December 17 17:30-18:00 Capital Suite 12 B

Bartosz Bieganowski
University of Warsaw
Poland

Co-Author(s): Federico Bernini, Daniel Strzelecki

Abstract:
We will present an abstract critical point theory that allows to study the multiplicity of critical points of strongly indefinite functionals with sing-changing nonlinear part. We are going to apply it to nonlinear Schrodinger-type equations that appear e.g. in nonlinear optics.

Limiting cases in Choquard type equations and Schroedinger-Poisson systems

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Schedule: December 17 12:30-13:00 Capital Suite 12 B

Daniele Cassani
University of Insubria & RISM
Italy

Abstract:
Quantitative and qualitative informations on nonlinear Schr\odinger equations strongly coupled with Poisson`s equation can be derived from nonlocal Choquard type equations. Limiting cases appear when the underlying function space setting is not well defined for the equation, as a consequence of the limiting Sobolev emedding which provides logarithmic kernels competing with exponential nonlinearities. We present two possible approaches to overcome this difficulty. The first one by establishing a suitable weighted Trudinger-Moser type inequality which eventually yields a proper functional setting. Alternatively, one can exploit a uniform approximation of the $\log$-kernel and then pass to the limit in the approximating equations. Both methods reveal new aspects which throw some light on the problem.

Special wave forms for a generalized semilinear wave equation

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Schedule: December 17 13:30-14:00 Capital Suite 12 B

Julia Henninger
KIT Karlsruhe
Germany

Co-Author(s): Wolfgang Reichel, Sebastian Ohrem

Abstract:
We study the generalized semilinear wave equation
$V(x)u_{tt} - d(t)M(x,\partial_x)u - V(x)|u|^{p-1}u = 0 \quad \text{for} \quad (x,t) \in \mathbb{R}^N \times \mathbb{R}$ where M is elliptic and d is a positive potential. Our goal is to construct solutions which are localized in space and/or time by means of variational methods. We present our approach with its main difficulties and discuss suitable examples for M and d. This is joint work with Sebastian Ohrem and Wolfgang Reichel.

Least energy solutions for nonlinear fractional Choquard-Kirchhoff equations in $\mathbb{R}^N$

Schedule: December 17 16:15-16:45 Capital Suite 12 B

Teresa Isernia
Universita` Politecnica delle Marche
Italy

Co-Author(s): Vincenzo Ambrosio, Letizia Temperini

Abstract:
In this talk, we will consider the following fractional Choquard--Kirchhoff equation

$$\left(a+b\iint_{\mathbb{R}^{2N}}\frac{|u(x)-u(y)|^2}{|x-y|^{N+2s}}\,dxdy\right)(-\Delta)^s u+u=(I_\alpha * F(u))\,F'(u) \quad \text{in } \mathbb{R}^N,$$

where $N \geq 2$, $a, b > 0$ are constants, $(-\Delta)^s$ is the fractional Laplacian operator of order $s \in (0,1)$, I_α is the Riesz potential of order $\alpha \in ((N-4s)^+, N)$, $F \in C^1(\mathbb{R},\mathbb{R})$ is a general nonlinearity of Berestycki--Lions type. Applying suitable variational methods, we analyze the existence of ground state solutions, along with the regularity, symmetry, and decay properties of these solutions.

Some recent results on normalized solutions for $(2,q)$-Laplacian equations

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Schedule: December 17 18:30-19:00 Capital Suite 12 B

Chao Ji
East China University of Science and Technology
Peoples Rep of China

Abstract:
In this talk, we will introduce some recent results on on normalized solutions for $(2,q)$-Laplacian equations. Specifically, we will explore the existence and multiplicity of normalized solutions to a class of $(2,q)$-Laplacian equations in the strongly sublinear regime, and provide existence and multiplicity of normalized solutions for $(2,q)$-Laplacian equations with the mixed nonlinearities.

On some doubly critical elliptic systems

Schedule: December 17 14:00-14:30 Capital Suite 12 B

Rafael Lopez-Soriano
Universidad de Granada
Spain

Abstract:
We will consider a type of cooperative nonlinear elliptic system in $\mathbb{R}^N$. The interest of this problem is based on the presence of Sobolev or Sobolev-Hardy critical power nonlinearities and a nonlinear coupling, possibly critical, as well as singular potentials of Hardy type. Using variational methods we will focus on the existence of bound and ground states of the underlying energy functional. Finally, for a certain range of parameters, we derive some qualitative properties and a classification criterion.

Quasilinear Schr\odinger Equation: a bifurcational approach

Schedule: December 17 18:00-18:30 Capital Suite 12 B

Miguel Martinez-Teruel
University of Granada
Spain

Co-Author(s): David Arcoya and Jose Carmona

Abstract:
This talk deals with existence and multiplicity results of positive solutions for the quasilinear Schr\odinger equation \begin{align*} \left\{\begin{array}{c} \displaystyle-\Delta u-\lambda m(x) u\Delta(u^2)=f(\mu,x,u)\text{ in }\Omega, \ u=0\text{ on }\partial\Omega. \end{array}\right. \end{align*} where Ω is a bounded open domain in $\mathbb{R}^N$ with smooth boundary and m is bounded positive continuous function. Under suitable assumptions on f and asymptotically linear behaviour, we can use bifurcation theory in order to give an analysis on the set of positive solutions.

Travelling waves for Maxwell`s equations in nonlinear and symmetric media

Schedule: December 17 13:00-13:30 Capital Suite 12 B

Jaroslaw Mederski
Institute of Mathematics, Polish Academy of Sciences
Poland

Co-Author(s): Jacopo Schino

Abstract:
We look for travelling wave fields satisfying Maxwell equations in a nonlinear and cylindrically symmetric medium. We obtain a sequence of solutions with diverging energy. The solutions represent the so-called TM-modes.

The problem of prescribing non-constant curvatures in a disk

Schedule: December 17 15:15-15:45 Capital Suite 12 B

Francisco Javier Reyes Sanchez
Universidad de Granada
Spain

Co-Author(s): Rafael Lopez Soriano and David Ruiz

Abstract:
In this talk we outlines a general existence result regarding the prescription of curvatures on a disk under conformal changes of the metric. This problem is equivalent to solving a nonlinear partial differential equation with nonlinear Neumann boundary conditions. We addresses the case of negative Gaussian curvature. As a preliminary step, we focus on a symmetric setting. Additionally, we present a non-existence result, demonstrating that the assumptions for existence are necessary. This is a work in collaboration with Rafael Lopez Soriano and David Ruiz from the University of Granada.

Special Session 118 : Recent advances in mathematical finance

Introduction: This session will concentrate on the recent applications of dynamic modelling and random processes theory to important problems in mathematical finance. Specifically, this session will feature recent contributions and advancements from both a mathematical perspective as well as in applications. Mainly focusing on mathematical statistics, partial differential and integro-partial differential equations, computational and stochastic optimization, machine learning techniques, discrete mathematics and approximation theory. Applied finance topics will include derivatives pricing, dynamic portfolio optimization, quantitative asset-liability management, risk capital allocation problems, risk modelling and management, dynamic mean-field games in economics and finance, and various others.

Irreversible Capital Accumulation with Economic Impact

Schedule: December 18 15:15-15:45 Capital Suite 3

Hessah Al-Motairi
Kuwait University
Kuwait

Co-Author(s): Mihail Zervos

Abstract:
\begin{abstract} We consider an irreversible capacity expansion model in which additional investment has a strictly negative effect on the value of an underlying stochastic economic indicator. The associated optimisation problem takes the form of a singular stochastic control problem that admits an explicit solution. A special characteristic of this stochastic control problem is that changes of the state process due to control action depend on the state process itself in a proportional way. \end{abstract}

Investments in Mining Farms under Uncertainty: Real Options Approach

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Schedule: December 18 17:00-17:30 Capital Suite 3

Ahmed alqubaisi
khalifa university
United Arab Emirates

Co-Author(s): Ahmed Alqubaisi, Yerkin Kitabpayev

Abstract:
This paper tackles the problem of optimal stopping on building a Bitcoin mining farm based on the real options framework. The framework uses the LSM method to value the spread option between stochastic Bitcoin and electricity price. Bitcoin prices and electricity prices are simulated for a farm in Texas and the option valuation framework is studied over time for a given project lifetime. We present option values for different scenarios for Bitcoin and electricity while also back-testing the model.

Optimal hedging of the interest rate swap book

Schedule: December 18 8:30-9:00 Capital Suite 3

Jorgen Blomall
Linkoping university
Sweden

Abstract:
With an optimization model interest rate curves are measured with increased accuracy from Overnight Index Swaps. Principal Component Analysis identifies the significant risk factors in interest rate markets. With these a Stochastic Programming model is formulated to determine the optimal hedge of the Overnight Index Swap book, where significant improvements are found relative to traditional delta hedging.

Dynamic portfolio risk budgeting through reinforcement learning

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Schedule: December 18 17:30-18:00 Capital Suite 3

Giorgio Consigli
Khalifa University of Science and Technology
United Arab Emirates

Co-Author(s): Sanabel Bisharat, Alvaro Gomez

Abstract:
In an early paper we have studied the correspondence between second order interval stochastic dominance (ISD-2) and interval conditional value-at-risk (ICVaR), a tail risk measure carrying specific properties and generalizing the popular conditional value-at-risk. Relying on the ICVaR, in this paper we present a reinforcement learning approach to solve a trade-off problem based on one side on a risk parity paradigm and on the other on an ICVaR function enforcing second order dominance with respect to a benchmark strategy. The bi-criteria objective helps clarifying the risk-budgeting implications induced by a progressive switch from risk parity towards SD against the benchmark for portfolio construction in a dynamic model. We consider a 1-year investment problem with an asset universe, or decision space of the problem, based on exchange traded funds (ETF) and market benchmarks spanning different risk classes. An extended in- and out-of-sample validation is performed on market data with a discussion on the computational properties of the problem.

Deep prediction and XAI on Financial Market Sequence for Enhancing economic policies

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Schedule: December 18 12:30-13:00 Capital Suite 3

Massimiliano Ferrara
University Mediterranea of Reggio Calabria
Italy

Co-Author(s): Massimiliano Ferrara

Abstract:
Numerous sectors are greatly impacted by the quick advancement of image and video processing technologies. Investors can make informed investment decisions based on the analysis and projection of ffnancial market income, and the government can create accurate policies for various forms of economic control. This study uses an artiffcial rabbits optimization algorithm in image processing technology to examine and forecast the returns on ffnancial markets and various indexes using a deep learning LSTM network. To successfully record the regional correlation properties of ffnancial market data, this research uses the time series technique. Convolution pooling in LSTM is then used to gather signiffcant details hidden in the time series data, generate the data`s trend curve, and incorporate the features using technology for image processing to ultimately arrive at the prediction of the ffnancial sector`s moment series earnings index. A popular kind of artiffcial neural network used in time series analysis is the Long Short-Term Memory (LSTM) network. By processing data with numerous input and output timesteps, it can accurately forecast ffnancial market prices. The correctness of ffnancial market predictions can be increased by optimizing the hyperparameters of an LSTM model using metaheuristic algorithms like the Artiffcial Rabbits Optimization Algorithm (ARO). This research presents the development of an optimized deep LSTM network with the ARO model (LSTM-ARO) for stock price prediction. The research`s deep learning system for ffnancial market series prediction is efffcient and precise, according to the ffndings. Technologies for data analysis and image processing offer useful approaches and signiffcantly advance the study of ffnance.

Price Formation Models with Common Noise: A Variational Approach

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Schedule: December 19 8:00-8:30 Capital Suite 3

Diogo Gomes
KAUST
Saudi Arabia

Co-Author(s): Majid Almarhoumi, Julian Gutierrez, Ricardo Ribeiro

Abstract:
In this work, we investigate price formation models under the influence of common noise, where agents continuously trade a commodity in a stochastic environment. The model incorporates stochastic supply dynamics and agent preferences, aiming to determine a market-clearing price that balances supply and demand. By employing a variational formulation, we derive a system of stochastic partial differential equations (SPDEs) that govern the price evolution, agent behavior, and asset distribution. We highlight key results, including the decoupling of variance dynamics in the quadratic case and the implications for market equilibrium.

Finite Element Method for HJB in Option Pricing with Stock Borrowing Fees

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Schedule: December 18 9:30-10:00 Capital Suite 3

Rakhymzhan Kazbek
Astana IT University
Kazakhstan

Co-Author(s): Aidana Abdukarimova

Abstract:
In mathematical finance, many derivatives from markets with frictions can be formulated as optimal control problems in the HJB framework. Analytical optimal control can result in highly nonlinear PDEs, which might yield unstable numerical results. Accurate and convergent numerical schemes are essential to leverage the benefits of the hedging process. In this study, we apply a finite element approach with a non-uniform mesh for the task of option pricing with stock borrowing fees, leading to an HJB equation that bypasses analytical optimal control in favor of direct PDE discretization. The time integration employs the theta-scheme, with initial modifications following Rannacher`s procedure. A Newton-type algorithm is applied to address the penalty-like term at each time step. Numerical experiments are conducted, demonstrating consistency with a benchmark problem and showing a strong match. The CPU time needed to reach the desired results favors P2-FEM over FDM and linear P1-FEM, with P2-FEM displaying superior convergence. This paper presents an efficient alternative framework for the HJB problem and contributes to the literature by introducing a finite element method (FEM)-based solution for HJB applications in mathematical finance.

A Coupled Optimal Stopping Approach to Pairs Trading over a Finite Horizon

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Schedule: December 18 16:15-16:45 Capital Suite 3

Yerkin Kitapbayev
Khalifa University
United Arab Emirates

Abstract:
We study the problem of trading a mean-reverting price spread over a finite horizon with transaction costs and an unbounded number of trades. Modeling the price spread by the Ornstein-Uhlenbeck process, we formulate a coupled optimal stopping problems to determine the optimal timing to switch positions. We analyze the corresponding free-boundary system for the value functions. Our solution approach involves deriving a system of Volterra-type integral equations that uniquely characterize the boundaries associated with the optimal timing decisions. These integral equations are used to numerically compute the optimal boundaries. Numerical examples are provided to illustrate the optimal trading boundaries and examine their sensitivity with respect to model parameters.

An exploration of different machine learning algorithms for financial forecasting in crypto markets

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Schedule: December 18 13:00-13:30 Capital Suite 3

Davide La Torre
SKEMA Business School, Cote d`Azur University
France

Co-Author(s): Filippo Dal Lago, Charles Webb, Jan Broekaert, Faizal Hafiz

Abstract:
In this talk, we will explore the challenge of forecasting Bitcoin price movements over various horizons - 1, 7, 14, and 30 days - from two perspectives: computer science and trading. We evaluated three distinct models: Support Vector Machines (SVM), Random Forest (RF), and Multi-Layer Perceptron (MLP). We begin with an overview of the current state of financial forecasting using machine learning, highlighting key findings from previous studies and the limitations they faced. The computer science segment will detail our rigorous approach to the problem, starting with the dataset construction and the features included. We will outline a data preparation pipeline for training the models, followed by a forecasting algorithm designed to train, evaluate, and optimize hyperparameters for the three models. Our findings will reveal that SVM exhibited superior predictive capabilities. In the trading section, we will discuss how we leveraged the SVM forecasts to create a long-only trading strategy. This part will demonstrate that while the SVM performs well in theory, it can also be applied to develop a potentially profitable trading strategy in practice. Join us to discover how these insights contribute to the intersection of machine learning and trading in the cryptocurrency market.

An optimal stopping problem for variable annuities

Schedule: December 18 9:00-9:30 Capital Suite 3

Alessandro Milazzo
University of Turin
Italy

Co-Author(s): T. De Angelis and G. Stabile.

Abstract:
Variable annuities are life-insurance contracts designed to meet long-term investment goals. Such contracts provide several financial guarantees to the policyholder. A minimum rate is guaranteed by the insurer in order to protect the policyholder`s capital against market downturns. Moreover, the policyholder has the right to early terminate the contract (early surrender) and to receive the account value. In general, a penalty, which decreases in time, is applied by the insurer in case of early surrender. We provide a theoretical analysis of variable annuities with a focus on the holder`s right to an early termination of the contract. We obtain a rigorous pricing formula and the optimal exercise boundary for the surrender option. We also illustrate our theoretical results with extensive numerical experiments. The pricing problem is formulated as an optimal stopping problem with a time-dependent payoff, which is discontinuous at the maturity of the contract. This structure leads to non-monotone optimal stopping boundaries, which we prove nevertheless to be continuous. Because of this lack of monotonicity, we cannot use classical methods from optimal stopping theory and, thus, we contribute a new methodology for non-monotone stopping boundaries.

The Boltzmann Equation in Finance

Schedule: December 19 8:30-9:00 Capital Suite 3

Giulio Occhionero
Al Ramz PSJC
United Arab Emirates

Co-Author(s): Michele Bogliardi, Zoubida Charif Khalifi, Yerkin Kitapbayev, Miquel Noguer Alonso, Giulio Occhionero, and Jorge P Zubelli

Abstract:
This article seeks to bypass the reliance on the Kolmogorov Partial Differential Equations (PDEs) typically rooted in Markov stochastic processes by proposing a more flexible formula to represent different functions of random variables. This novel framework will result in the formulation of integro-differential and integro-difference equations, also referred to as Boltzmann equations, in the space of probability distributions. This approach offers greater flexibility as it governs several kinds of stochastic processes, including cases of both diffusion and concentration. Additionally, this framework allows for the derivation of the probability distribution of the price of a European contingent claim at maturity.

Optimal trading with regime switching: Numerical and analytic techniques applied to valuing storage in an electricity balancing market

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Schedule: December 18 14:45-15:15 Capital Suite 3

David Zoltan Szabo
Corvinus University of Budapest
Hungary

Co-Author(s): Paul Johnson, Peter Duck

Abstract:
Accurately valuing storage in the electricity market recognizes its role in enhancing grid flexibility, integrating renewable energy, managing peak loads, providing ancillary services and improving market efficiency. In this paper we outline an optimal trading problem for an Energy Storage Device trading on the electricity balancing (or regulating) market. To capture the features of the balancing (or regulating) market price we combine stochastic differential equations with Markov regime switching to create a novel model, and outline how this can be calibrated to real market data available from NordPool. By modelling a battery that can be filled or emptied instantaneously, this simplifying assumption allows us to generate numerical and quasi analytic solutions. We implement a case study to investigate the behaviour of the optimal strategy, how it is affected by price and underlying model parameters. Using numerical (finite-difference) techniques to solve the dynamic programming problem, we can estimate the value of operating an Energy Storage Device in the market given fixed costs to charge or discharge. Finally we use properties of the numerical solution to propose a simple quasi-analytic approximation to the problem. We find that analytic techniques can be used to give a benchmark value for the storage price when price variations during the day are relatively small.

No-arbitrage perturbations of implied volatility

Schedule: December 18 8:00-8:30 Capital Suite 3

Michael Tehranchi
University of Cambridge
England

Abstract:
Possible shapes of the implied volatility smile are constrained by the absence of static arbitrage. For the sake of generating stress-testing scenarios, it is useful to consider prices after a perturbation of an observed implied volatility smile. However, some perturbations (for example, parallel shifts and scalings) do not respect the no-arbitrage constraints. A family of admissible perturbations is proposed.

Special Session 120 : Congestion Games on Networks and the Price of Anarchy: Theory and Applications

Introduction: The special session deals with games on networks, network equilibrium and the price of anarchy, with their various applications, where decisions/behaviors of agents depend on the actions of their peers. This area has witnessed recent breakthroughs and advances related to the optimal flow distribution on congested networks; the study of the price of anarchy in congestion games on networks; the analysis of network game dynamics and its long-term behavior; the mean-field games in the study of traffic and pedestrian flows; and the price of anarchy in multi-agent learning. The session will focus on connections between network games, dynamical systems, optimization, and learning dynamics in games on networks. The main topics include, but not limited to: evolutionary game dynamics and Wardrop optimal networks, with applications in neural networks and learning; mean-field games on networks and Wardrop-Nash equilibria; congestion games and the price of anarchy; dynamic network games with applications to transportation, communication, social and economic, and neural networks. By bringing together specialists working in Dynamic Network Games field, we want to stimulate and initiate future developments and possible collaborations in this active field of study lying at the intersection of game theory, network dynamics and optimization, multi-agent learning and dynamical systems.

Traditional selfish routing models in network flow

Schedule:

Ovidiu O Bagdasar
University of Derby
England

Abstract:
Traditional selfish routing models in network flow typically focus on a single objective, such as travel time or distance, and are guided by the principle of user equilibrium (UE). However, real-world scenarios demand the consideration of multiple objectives, such as distance, travel time, and pollution. This paper addresses a bi-criteria problem where individual road users aim to minimize their travel time, conflicting with the collective objective of minimizing total fuel consumption. By adjusting `free` parameters, specifically speed limits, we explore how user behavior can be influenced to align better with the fuel consumption objective. Inspired by the Price of Anarchy (PoA) concept, which measures the suboptimality of equilibrium based on minimum total travel time, we classify equilibrium solutions using a weighted model that balances travel time and fuel consumption. Our results indicate that modest parameter adjustments can yield Pareto-improving solutions, demonstrating that while our equilibrium suboptimality measure reveals network inefficiencies, it may not fully capture solution quality when comparing different network configurations.

Discrete-time replicator equations on Wardrop optimal transport networks

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Schedule: December 19 17:30-18:00

Armen Bagdasaryan
American University of the Middle East
Kuwait

Co-Author(s): Mansur Saburov

Abstract:
In this talk, we consider a novel field of application of replicator dynamics by proposing the discrete-time replicator equations for studying optimal transport networks with congestion. We first introduce the concept of a Wardrop optimal network that admits Wardrop optimal flows that are both Nash equilibrium and system optimum, and are the only networks with the price of anarchy exactly equal to its least value of 1. Then we present a novel dynamical model of optimal flow distribution on Wardrop optimal networks, using the ideas of evolutionary game theory, which unlike the classical game theory, focuses on the dynamics of strategy change. Our dynamical model is based on discrete-time mean-field replicator equations defined over probability simplices, generated by nonlinear order-preserving mappings. In particular, we study replicator dynamics induced by convex differentiable functions and Schur-convex potential functions. As examples, we employ complete symmetric functions, gamma functions, and symmetric gauge functions in generating replicator dynamics. We analyze the dynamic behavior of these systems, focusing on convergence and stability properties. Using techniques from dynamical systems theory, including Lyapunov functions, we examine Nash equilibria, convergence to fixed points, and conditions for asymptotic stability. For the replicator equations under consideration, the Nash equilibrium, the Wardrop equilibrium, and the system optimum coincide, thus representing the same point in the state space. Certain affine and nonlinear deformations of networks that preserve the property of Wardrop optimality and stochastic method of the construction of Wardrop optimal networks will be presented.

Mean-Field Game Multi-Population Opinion Dynamics Model

Schedule: December 19 18:00-18:30

Tigran Bakaryan
Institute of Mathematics NAS of RA, Center For Scientific Innovation and Education
Armenia

Co-Author(s): Ishkanuhi Hakobyan, Yuliang Gu, Xianjin Yang, Naira Hovakimyan

Abstract:
This work presents a scalable and accurate multi-population opinion dynamics model aimed at understanding how interactions within populations lead to consensus, polarization, or fragmentation. Scalability and accuracy are achieved by leveraging group affiliations to define agent similarities, integrating both individual- and group-level interactions. The dual nature of the proposed method enables the examination of micro-level (individual) interactions and macro-level (group) dynamics, providing insights into the reciprocal influence between individual behaviors and group dynamics. Moreover, a corresponding mean-field game (MFG) model is also considered, leading to the examination of a coupled system of MFG equations. We prove the existence of solutions to the MFG model and provide numerical experiments capturing complex social phenomena.

Exact Solutions to Stationary Mean-Field Games on Networks

Schedule: December 19 18:30-19:00

Ricardo L Ribeiro
KAUST
Saudi Arabia

Co-Author(s): Fatimah Al Saleh, Tigran Bakaryan, Diogo A. Gomes

Abstract:
In this talk, I will present a recursive algorithm developed to solve stationary critical congestion mean-field games (MFGs) on networks. These games model scenarios where a large number of agents move through a network -- such as transportation systems -- seeking to minimize costs based on their actions and the congestion created by others. The MFG formulation leads to an algebraic system consisting of linear equations, inequalities, and complementarity conditions. The algorithm I will discuss handles the complexity of the problem. We implement preprocessing steps that reduce the system\`s size and complexity, along with a custom approach for managing the combinatorial challenges at key network nodes. However, the recursive nature of the algorithm introduces some limitations, particularly with regard to scalability. I will illustrate the algorithm\`s performance using several case studies, including road merges and forks, and a real-world scenario inspired by the Jamarat bridge during the Hajj pilgrimage. Finally, if time permits, I will discuss the challenges posed by non-critical congestion cases and explore future directions for improving the algorithm\`s efficiency and applicability.

Special Session 121 : Recent developments on nonlinear geometric PDEs

Introduction: The applications of partial differential equations (PDEs) to a wide variety of geometry related problems arising in both pure mathematics and applied sciences have been largely studied in the past years. The aim of this section is to present recent progress in PDEs from geometric perspectives and to bring together researchers who are interested in this field.

A mean field approach for the double curvature prescription problem

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Schedule: December 19 14:00-14:30 Capital Suite 1

Luca Battaglia
Universita degli Studi Roma Tre
Italy

Co-Author(s): Rafael Lopez-Soriano

Abstract:
We establish a new mean field-type formulation to study the problem of prescribing Gaussian and geodesic curvature on compact surfaces, which is equivalent to a Liouville-type PDE with nonlinear Neumann conditions. We provide three different existence results in the case of positive, zero and negative Euler characteristics.

Rigidity results for critical elliptic equations

Schedule: December 19 13:30-14:00 Capital Suite 1

Giovanni G Catino
Politecnico di Milano
Italy

Abstract:
In this talk I will present some classification results for positive solutions to some classical critical elliptic equations in the Riemannian and sub-Riemannian setting. These are joint works with D.D. Monticelli, A. Roncoroni (Politecnico di Milano), Y.Y. Li (Rutgers University) and X. Wang (Michigan State University).

Sharp quantitative estimates of the Yamabe problem

Schedule: December 19 17:30-18:00 Capital Suite 1

Haixia Chen
Hanyang University
Korea

Co-Author(s): Seunghyeok Kim

Abstract:
In this talk, I will discuss the sharp quantitative stability estimates for nonnegative functions near the solution set of the Yamabe problem on a smooth closed Riemannian manifold (M, g) of dimension $N \geq 3$ which is not conformally equivalent to $\S^N$. For $3 \leq N \leq 5$, our result is consistent with the result of Figalli and Glaudo (2020) on $\S^N$. In the case of $N \geq 6$, we investigate the single-bubbling phenomenon on generic Riemannian manifolds (M, g). Surprisingly, numerological (specifically, the dimension N) and geometric effects occur in such a way that they may cause the sharp exponent to become much less than 1.This exhibits a striking difference from the result of Ciraolo, Figalli, and Maggi (2018) on $\S^N$. This work is in collaboration with Seunghyeok Kim.

Existence and Non-existence results for non-linear elliptic systems involving Hardy potential

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Schedule: December 19 18:00-18:30 Capital Suite 1

Abdelrazek Dieb
University Ibn khaldoun of Tiaret
Algeria

Abstract:
The main goal of this work is to study existence\non-existence of non-negative super-solution to a class of grad systems with Hardy term. More precisely, we consider the system

$$\begin{cases} -\Delta u - \backslash 1 \frac{u}{|x|^2} = f_1(x, v, \nabla v) \quad \text{in } \Omega, \ -\Delta v - \backslash 1 \frac{v}{|x|^2} = f_2(x, u, \nabla u) \quad \text{in } \Omega, \ u = v = 0 \quad \text{or} \end{cases}$$

where $\Omega \subset \mathbb{R}^N$, $N \geq 3$, is a bounded regular domain such that $0 \in \Omega$. Here, 01, we prove the existence of an opti curve in the $(p,\ q)$-plane, that separates the existence and non-existence regions.

Nonradial solutions to competitive critical elliptic systems in 3d

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Schedule: December 19 14:30-15:00 Capital Suite 1

Antonio J. Fernandez
Universidad Autonoma de Madrid
Spain

Co-Author(s): Maria Medina (Universidad Aut\`onoma de Madrid, Madrid (Spain)); Angela Pistoia (Sapienza Universit\`a di Roma, Roma (Italy))

Abstract:
In this talk, we will see how to construct nonradial positive entire solutions to critical competitive systems in dimension $d = 3$. More precisely, we will see how to use sing-changing entire solutions to the Yamabe equation to construct solutions blowing-up at the vertices of suitable regular polygons. Finally, we will compare our solutions with their counterpart in dimension $d = 4$, revealing some particular features of the $3d$ case.

Uniqueness and nondegeneracy for fractional Dirichlet problems

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Schedule: December 19 13:00-13:30 Capital Suite 1

Isabella Ianni
Sapienza Universita di Roma
Italy

Abstract:
We discuss some recent uniqueness and nondegeneracy results for non-negative solutions of some fractional semilinear problems in bounded domains with Dirichlet exterior condition.\ In particular we consider least energy solutions in balls or in more general symmetric domains, for problems with power nonlinearities. The symmetry properties of the solutions of the associated linearized equation are also investigated. \ The talk is mainly based on the following joint works:\ [1] A. Dieb, I. Ianni, A. Saldana, Uniqueness and nondegeneracy for Dirichlet fractional problems in bounded domains via asymptotic methods, Nonlinear Analysis, 236, 2023; \ [2] A. Dieb, I. Ianni, A. Saldana, Uniqueness and nondegeneracy of least-energy solutions to fractional Dirichlet problems, Calc. Var. PDEs, to appear.

Characterizations of Compactness and Weighted Eigenvalue Problem for Fractional p-Laplacian in $\mathbb{R}^N$

Schedule: December 19 19:00-19:30 Capital Suite 1

Rohit Kumar
Indian Institute of Technology Jodhpur
India

Co-Author(s): Dr. Ujjal Das, Dr. Abhishek Sarkar

Abstract:
The study of Hardy inequalities started in 1925 with a seminal paper by G.H. Hardy. For $s \in (0,1), p \in (1, \frac{N}{s})$ and $w \in L^1_{\text{loc}}(\mathbb{R}^N)$, we study the following fractional Hardy inequality

$$\int_{\mathbb{R}^N} |w(x)||u(x)|^p \,\mathrm{d}x \leq C \iint_{\mathbb{R}^N \times \mathbb{R}^N} \frac{|u(x)-u(y)|^p}{|x-y|^{N+sp}} \mathrm{d}x \mathrm{d}y := \|u\|^p_{s,p}\,,\ \forall u \in \mathcal{D}^{s,p}(\mathbb{R}^N), \tag{FH}$$

for some positive constant $C = C(N,s,p)$ depending on N, s and p only. The space $\mathcal{D}^{s,p}(\mathbb{R}^N)$ is the completion of $C_c^\infty(\mathbb{R}^N)$ with respect to the norm $\|\cdot\|_{s,p}$. The set of all w satisfying (FH) is denoted by $\mathcal{H}_{s,p}(\mathbb{R}^N)$. The space $\mathcal{H}_{s,p}(\mathbb{R}^N)$ admits a Banach function space structure using Maz`ya-type characterization of capacity functions. Our aim is also to look for the least possible constant such that equality holds in (FH) for some $u \in \mathcal{D}^{s,p}(\mathbb{R}^N)$. The attainment of the least possible constant in (FH) depends on the compactness of the map $W(u) = \int_{\mathbb{R}^N} |w||u|^p \,\mathrm{d}x$ on $\mathcal{D}^{s,p}(\mathbb{R}^N)$. The Banach function space structure of $\mathcal{H}_{s,p}(\mathbb{R}^N)$ and the concentration-compactness type arguments help us in characterizing the compactness of the map $W(u) = \int_{\mathbb{R}^N} |w||u|^p \,\mathrm{d}x$ on $\mathcal{D}^{s,p}(\mathbb{R}^N)$. As an application, we study the qualitative and quantitative behavior of the eigenvalues of the weighted eigenvalue problem $(-\Delta)^s_p u = \lambda w |u|^{p-2} u \text{ in } \mathbb{R}^N$.

A double prescription curvature problem

Schedule: December 19 16:15-16:45 Capital Suite 1

Rafael Lopez-Soriano
Universidad de Granada
Spain

Abstract:
This talk is concerned with a Liouville type problem on compact surfaces with boundary. More precisely, this equation allows us to assign Gauss and geodesic curvatures under a conformal change of the metric. We derive existence using a direct variational structure of the problem and compactness of solutions analyzing the blow-up phenomenon.

A mountain pass Theorem and moduli space of minimal immersions

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Schedule: December 19 8:30-9:00 Capital Suite 1

Marcello Lucia
City University of New York
USA

Abstract:
We consider a class of functionals that depends on two arguments, whose partial map with respect to one of the arguments achieves its minimum, and for which the Palais-Smale condition is only partially satisfied in the other variable. Under some mild further assumption, we show existence of a global minimizer and uniqueness of critical points by using a new mountain pass theorem. This abstract functional framework can be applied to the geometric question of parametrizing the moduli space of minimal immersions in 3-hyperbolic manifolds by using suitable data arising from the second fundamental forms of the immersion.

Existence and non-degeneracy of Liouville bubbles in dimension one.

Schedule: December 19 15:45-16:15 Capital Suite 1

Gabriele Mancini
University of Bari Aldo Moro
Italy

Co-Author(s): Azahara DelaTorre, Angela Pistoia

Abstract:
In this talk, I will discuss existence, classification, and non-degeneracy results for solutions to singular Liouville-type equations in dimension one. This problem has applications in the mathematical modeling of galvanic corrosion phenomena for ideal electrochemical cells consisting of an electrolyte solution confined in a bounded domain with an electrochemically active portion of the boundary. In higher dimensions, Liouville equations have applications to prescribed curvature problems in conformal geometry, where solutions correspond to constant Q-curvature metrics on Euclidean space, with a singular point at the origin. After providing a general overview of the existing literature, I will focus on the one-dimensional case and prove that solutions are non-degenerate, under mild assumptions on the singular weight. The proof relies on the use of harmonic extensions and conformal transformations to rewrite the linearized Liouville equation as a Steklov eigenvalue problem on either the intersection or the union of two disks. These results were obtained in collaboration with A. DelaTorre and A. Pistoia.

Liouville type theorems for anisotropic degenerate elliptic equations on strips

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Schedule: December 19 15:15-15:45 Capital Suite 1

Luisa Moschini
Sapienza, University of Rome
Italy

Abstract:
We discuss some recent results concerning (L^∞) Liouville type theorems for anisotropic degenerate elliptic equations in divergence form on the strip $S = \mathbb{R}^{N-1} \times (-1, 1)$ where $x = (x', \lambda)$. The model equation is $div_{x'}(w_1 \nabla_{x'} \sigma) + \partial_\lambda (w_1 w_2 \partial_\lambda \sigma) = 0$, where $w_i(x', \lambda)$ are positive and locally bounded in S. We deduce them by means of a modification of De Giorgi`s oscillation decrease argument for uniformly elliptic equations, under appropriate conditions on the weight functions w_i; the key one being the existence of a positive unbounded supersolution close to the degeneration set ∂S. For example our approach works in the case $w_1 = 1 - |\lambda|$ and $w_2 = (1 - |\lambda|)^2$, for which the corresponding (L^∞) Liouville type theorem entails an alternative proof of the (known) positive answer to a famous conjecture of De Giorgi in any space dimension under the additional assumption that the zero level set of the solution is a Lipschitz graph. A complete picture of the problem is given for weights $w_1 = (1 - |\lambda|)^\alpha$, with $\alpha > -1$ and $w_2 = (1 - |\lambda|)^\nu$. The case $\nu = 2$ and $\nu = 1 - \alpha$ being borderline cases. For some values of α, ν these operators are connected to fractional Laplacians. The talk is mainly based on the following works: Liouville type theorems for anisotropic degenerate elliptic equations on strips, L. Moschini, CPAA 2023 and Anisotropic degenerate elliptic operators with distance function weights on strips, S. Filippas, L. Moschini and A. Tertikas (submitted).

A new look at beams

Schedule: December 19 9:00-9:30 Capital Suite 1

Dimitri Mugnai
Tuscia University
Italy

Co-Author(s): Genni Fragnelli

Abstract:
We present a new look to beams, in which local and nonlocal operators join under a peridynamical approach. Elliptic, parabolic and hyperbolic equations will be addressed.

Prescribing curvatures on surfaces with conical singularities and corners

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Schedule: December 19 18:30-19:00 Capital Suite 1

Francisco Javier Reyes Sanchez
Universidad de Granada
Spain

Co-Author(s): Luca Battaglia

Abstract:
In this talk, we will explore the construction of conformal metrics on compact Riemannian surface with boundary, featuring conical singularities and corners while prescribing Gaussian and geodesic curvatures. We will establish conditions for the existence of such metrics by studying a nonlinear elliptic partial differential equation (PDE) using a variational approach. This work is in collaboration with L. Battaglia from the University of Roma TRE.

A priori regularity estimates for equations degenerating on nodal sets

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Schedule: December 19 8:00-8:30 Capital Suite 1

Susanna Terracini
University of Turin
Italy

Co-Author(s): Giorgio Tortone and Stefano Vita

Abstract:
We prove a priori and a posteriori Holder bounds and Schauder $C^{1,\alpha}$ estimates for continuous solutions to singular/degenerate equations with variable coefficients of type $\mathrm{div}\left(|u|^a A\nabla w\right)=0 \qquad \mathrm{in}\ \Omega\subset\mathbb{R}^n$, where the weight u solves an elliptic equation of type $\mathrm{div}\,(A\nabla u)=0$ with a Lipschitz-continuous and uniformly elliptic matrix A and has a nontrivial, possibly singular, nodal set. Such estimates are uniform with respect to u in a class of normalized solutions having bounded Almgren`s frequency. More precisely, we provide a priori Holder bounds in any space dimension, and Schauder estimates when $n=2$. When $a=2$, the results apply to the ratios of two solutions to the same PDE sharing their zero sets. Then, one can infer higher order boundary Harnack principles on nodal domains by applying the Schauder estimates for solutions to the auxiliary degenerate equation. The results are based upon a fine blow-up argument, Liouville theorems and quasiconformal maps.

Modica type estimates and curvature results for overdetermined elliptic problems

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Schedule: December 19 16:45-17:15 Capital Suite 1

Jing Wu
Autonomous University of Madrid
Spain

Co-Author(s): David Ruiz and Pieralberto Sicbaldi

Abstract:
In this talk, we first establish a Modica type estimate for bounded solutions to the overdetermined elliptic problem. The case of equality will also be discussed. Finally, we will give some information about the curvature of the boundary from such estimates. The proof uses the maximum principle together with scaling and contradiction arguments.

Special Session 122 : Understanding the Learning of Deep Networks: Expressivity, Optimization, and Generalization

Introduction: The rapid advancements in deep learning, demonstrated by technologies like ChatGPT and GPT-4, highlight the race towards artificial general intelligence. However, deploying these sophisticated AI systems raises severe concerns about risks, necessitating rigorous audits and oversight to ensure safety, robustness, and alignment with human values. Currently, managing an AI system is hindered by the lack of mathematical theory, making it challenging to intrinsically understand their learning functions, training processes, and generalizability. To address these issues, the proposed special session will focus on the latest theoretical advancements in deep networks, covering expressivity, optimization, and generalization. The session will examine the capacity of networks to model complex functions, the implications of their non-convex optimization landscapes, and their ability to generalize and make accurate predictions about unseen data. This gathering will bring together leading researchers and practitioners to discuss recent progress, ongoing challenges, and future directions in the mathematical underpinnings of neural networks.

Functional neural network on infinite-dimensional data

Schedule: December 20 8:00-8:30 Conference Hall B (C)

Jun Fan
Hong Kong Baptist University
Hong Kong

Abstract:
Neural networks have proven their versatility in approximating continuous functions, but their capabilities extend far beyond. In this talk, we delve into the realm of functional neural networks, which offer a promising approach for approximating nonlinear smooth functionals. By investigating the convergence rates of approximation and generalization errors under different regularity conditions, we gain insights into the theoretical properties of these networks under the empirical risk minimization framework. This analysis contributes to a deeper understanding of functional neural networks and opens up new possibilities for their effective application in domains such as functional data analysis and scientific machine learning.

On the Expressivity of Neural Networks and Its Applications

Schedule: December 20 14:30-15:00 Conference Hall B (C)

Juncai He
The King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): Jinchao Xu and Lin Li

Abstract:
In this talk, I will present some recent results on the expressivity of neural networks and its applications. First, we will illustrate the connections between linear finite elements and ReLU DNNs, as well as between spectral methods and ReLU^k DNNs. Second, we will share our latest findings regarding the open question of whether DNNs can precisely recover piecewise polynomials of arbitrary order on any simplicial mesh in any dimension. Then, we will discuss a specific result on the optimal expressivity of ReLU DNNs and its application, combining it with the Kolmogorov-Arnold representation theorem. Finally, I will offer a remark on the study of convolutional neural networks from an expressivity perspective.

Optimization and Generalization of Gradient Descent for Shallow ReLU Networks

Schedule: December 20 9:00-9:30 Conference Hall B (C)

Yunwen Lei
The University of Hong Kong
Peoples Rep of China

Co-Author(s): Puyu Wang, Yiming Ying, Ding-Xuan Zhou

Abstract:
Understanding the generalization and optimization of neural networks is a longstanding problem in modern learning theory. The prior analysis often leads to risk bounds of order $1/\sqrt{n}$ for ReLU networks, where n is the sample size. In this talk, we present a general optimization and generalization analysis for gradient descent applied to shallow ReLU networks. We develop convergence rates of order $1/T$ for gradient descent with T iterations, and show that the gradient descent iterates fall inside local balls around either an initialization point or a reference point. We also develop improved Rademacher complexity estimates by using the activation pattern of the ReLU function in these local balls.

Faster Convergence and Acceleration for Diffusion-Based Generative Models

Schedule: December 20 14:00-14:30 Conference Hall B (C)

Gen Li
The Chinese University of Hong Kong
Hong Kong

Abstract:
Diffusion models, which generate new data instances by learning to reverse a Markov diffusion process from noise, have become a cornerstone in contemporary generative modeling. While their practical power has now been widely recognized, theoretical underpinnings for mainstream samplers remain underdeveloped. Moreover, despite the recent surge of interest in accelerating diffusion-based samplers, convergence theory for these acceleration techniques remains limited. In this talk, I will introduce a new suite of non-asymptotic results aimed at better understanding popular samplers like DDPM and DDIM in discrete time, offering significantly improved convergence guarantees over previous work. Our theory accommodates L2-accurate score estimates, and does not require log-concavity or smoothness on the target distribution. Building on these insights, we propose training-free algorithms that provably accelerate diffusion-based samplers, leveraging ideas from higher-order approximation similar to those used in high-order ODE solvers like DPM-Solver. Our acceleration algorithms achieve state-of-the-art sample quality compared to existing methods.

Overcoming High-Frequency Challenges: From Shallow to Multi-layer Neural Networks

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Schedule: December 20 15:30-16:00 Conference Hall B (C)

Shijun Zhang
The Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Hongkai Zhao, Yimin Zhong, Haomin Zhou

Abstract:
This talk explores the limitations of shallow neural networks in handling high-frequency functions and presents a solution through a novel multi-layer, multi-component neural network (MMNN) architecture. We show how shallow networks act as low-pass filters, struggling with high-frequency components due to machine precision and slow learning dynamics. The MMNN architecture addresses these challenges by efficiently decomposing complex functions, significantly improving accuracy and reducing computational costs. Numerical experiments demonstrate the effectiveness of this approach in capturing fine details in oscillatory functions.

Special Session 123 : New trends in elliptic and parabolic PDEs

Introduction: Regularity theories of elliptic and parabolic PDEs have long been a central topic in mathematical research. This special session will specifically focus on non-standard regularity theories that address issues involving rough coefficients, irregular boundaries, and certain types of degeneracy, as well as equations from fluids and materials. The objective of this session is to bring together experts in the field to exchange ideas, explore potential new directions, and foster collaborations.

Green functions for stationary Stokes systems in two dimensions

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Schedule: December 17 8:00-8:30 Capital Suite 11 A

Jongkeun Choi
Pusan National University
Korea

Abstract:
This talk presents Green functions for the stationary Stokes system with measurable coefficients in two dimensions, along with a unified approach to constructing Green functions for both elliptic and Stokes systems with various boundary conditions in two-or higher-dimensional domains.

The Stokes System on Convex Domains

Schedule: December 17 9:30-10:00 Capital Suite 11 A

Jun Geng
Lanzhou University
Peoples Rep of China

Co-Author(s): Zhongwei Shen

Abstract:
We investigate the Neumann problem for Stokes system on convex domain Ω. The L^p solvability and $W^{1,p}$ solvability are obtained for certain ranges of p. The ranges of p are sharp for $d = 2$ and these intervals are larger than the known interval on Lipschitz domain.

Conformal metrics of constant scalar curvature with unbounded volumes

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Schedule: December 17 17:00-17:30 Capital Suite 11 A

Liuwei Gong
The Chinese University of Hong Kong
Hong Kong

Co-Author(s): Yanyan Li

Abstract:
When $n > 24$, Brendle and Marques constructed a smooth metric on S^n such that there exists a sequence of conformal metrics with the same positive constant scalar curvature but with unbounded Ricci curvatures. We find a ``worse`` blowup phenomenon when $n > 24$: a smooth metric on S^n such that there exists a sequence of conformal metrics with the same positive constant scalar curvature but with unbounded volumes (and, in particular, unbounded Ricci curvatures). This is a joint work with Yanyan Li.

Concentration of weak solutions in compressible flows

Schedule: December 17 18:30-19:00 Capital Suite 11 A

Xianpeng Hu
The Hong Kong Polytechnic University
Peoples Rep of China

Abstract:
In this talk, we will discuss some recent progress in the mathematical analysis of weak solutions for compressible flows. Global existences of weak solutions will be the main subject. The oscillation and concentration of approximating solutions are two main obstacles.

Blow up phenomena of mean field type equations

Schedule: December 17 18:00-18:30 Capital Suite 11 A

Yeyao Hu
Central South University
Peoples Rep of China

Co-Author(s): Bartolucci, Cheng, Gu, Gui, Jevnikar, Li, Xie and Yang

Abstract:
We constructed blow-up solutions of mean field type equations on degenerate surfaces, including flat torus and standard sphere in dimension two. More recently, we built the blow-up solutions of mean field equation on four dimensional standard sphere, basing on point configurations inherited from the dimension two. New progress towards the planar Neumann problem will also be mentioned, particularly the construction of boundary and interior bubble assemblies.

Parabolic equations with a half-order time derivative and their application to boundary value problems

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Schedule: December 17 14:45-15:15 Capital Suite 11 A

Doyoon Kim
Korea University
Korea

Co-Author(s): Pilgyu Jung, Hongjie Dong

Abstract:
We present parabolic equations in divergence form that include a half-order time derivative term on the right-hand side. We discuss the motivation for considering such equations, particularly their usefulness (or necessity) when dealing with parabolic equations in divergence form with highly irregular coefficients or domains. As an application, we demonstrate the L_p solvability of parabolic equations with the conormal derivative boundary condition in very irregular domains, assuming the coefficients are only measurable in time. A key challenge to solvability, when obtaining necessary estimates, is the presence of the time derivative of the solution on the right-hand side, which may lack sufficient regularity to belong to L_p spaces. To address this, we reformulate the term as the half-order time derivative of a function in L_p spaces and employ the aforementioned results.

Harnack inequality for parabolic equations in double-divergence form with singular lower order coefficients

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Schedule: December 17 8:30-9:00 Capital Suite 11 A

Seick Kim
Yonsei University
Korea

Co-Author(s): Istvan Gyongy

Abstract:
This paper investigates the Harnack inequality for nonnegative solutions to second-order parabolic equations in double divergence form. We impose conditions where the principal coefficients satisfy the Dini mean oscillation condition in , while the drift and zeroth-order coefficients belong to specific Morrey classes. Our analysis contributes to advancing the theoretical foundations of parabolic equations in double divergence form, including Fokker-Planck-Kolmogorov equations for probability densities.

Some Liouville type theorems about Q-curvature

Schedule: December 17 17:30-18:00 Capital Suite 11 A

Mingxiang Li
Chinese University of Hong Kong
Hong Kong

Co-Author(s): Juncheng Wei

Abstract:
In this talk, I will introdue a Case-Gursky-V\`etois formula on compact Einstein manifolds and make use of such identity to estbalish some Liouville type theorems on compact Einstein manifolds related to Paneitz operator. This is a joint work with Prof. Juncheng Wei.

Sobolev estimates for degenerate linear equations on the upper half space

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Schedule: December 17 15:15-15:45 Capital Suite 11 A

Junhee Ryu
Korea University
Korea

Co-Author(s): Hongjie Dong

Abstract:
In this talk, we present both divergence and nondivergence degenerate equations on the upper half space. The coefficient matrices of the equations are the product of x_d^2 and bounded uniformly elliptic matrices. Under a partially weighted mean oscillation assumption on the coefficients, we obtain the wellposedness and regularity of solutions in weighted Sobolev spaces. This talk is based on a joint work with Hongjie Dong.

The scaling limit of the continuous solid-on-solid model

Schedule: December 17 16:15-16:45 Capital Suite 11 A

Wei Wu
NYU Shanghai
Peoples Rep of China

Co-Author(s): Scott Armstrong

Abstract:
We prove that the scaling limit of the continuous solid-on-solid model in Zd is a multiple of the Gaussian free field, based on methods from degenerate stochastic homogenization.

Resonant modes of two hard inclusions within a soft elastic material and their stress estimates

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Schedule: December 17 9:00-9:30 Capital Suite 11 A

Longjuan Xu
Capital Normal University
Peoples Rep of China

Abstract:
In this talk, we will discuss subwavelength resonant modes of two hard inclusions embedding in soft elastic materials to realize negative materials in elasticity. We will show that the resonant modes are categorized into dipolar, quadrupolar, and hybrid groups, facilitating the effective realization of negative mass density, negative shear modulus and double-negative properties in elastic metamaterials. Moreover, we will analyze the stress distribution between two hard inclusions when they are closely touching.

On the fast growth of some active scalar equations

Schedule: December 17 19:00-19:30   Capital Suite 11 A

Xiaoqian Xu
Duke Kunshan University
Peoples Rep of China

Co-Author(s): Xiaoqian Xu

Abstract:
In this talk, we discuss the small scale creation and the optimal growth in PDEs of fluid mechanics, especially the Euler equations and the related models. We first give a clear and understandable picture of so-called hyperbolic flow restricted in 1D. Then, we will look into the hyperbolic flow in 2D, based on the study of Green functions of elliptic equations.

Scale separation in multiscale elliptic homogenization

Schedule: December 17 15:45-16:15   Capital Suite 11 A

Jinping Zhuge
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Weisheng Niu

Abstract:
Multiscale homogenization is a mathematical method used to analyze partial differential equations (PDEs) in heterogeneous media with coefficients that vary on multiple oscillating scales. The classical homogenization theory, which addresses PDEs with a single oscillating scale, has been well-established so far. The multiscale homogenization is more complicated due to the interactions between different oscillating scales, particularly when these scales are not separated. In this talk, I will discuss a new scale separation idea in multiscale elliptic homogenization by using the simultaneous Diophantine approximation from number theory.

Special Session 124 : Recent Advances in Hydrodynamic Stability Analysis

Introduction: This session aims to explore diverse perspectives on hydrodynamic stability, encompassing theoretical analysis, PDE analysis, dynamical systems, and other mathematical approaches, alongside computational simulations. Hydrodynamic stability is pivotal in understanding various natural and engineering systems, influencing phenomena such as laminar-turbulent transitions and flow instabilities in complex geometries. By convening researchers from different backgrounds, including theoretical, applied, and computational scientists, this session seeks to foster interdisciplinary dialogue and the exchange of insights. Topics of interest include theoretical frameworks for stability analysis, applied analysis studying flow stability, and advanced computational approaches for predicting and analyzing hydrodynamic instabilities. Through this session, we aim to advance our collective understanding of hydrodynamic stability and its practical implications across diverse domains.

A nonlinear Schr\{o}dinger equation for capillary waves on arbitrary depth with constant vorticity

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Schedule: December 16 12:30-13:00 Capital Suite 2

Malek ABID
Aix-Marseille Universit\`e
France

Co-Author(s): Christian Kharif, Yang-Yih Chen and Hung-Chu Hsu

Abstract:
A nonlinear Schr\{o}dinger equation for pure capillary waves propagating at the free surface of a vertically sheared current has been \red{used} to study the stability and bifurcation of capillary Stokes waves on arbitrary depth. \newline A linear stability analysis of weakly nonlinear capillary Stokes waves on arbitrary depth has shown that (i) the growth rate of modulational instability increases as the vorticity decreases whatever the dispersive parameter kh where k is the carrier wavenumber and h the depth (ii) the growth rate is significantly amplified for shallow water depths and (iii) the instability bandwidth widens as the vorticity decreases. A particular attention has been paid to damping due to viscosity and forcing effects on modulational instability. In addition, a linear stability analysis to transverse perturbations in deep water has been carried out, demonstrating that the dominant modulational instability is two-dimensional whatever the vorticity. \newline Near the minimum of linear phase velocity in deep water, we have shown that generalized capillary solitary waves bifurcate from linear capillary Stokes waves when the vorticity is positive. \newline Moreover, we have shown that the envelope of pure capillary waves in deep water is unstable to transverse perturbations. Consequently, deep water generalized capillary solitary waves are expected to be unstable to transverse perturbations.

Symmetry Breaking in Chemical Systems: Engineering Complexity through Self-Organization and Marangoni Flows

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Schedule: December 16 13:00-13:30 Capital Suite 2

Azam Gholami
New York University, Abu Dhabi, UAE
United Arab Emirates

Co-Author(s): Sangram Gore, Binaya Paudyal, Mohammed Ali, Nader Masmoudi, Albert Bae, Oliver Steinbock, Azam Gholami

Abstract:
Far from equilibrium, chemical and biological systems can form complex patterns and waves through reaction-diffusion coupling. Fluid motion often tends to disrupt these self-organized concentration patterns. In this study, we investigate the influence of Marangoni-driven flows in a thin layer of fluid ascending the outer surfaces of hydrophilic obstacles on the spatio-temporal dynamics of chemical waves in the modified Belousov-Zhabotinsky reaction. Our observations reveal that circular waves originate nearly simultaneously at the obstacles and propagate outward. In a covered setup, where evaporation is minimal, the wavefronts maintain their circular shape. However, in an uncovered setup with significant evaporative cooling, the interplay between surface tension-driven Marangoni flows and gravity destabilizes the wavefronts, creating distinctive flower-like patterns around the obstacles. Our experiments further show that the number of petals formed increases linearly with the obstacle`s diameter, though a minimum diameter is required for these instabilities to appear. These findings demonstrate the potential to `engineer` specific wave patterns, offering a method to control and direct reaction dynamics. This capability is especially important for developing microfluidic devices requiring precise control over chemical wave propagation.

Ergodicity of randomly forced PDEs via controllability

Schedule: December 16 13:30-14:00 Capital Suite 2

Vahagn Nersesyan
NYU Shanghai
Peoples Rep of China

Abstract:
The problem of ergodicity of randomly forced dissipative PDEs has attracted a lot of attention in the last twenty years. It is well understood that if all or sufficiently many Fourier modes of the PDE are directly perturbed by the noise, then the problem has a unique stationary measure which is exponentially stable in an appropriate metric. The case when the random perturbation acts directly only on few Fourier modes is much less understood and is the main subject of this talk. We will explain how the controllability properties of the underlying deterministic system can be used to study the ergodic behavior of the stochastic dynamics. The results will be illustrated through the examples of 2D Navier-Stokes and Ginzburg-Landau equations; however, the methods apply to a wide variety of systems as soon as they satisfy appropriate controllability conditions. This talk is partially based on joint works with Sergei Kuksin (Universite Paris Cite) and Armen Shirikyan (CY Cergy Paris Universite).

Stability Analysis of Two-Dimensional Laminar Elliptic Cylinder Wakes Using Reduced-Order Galerkin Models

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Schedule: December 16 14:45-15:15 Capital Suite 2

Immanuvel Paul
Khalifa University of Science and Technology
United Arab Emirates

Co-Author(s): Immanuvel Paul

Abstract:
The stability of two-dimensional laminar wakes behind elliptic cylinders is studied using a reduced-order Galerkin model. This approach employs proper orthogonal decomposition (POD) to extract the dominant coherent structures from flow simulations. It constructs a reduced dynamical system by projecting the governing Navier-Stokes equations onto the subspace spanned by these modes. The resulting low-dimensional Galerkin system effectively captures the essential dynamics of the wake flow while significantly reducing the computational cost. A linear stability analysis of the reduced-order system is performed to examine the onset of wake instability and identify the critical Reynolds number where the transition to unsteady flow occurs. The study further explores the influence of cylinder aspect ratio on wake behavior and the development of wake vortex shedding patterns. The reduced model demonstrates its capability to predict wake instabilities accurately and offers insights into the flow`s sensitivity to perturbations. These findings contribute to a better understanding of laminar wake dynamics and provide a foundation for designing flow control strategies to mitigate instability in practical applications.

Towards a Variational Theory of Hydrodynamic Stability

Schedule: December 16 15:15-15:45 Capital Suite 2

Haithem Taha
University of California, Irvine
USA

Co-Author(s): Ahmed Roman

Abstract:
The projection of Navier-Stokes on the space of divergence-free vector fields is associated with a minimization problem. We recently formulated such a minimization problem in what we call The Principle of Minimum Pressure Gradient (PMPG). The principle asserts that an incompressible flow evolves from one instant to another in order to minimize the L2 norm of the pressure gradient. We proved that Navier-Stokes equation is the necessary condition for minimizing the pressure gradient cost subject to the divergence-free condition on the local acceleration. In the discretized domain, this problem is a convex quadratic programming problem, which has a closed-form solution. The resulting necessary condition is a quadratic ODE in velocity, directly without the need to solve for pressure, avoiding the need to solve the Poisson equation in pressure at every instant of time. This approach is expected to provide significant savings in computations. Moreover, it should facilitate the mathematical analysis of incompressible flows by exploiting tools from nonlinear systems theory to analyze the resulting quadratic ODE. Based on this view, we provide a conjecture for a necessary condition for nonlinear hydrodynamic stability: If an equilibrium solution is stable, it must minimize the L2 norm of the convective (and viscous) acceleration among all equilibrium, divergence-free solutions. This conjecture applies successfully to the ideal flow over an airfoil.

Well-posedness of Free Boundary Inviscid Flow-Structure Interaction models

Schedule: December 16 15:45-16:15 Capital Suite 2

Amjad Tuffaha
American University of Sharjah
United Arab Emirates

Co-Author(s): Igor Kuykavica. Sarka Necasova

Abstract:
We obtain the local existence and uniqueness of solutions for a system describing interaction of an incompressible inviscid fluid, modeled by the Euler equations, and an elastic plate, represented by the fourth-order hyperbolic PDE. We provide a~priori estimates for the existence with the optimal regularity H^r, for $r > 2.5$, on the fluid initial data and construct a unique solution of the system for initial data $u_0 \in H^r$ for $r \geq 3$. We also address the compressible Euler equations in a domain with a free elastic boundary, evolving according to a weakly damped fourth order hyperbolic equation forced by the fluid pressure. We establish a~priori estimates on local-in-time solutions in low regularity Sobolev spaces, namely with velocity and density initial data %v_0, R_0 in~H^3. This is joint work with Igor Kukavica and Sarka Necasova.

Special Session 125 : Analysis, Algorithms, and Applications of Neural Networks

Introduction: In the rapidly evolving landscape of neural network applications, including convolutional, recurrent, graph networks, and Transformers, the understanding of these NN-based models has become critically important in the fields of computational and applied mathematics. This special session at AIMS 2024 aims to provide a platform for researchers and practitioners to share insights, methodologies, and breakthroughs focused on the mathematical and numerical analysis, efficient algorithm developments, and explainable applications of these models and methods. The session will primarily feature contributions from junior professors and young researchers from various universities and countries, fostering a collaborative and dynamic exchange of ideas.

Neural network, dynamical system and formal language

Schedule: December 20 8:00-8:30 Capital Suite 9

Yongqiang Cai
Beijing Normal University
Peoples Rep of China

Abstract:
Deep learning has made significant progress in data science and natural science. Some studies have linked deep neural networks to dynamical systems, but the network structure is restricted to a residual network. It is known that residual networks can be regarded as a numerical discretization of dynamical systems. In this talk, we consider the traditional network structure and prove that vanilla feedforward networks can also be used for the numerical discretization of dynamical systems, where the width of the network is equal to the input and output dimensions. The proof is based on the properties of the leaky-ReLU function and the numerical technique of the splitting method for solving differential equations. The results could provide a new perspective for understanding the approximation properties of feedforward neural networks. In particular, the minimum width of neural networks for universal approximation can be derived and the relationship between mapping conpositions and regular languages can be constructed.

Structure-conforming Operator Learning for Geometric Inverse Problems

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Schedule: December 19 16:15-16:45 Capital Suite 9

Ruchi Guo
Sichuan University
Peoples Rep of China

Co-Author(s): Long Chen, Shuhao Can, Huayi Wei

Abstract:
The principle of developing structure-conforming numerical algorithms widely exists in scientific computing. In this work, following this principle, we propose an operator learning method for solving a class of geometric inverse problems. The architecture here is inspired by Direct Sampling Methods and is also closely related to convolutional network and Transformer. The latter one is state-of-art architecture for many scientific computing tasks. To obtain the optimal hyperparameters in this method, we propose a FEM and OpL joint-training framework and a Leaning-Automated FEM package. Numerical examples demonstrate that the proposed architecture outperforms many existing operator learning methods in the literature.

Neural Networks and Operators Based on Convolution and Multigrid Structure

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Schedule: December 20 9:00-9:30 Capital Suite 9

Juncai He
The King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): Jinchao Xu and Xinliang Liu

Abstract:

In this talk, we will present recent results on applying multigrid structures to both neural networks and operators for problems in images and numerical PDEs. First, we will illustrate MgNet as a unified framework for convolutional neural networks and multigrid methods with some preliminary theories and applications. Then, we will discuss some basic background on operator learning, including the problem setup, a uniform framework, and a general universal approximation result. Motivated by the general definition of neural operators and the MgNet structure, we propose MgNO, which utilizes multigrid structures to parameterize these linear operators between neurons, offering a new and concise architecture in operator learning. This approach provides both mathematical rigor and practical expressivity, with many interesting numerical properties and observations.

DualFL-CS: an accelerated, inexact, and parallel coordinate descent method for federated learning

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Schedule: December 19 18:30-19:00   Capital Suite 9

Boou Jiang
The King Abdullah University of Science and Technology
Peoples Rep of China

Co-Author(s): Boou Jiang, Jongho Park, Jinchao Xu

Abstract:

This work presents a novel approach to Federated Learning (FL), a collaborative learning model that leverages data distributed across numerous clients. We establish a duality connection between the widely studied FL problem and the parallel subspace correction problem, leading to the development of our accelerated FL algorithm, DualFL-CS. By employing a novel randomized coordinate descent method, our algorithm effectively incorporates client sampling and allows for the use of inexact local solvers, thereby reducing computational costs in both smooth and non-smooth cases. For smooth FL problems, DualFL-CS achieves optimal linear convergence rates, while for non-smooth problems, it attains accelerated sub-linear convergence rates. Numerical experiments demonstrate the superior performance of our algorithm compared to existing state-of-the-art FL algorithms.

A deformation-based framework for learning solution mappings of PDEs defined on varying domains

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Schedule: December 19 16:45-17:15   Capital Suite 9

Pengzhan Jin
Peking University
Peoples Rep of China

Abstract:
In this work, we establish a deformation-based framework for learning solution mappings of PDEs defined on varying domains. The union of functions defined on varying domains can be identified as a metric space according to the deformation, then the solution mapping is regarded as a continuous metric-to-metric mapping, and subsequently can be represented by another continuous metric-to-Banach mapping using two different strategies, referred to as the D2D framework and the D2E framework, respectively. We point out that such a metric-to-Banach mapping can be learned by neural operators, hence the solution mapping is accordingly learned. With this framework, a rigorous convergence analysis is built for the problem of learning solution mappings of PDEs on varying domains. As the theoretical framework holds based on several pivotal assumptions which need to be verified for a given specific problem, we study the star domains as a typical example, and other situations could be similarly verified. There are three important features of this framework: (1) The domains under consideration are not required to be diffeomorphic, therefore a wide range of regions can be covered by one model provided they are homeomorphic. (2) The deformation mapping is unnecessary to be continuous, thus it can be flexibly established via combining a main body identity mapping and a local deformation mapping. This feature makes it possible to achieve inverse design for the large system where only local parts of the shape are tuned. (3) If a linearity-preserving neural operator such as MIONet is adopted, this framework still preserves the linearity of the surrogate solution mapping on its source term for linear PDEs, thus it can be applied to the hybrid iterative method. We finally present several numerical experiments to validate our theoretical results.

Entropy-based convergence rates of greedy algorithms

Schedule: December 19 18:00-18:30 Capital Suite 9

Yuwen Li
Zhejiang University
Peoples Rep of China

Co-Author(s): Yuwen Li

Abstract:
In this talk, I will present novel convergence estimates of greedy algorithms including the reduced basis method for parametrized PDEs, the empirical interpolation method for approximating parametric functions, and the orthogonal/Chebyshev greedy algorithms for nonlinear dictionary approximation. The proposed convergence rates are all based on the metric entropy of underlying compact sets. This talk is partially based on joint work Jonathan Siegel.

Expressivity and Approximation Properties of Deep Neural Networks with ReLUk Activation

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Schedule: December 20 8:30-9:00 Capital Suite 9

Tong Mao
King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): J. He, J. Xu

Abstract:
Deep ReLU^k networks have the capability to represent higher-degree polynomials precisely. We provide a comprehensive constructive proof for polynomial representation using deep ReLU^k networks. This allows us to establish an upper bound on both the size and count of network parameters. Consequently, we are able to demonstrate a suboptimal approximation rate for functions from Sobolev spaces as well as for analytic functions. Additionally, we reveal that deep ReLU^k networks can approximate functions from a range of variation spaces, extending beyond those generated solely by the ReLU^k activation function. This finding demonstrates the adaptability of deep ReLU^k networks in approximating functions within various variation spaces.

Adaptive Growing Randomized Neural Networks for Solving Partial Differential Equations

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Schedule: December 19 15:15-15:45 Capital Suite 9

Fei Wang
Xi`an Jiaotong University
Peoples Rep of China

Co-Author(s): Haoning Dang and Song Jiang

Abstract:
Traditional numerical methods face numerous challenges in handling high-dimensional problems, complex regional segmentation, and error accumulation caused by time iteration. Concurrently, neural network methods based on optimization training suffer from insufficient accuracy, slow training speeds, and uncontrollable errors due to the lack of efficient optimization algorithms. To combine the advantages of these two approaches and overcome their shortcomings, randomized neural network methods have been proposed. This method not only leverages the strong approximation capabilities of neural networks to circumvent the limitations of classical numerical methods but also aims to resolve issues related to accuracy and training efficiency in neural networks. By incorporating a posterior error estimation as feedback, in this talk, we propose Adaptive Growing Randomized Neural Networks for solving PDEs. This approach can adaptively generate network structures, significantly improving the approximation capabilities.

Optimistic Sample Size Estimate for Deep Neural Networks

Schedule: December 19 17:30-18:00 Capital Suite 9

Yaoyu Zhang
Shanghai Jiao Tong University
Peoples Rep of China

Abstract:
Estimating the sample size required for a deep neural network (DNN) to accurately fit a target function is a crucial issue in deep learning. In this talk, we introduce a novel sample size estimation method based on the phenomenon of condensation, which we term the optimistic estimate. This method quantitatively characterizes the best possible performance achievable by neural networks through condensation. Our findings suggest that increasing the width and depth of a DNN preserves its sample efficiency. However, increasing the number of unnecessary connections significantly deteriorates sample efficiency. This analysis provides theoretical support for the commonly adopted strategy in practice of expanding network width and depth rather than increasing the number of connections.

Special Session 126 : Machine Learning and New Framework for Solving Partial Differential Equations

Introduction: Recently, it has been a groundbreaking trend that synergistically combines the principles of partial differential equation (PDE) solvers and machine learning (ML) techniques to advance the solution of complex PDE systems. The new methodology may transcend traditional approaches in harnessing the predictive power of ML algorithms while preserving the mathematical rigor and interpretability inherent in PDE-based models. The interaction between PDE and ML may also introduce comprehensively new insights to the traditional approaches of PDE solution as well as the ML techniques. This mini-symposium proposes to gather experts in the fields of PDE solution and machine learning to communicated latest progress in the new framework of solving PDE particularly by/for machine learning. The framework is demonstrated through a series of case studies spanning diverse application domains. Moreover, the framework' s modular design allows for seamless integration into existing computational workflows and mathematical rigors, fostering broader adoption across scientific and engineering disciplines, and unlocking novel avenues for interdisciplinary research.

Learning coarse-grained models and quantifying transitions between metastable states in molecules and clusters of interacting particles

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Schedule: December 19 13:00-13:30 Capital Suite 3

Maria K Cameron
University of Maryland, College Park
USA

Co-Author(s): Maria Cameron, Shashank Sule, Jiaxin Yuan

Abstract:
Many processes in nature such as conformal changes in biomolecules and clusters of interacting particles are modeled using stochastic differential equations with small noise. The study of rare transitions between metastable states in such systems is of great interest and importance. The direct simulation of rare transitions is difficult due to long waiting times and high dimensionality. Transition Path Theory (E and Vanden-Eijnden, 2006) is a mathematical framework for describing transition processes. The key component of its implementation is the numerical solution of the committor problem, a certain boundary value problem for the stationary Backward Kolmogorov equation. In this talk, I will discuss how one can learn coarse-grained models, solve the committor problem accurately in moderately high dimensions, and use optimal stochastic control to quantify transition processes between the metastable states.

A novel shape optimization approach for source identification in elliptic equations

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Schedule: December 19 13:30-14:00 Capital Suite 3

Wei Gong
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Wei Gong and Ziyi Zhang

Abstract:
In this talk, we propose a novel shape optimization approach for the source identification of elliptic equations. This identification problem arises from two application backgrounds: actuator placement in PDE-constrained optimal controls and the regularized least-squares formulation of source identifications. The optimization problem seeks both the source strength and its support. By eliminating the variable associated with the source strength, we reduce the problem to a shape optimization problem for a coupled elliptic system, known as the first-order optimality system. As a model problem, we derive the shape derivative for the regularized least-squares formulation of the inverse source problem and propose a gradient descent shape optimization algorithm, implemented using the level-set method. Several numerical experiments are presented to demonstrate the efficiency of our proposed algorithms.

A new method using C0IPG for the biharmonic eigenvalue problem

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Schedule: December 19 14:00-14:30 Capital Suite 3

Xia Ji
Beijing institute of technology
Peoples Rep of China

Co-Author(s): yongxiang xi, jiguang sun

Abstract:

The talk presents a new proof of the C^0IPG method (C^0 interior penalty Galerkin method) for the biharmonic eigenvalue problem. Instead of using the proof following the structure of discontinuous Galerkin method, we rewrite the problem as the eigenvalue problem of a holomorphic Fredholm operator function of index zero. The convergence for C^0IPG is proved using the abstract approximation theory for holomorphic operator functions. We employ the spectral indicator method which is easy in coding to compute the eigenvalues. Numerical examples are presented to validate the theory.

Solving Reaction Diffusion Equation Using Transformer-based Koopman Autoencoder

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Schedule: December 19 14:30-15:00 Capital Suite 3

Nitu Kumari
Indian Institute of Technology Mandi
India

Abstract:

A Transformer based Koopman autoencoder is proposed for linearizing reaction diffusion equation. The primary focus of this study is on using deep learning techniques to find complex spatiotemporal patterns in the reaction diffusion system. The emphasis is not just solving the equation but also transforming the system dynamics into a more comprehensible, linear form. Global coordinate transformations are achieved through the autoencoder, which learns to capture the underlying dynamics by training on a dataset with 60,000 initial conditions. Extensive testing on multiple datasets was used to assess the efficacy of the proposed model, demonstrating its ability to accurately predict the system evolution as well as to generalize. We provide a thorough comparison study, comparing our suggested design to a few other comparable methods using experiments on various PDEs. Results show improved accuracy, highlighting the capabilities of the Transformer based Koopman autoencoder. The proposed architecture is significantly ahead of other architectures, in terms of solving different types of PDEs using a single architecture. Our method relies entirely on the data, without requiring any knowledge of the underlying equations. This makes it applicable to even the datasets where the governing equations are not known.

Ball Mass-preserving Parameterizations with Applications on Brain Tumor Segmentations

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Schedule: December 19 15:15-15:45 Capital Suite 3

Tiexiang Li
Southeast University
Peoples Rep of China

Abstract:
A parameterization of a given manifold refers to a bijective map which transforms the manifold to a canonical domain. In this talk, we introduce an optimal mass transport (OMT) algorithm for achieving mass-preserving parameterizations, which transforms a 3-manifold into a unit ball. The OMT theory inherently guarantees the mass-preservation of the map. The accuracy and efficiency of the proposed OMT algorithm are shown in the numerical experiments. We leverage the OMT algorithm in the context of brain tumor segmentations. The integrated UNet combined with OMT demonstrates notable performance in the Brain Tumor Segmentation (BraTS) Challenge.

Reduced Krylov Basis Methods

Schedule: December 19 15:45-16:15 Capital Suite 3

Yuwen Li
Zhejiang University
Peoples Rep of China

Co-Author(s): Yuwen Li

Abstract:
The reduced basis method is popular for numerically solving a family of parametrized PDEs. In this talk, I will present our new reduced basis algorithm based on preconditioned Krylov subspace methods. The proposed methods use a preconditioned Krylov subspace method for a high-fidelity discretization of one parameter instance to generate orthogonal basis vectors of the reduced basis subspace. Then the family of large-scale discrete parameter-dependent problems are approximately solved in the low-dimensional Krylov subspace. The material in my talk is based on joint works with Ludmil Zikatanov and Cheng Zuo.

Structure-preserving parametric finite element methods for curve diffusion

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Schedule: December 19 19:00-19:30 Capital Suite 3

Chunmei Su
Tsinghua University
Peoples Rep of China

Co-Author(s): Harald Garcke, Wei Jiang, Ganghui Zhang

Abstract:

We propose a novel formulation for parametric finite element methods to simulate surface diffusion of closed curves, which is also called as the curve diffusion. Several high-order temporal discretizations are proposed based on this new formulation. To ensure that the numerical methods preserve geometric structures of curve diffusion (i.e., the perimeter-decreasing and area-preserving properties), our formulation incorporates two scalar Lagrange multipliers and two evolution equations involving the perimeter and area, respectively. By discretizing the spatial variable using piecewise linear finite elements and the temporal variable using either the Crank-Nicolson method or the backward differentiation formulae method, we develop high-order temporal schemes that efectively preserve the structure at a fully discrete level. These new schemes are implicit and can be efficiently solved using Newtons method. Extensive numerical experiments demonstrate that our methods achieve the desired temporal accuracy, as measured by the manifold distance, while simultaneously preserving the geometric structure of the curve diffusion.

Dual-robust iterative analysis of divergence-conforming IPDG FEM for thermally coupled inductionless MHD system

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Schedule: December 19 16:15-16:45 Capital Suite 3

Haiyan Su
Xinjiang University
Peoples Rep of China

Co-Author(s): Guodong Zhang

Abstract:

This talk presents dual-robust iterative algorithms for the 2D/3D steady thermally coupled inductionless magnetohydrodynamics system in a general Lipschitz domain. Both velocity and current density are discretized by the divergence-conforming elements. Furthermore, we utilize an interior penalty discontinuous Galerkin (IPDG) approach to guarantee the H^1-continuity of velocity. With the system strong nonlinearity, we propose three iterative algorithms (Stokes, Newton and Oseen iterations) and provide analytical proofs for their stability and convergence. And the feature of these methods is that simultaneously ensures the complete divergence-free of discrete velocity and discrete current density. Finally, the numerical simulations verify theoretical analysis and the effectiveness of proposed algorithms.

Deep Neural Networks with Rectified Power Units: Efficient Training and Applications in Partial Differential Equations

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Schedule: December 19 16:45-17:15 Capital Suite 3

Haijun Yu
Academy of Mathematics and Systems Science, Chinese Academy of Science
Peoples Rep of China

Co-Author(s): Haijun Yu

Abstract:
Deep neural networks (DNN) equipped with rectified power units (RePU) have demonstrated superior approximation capabilities compared to those utilizing rectified linear units (ReLU), as highlighted by B. Li, S. Tang, and H. Yu [Commun. Comput. Phys., 2020, 27(2): 379-411]. These units are particularly advantageous for machine learning tasks requiring high-order continuity in the functions represented by neural networks. Despite their theoretical benefits, however, the practical application of RePU DNNs has been limited due to challenges such as gradient vanishing and explosion during training. In this talk, we explore various strategies aimed at facilitating the training of RePU DNNs. Our primary focus lies on the numerical solutions of partial differential equations. We demonstrate that, with appropriate training techniques, RePU DNNs can achieve better results than standard DNNs employing other commonly used activation functions, and do so with a faster training rate.

A deep learning enabled massive parallel simulator for porous media flow

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Schedule: December 19 17:30-18:00 Capital Suite 3

Chensong Zhang
Academy of Mathematics and Systems Science
Peoples Rep of China

Abstract:
Due to the complex composition of oil and gas resources, reservoir engineers usually switch between different mathematical models when describing the properties of petroleum reservoirs. In addition to the commonly used black oil model, various compositional models have been proposed. Some EOR techniques, such as polymer flooding, must be simulated based on the framework of compositional models. Some other applications of porous media flow, such as CO2 sequestration, groundwater contamination, and geothermal resource development, can also be simulated using compositional models. But the compositional models tend to be associated with more complex PDEs, more variables, and higher computational costs. In this talk, we will discuss a general-purpose compositional framework and our efforts in developing its solution methods, including discretizations, nonlinear solvers, linear solvers, parallelization and AI capabilities. Furthermore, we will introduce an open-source software project for simulating multi-component multi-phase porous media flow.

Complex dualities and new solution frameworks

Schedule: December 19 18:30-19:00 Capital Suite 3

Shuo Zhang
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Abstract:
Once a series of operators with domain spaces formulate a complex, their respective adjoint operators formulate a complex simultaneously; such pairs of complexes are called complex dualities. New solution framework can be stimulated, with respect to both classical numerical methodologies and machine learning type methodologies, by revealing the structure of complex dualities at continuous or discrete levels. Novel neural network methods and finite element methods for certain model problems are presented for example.

Weak Generative Sampler to Solve High - Dimensional PDEs for Stochastic Models: Efficiency and Adaptivity

Schedule: December 19 18:00-18:30 Capital Suite 3

Xiang ZHOU
City University of Hong Kong
Hong Kong

Co-Author(s): Zhiqiang CAI, Yu CAO, Yuanfei Huang

Abstract:
The solution of many typical high-dimensional PDEs (such as the Fokker-Planck, and McKean-Vlasov equations) is associated with a probability distribution. To solve such PDEs by deep learning techniques is usually to simply find a neural network for the density function itself, subject to certain positivity and normalization conditions. The further utilization of the solution requires random sampling again. We introduce a framework of Weak Generative Sampler (WGS) to both solve the PDE and generate samples more efficiently than the PINN and the Ritz method. Our proposed loss function is based on the weak form and the generic probability interpretation of the loss function. The details of this talk will explain why the efficiency and adaptivity are so easy to achieve in this WGS for high-dimensional PDEs.

Special Session 127 : Recent Advances in Inverse Problems, Imaging, and Their Applications

Introduction: This session aims to bring together researchers from diverse fields involving inverse problems and imaging. It fosters the exchange of ideas among experts in modeling, analysis, and computation of inverse problems, as well as their applications. Additionally, the session seeks to explore and identify future research directions in these areas.

Uniqueness of an inverse cavity scattering problem for the time-harmonic biharmonic wave equation

Schedule: December 19 14:30-15:00 Capital Suite 21 B

Heping Dong
School of Mathematics, Jilin University
Peoples Rep of China

Co-Author(s): Peijun Li

Abstract:
This talk addresses an inverse cavity scattering problem associated with the biharmonic wave equation in two dimensions. The objective is to determine the domain or shape of the cavity. The Green`s representations are demonstrated for the solution to the boundary value problem, and the one-to-one correspondence is confirmed between the Helmholtz component of biharmonic waves and the resulting far-field patterns. Two mixed reciprocity relations are deduced, linking the scattered field generated by plane waves to the far-field pattern produced by various types of point sources. Furthermore, the symmetry relations are explored for the scattered fields generated by point sources. Finally, we present two uniqueness results for the inverse problem by utilizing both far-field patterns and phaseless near-field data.

Reduced order model approach for imaging with waves

Schedule: December 19 8:00-8:30 Capital Suite 21 B

Josselin Garnier
Ecole polytechnique
France

Co-Author(s): Liliana Borcea Alex Mamonov Jorn Zimmerling

Abstract:
We consider the inverse problem for the scalar wave equation. Sensors probe the unknown medium to be imaged with a pulse and measure the backscattered waves. The objective is to estimate the velocity map from the array response matrix of the sensors. Under such circumstances, conventional Full Waveform Inversion (FWI) can be carried out by nonlinear least-squares data fitting. It turns out that the FWI misfit function is high-dimensional and non-convex and it has many local minima. A novel approach to FWI based on a data-driven reduced order model (ROM) of the wave equation operator is introduced and it is shown that the minimization of ROM misfit function performs much better.

Time-domain and frequency-domain methods to inverse moving source problems

Schedule: December 19 9:00-9:30 Capital Suite 21 B

Guanghui Hu
Nankai University
Peoples Rep of China

Abstract:
This talk is concerned with uniqueness, stability and algorithms for inverse moving point source problems modeled by the acoustic wave equation. The purpose is to recover the orbit of a moving point source from the dynamical data recorded at a finite number of observation points. In the time domain, we derive an ordinary differential equation for the distance function between an observation point and the moving target. Solving such ODEs at four observation points yields the orbit function of the moving source. The frequency-domain method is to Fourier-transform the time-dependent source problem of the wave equation into an equivalent source problem of the Helmholtz equation with multi-frequency near-field data. This turns out to be a special wavenumber-dependent inverse source problem in the time-harmonic regime. We shall discuss the concept of non-observation directions and a non-iterative approach for imaging the orbit function. A comparision of the time-domain and frequency-domain method will be remarked at the end of the talk.

Direct sampling methods for inverse source problems

Schedule: December 19 13:30-14:00 Capital Suite 21 B

Xiaodong Liu
Academy of Mathematics and Systems Science of Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Xiaodong Liu

Abstract:
This talk is dedicated to a short review of the direct sampling methods for inverse source problems. In particular, we show that the recently developed direct sampling method is able to give a high resolution imaging for the source support and to produce an acceptable reconstruction of the source function.

A high-order fast sweeping method for eikonal and transport equations in attenuating media

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Schedule: December 19 15:45-16:15 Capital Suite 21 B

Wangtao Lu
Zhejiang University
Peoples Rep of China

Co-Author(s): Gang Bao, Tianlu Chen, Wangtao Lu and Jianliang Qian

Abstract:
Eikonal and transport equations arise from using the geometrical-optics ansatz in solving wave equations in the high-frequency regime. In attenuating media, the unknowns are complex-valued so that the real and imaginary parts are coupled with each other. In this talk, we present an effective fast sweeping solver for solving the two equations. Based on a specially designed numerical Hamiltonian, we develop a fast Gauss-Seidel iterative scheme, and establish its convergence theory. Numerical experiments are carried out to demonstrate the effectiveness of the new scheme.

A prediction-correction based iterative convolution-thresholding method for topology optimization of heat transfer problems

Schedule: December 19 18:00-18:30 Capital Suite 21 B

Dong Wang
The Chinese University of Hong Kong, Shenzhen & Shenzhen International Center for Industrial and Applied Mathematics
Peoples Rep of China

Co-Author(s): Dong Wang, Chinese University of Hong Kong, Shenzhen

Abstract:
In this talk, we propose an iterative convolution-thresholding method (ICTM) based on prediction-correction for solving the topology optimization problem in steady-state heat transfer equations. The problem is formulated as a constrained minimization problem of the complementary energy, incorporating a perimeter/surface-area regularization term, while satisfying a steady-state heat transfer equation. The decision variables of the optimization problem represent the domains of different materials and are represented by indicator functions. The perimeter/surface-area term of the domain is approximated using Gaussian kernel convolution with indicator functions. In each iteration, the indicator function is updated using a prediction-correction approach. The prediction step is based on the variation of the objective functional by imposing the constraints, while the correction step ensures the monotonically decreasing behavior of the objective functional. Numerical results demonstrate the efficiency and robustness of our proposed method, particularly when compared to classical approaches based on the ICTM.

Inverse random potential scattering for stochastic polyharmonic wave equations

Schedule: December 19 19:00-19:30 Capital Suite 21 B

Xu Wang
Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Peijun Li and Guanlin Yang

Abstract:
In this talk, we mainly discuss the uniqueness of the inverse scattering problem for the random potential involved in stochastic polyharmonic wave equations. The random potential is assumed to be an isotropic generalized Gaussian random field. With limited measurements, we show the unique determination of the correlation strength of the random potential through a single realization of the scattered wave field averaged over the frequency band.

Near-field inverse obstacle scattering by flexural waves: method of transformed field expansion

Schedule: December 19 17:30-18:00 Capital Suite 21 B

Yuliang Wang
Beijing Normal University
Peoples Rep of China

Co-Author(s): Peijun Li, Yuliang Wang

Abstract:
In this talk, we investigate the inverse scattering problem of an obstacle embedded in a thin plate using near-field measurements of flexural waves. The forward scattering problem is reduced to a coupled system of boundary value problems for the propagating and evanescent waves. Assuming the obstacle is a small perturbation of a circle, we employ the method of transformed field expansions to express the solution as a power series, obtaining closed-form expressions for the zeroth and first-order terms. These expressions are then used to derive an approximate reconstruction formula for the inverse scattering problem. We explore different types of incident fields, some of which lead to simplified and more efficient reconstruction methods. Numerical experiments demonstrate the effectiveness and efficiency of the proposed approach.

Unsupervised diffusion approach with null space learning for cloud removal in remote sensing images

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Schedule: December 19 15:15-15:45 Capital Suite 21 B

Liwei Xu
University of Electronic Science and Technology of China
Peoples Rep of China

Abstract:
Clouds are ubiquitous in remote sensing images. Most of the existing methods for cloud removal are limited to either implementing on multi spectral images or exploiting supervised learning technique. In this paper, we propose an unsupervised diffusion approach by deploying the null space learning. The proposed approach is built upon two trained denoising diffusion probabilistic models by diverse remote sensing datasets so as to tackle the mixture of data from different sources. The simplified degradation and self-adaptive generalized inverse matrices are devised for the null space decomposition. For the diffusion model with null space decomposition, we derive its continuous reverse-time stochastic differential equation (SDE), which is theoretically proven to be variance preserving. We further derive the explicit formula for the expectation of the reverse-time SDE, which is conducive to algorithm improvement. As a byproduct, the proposed approach can also be applicable to the transparency separation. Numerical experiments on some remote sensing images demonstrate that the proposed approach outperforms some state-of-the-art unsupervised, even supervised, cloud removal methods.

Inverse random potential scattering for stochastic polyharmonic wave equations

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Schedule: December 19 18:30-19:00 Capital Suite 21 B

Guanlin Yang
Institute of Computational Mathematics and Scientific/Engineering Computing, Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Guanlin Yang

Abstract:
In this talk, we mainly discuss the uniqueness of the inverse scattering problem for the random potential involved in stochastic polyharmonic wave equations. The random potential is assumed to be an isotropic generalized Gaussian random field. With limited measurements, we show the unique determination of the correlation strength of the random potential through a single realization of the scattered wave field averaged over the frequency band.

DtN-FEM for thermoelastic scattering problem

Schedule: December 19 16:15-16:45 Capital Suite 21 B

Tao Yin
Chinese Academy of Sciences
Peoples Rep of China

Abstract:
This talk will present our recent works on the wellposedness analysis and numerical schemes for solving the thermo/poro-elastic scattering problems. Based on the Helmholtz decomposition, the vector coupled governing equations of thermoelastic wave are decomposed into three Helmholtz equations of scalar potentials with different wavenumbers. Then the Dirichlet-to-Neumann (DtN) map and the corresponding transparent boundary condition are constructed by using Fourier series expansions of the scalar potentials. The well-posedness results are established for the variational problem and its modification due to the truncation of the DtN map. A priori and a posteriori error estimates, including both the effects of the finite element approximation and truncation of the DtN operator, are derived. Numerical experiments are presented to validate the theoretical results.

Convergence of the TBC/PML method for the biharmonic wave scattering problem in periodic structures

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Schedule: December 19 16:45-17:15 Capital Suite 21 B

Xiaokai Yuan
Jilin University
Peoples Rep of China

Co-Author(s): Gang Bao and Peijun Li

Abstract:
This talk investigates the scattering of biharmonic waves by a one-dimensional periodic array of cavities embedded in an infinite elastic thin plate. The transparent boundary conditions are introduced to formulate the problem from an unbounded domain to a bounded one. The well-posedness of the associated variational problem is demonstrated utilizing the Fredholm alternative theorem. The perfectly matched layer (PML) method is employed to reformulate the original scattering problem, transforming it from an unbounded domain to a bounded one. The transparent boundary conditions for the PML problem are deduced, and the well-posedness of its variational problem is established. Moreover, exponential convergence is achieved between the solution of the PML problem and that of the original scattering problem.

Iterative regularized contrast source inversion type methods for the inverse medium scattering problem

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Schedule: December 19 14:00-14:30 Capital Suite 21 B

Haiwen Zhang
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Co-Author(s): Qiao Hu and Bo Zhang

Abstract:
This talk is concerned with the inverse problem of reconstructing an inhomogeneous medium from the acoustic far-field data. The contrast source inversion (CSI) methods are the well-known algorithms for such kind of inverse scattering problem, which are very fast and efficient. Recently, we propose two iterative regularized CSI-type methods. Our methods have very low computational complexity. Moreover, we prove the global convergence of the proposed methods. Numerical experiments show that our methods are very robust and have faster convergence rates than the original CSI-type methods.

INVERSE PROBLEMS FOR NON-LINEAR FRACTIONAL MAGNETIC SCHRODINGER EQUATIONS

Schedule: December 19 8:30-9:00 Capital Suite 21 B

Ting Zhou
Zhejiang University
Peoples Rep of China

Co-Author(s): Ting Zhou and Ru-Yu Lai

Abstract:
This talk focus on the forward problem and inverse problem for the fractional magnetic Schrodinger equation with nonlinear electric potential. We first investigate the maximum principle for the linearized equation and apply it to show that the problem is well-posed under suitable assumptions on the exterior data. Moreover, we explore uniqueness of recovery of both magnetic and electric potentials.

Special Session 128 : Recent Advances in Kinetic Theory and Related Applications

Introduction: Kinetic theory provides a fundamental framework for describing the statistical behavior of systems composed of a large number of particles and has seen remarkable progress in recent years. These advancements have profound implications for a wide range of applications, from fluid dynamics, radiative transfer, and biological systems to crowd and traffic flow models. This session will serve as a platform for exchanging recent results and applications and fostering collaborations among experts in the field.

Derivation of the acoustic system for fermionic condensates from the Boltzmann-Fermi-Dirac equation

Schedule: December 19 9:00-9:30 Capital Suite 21 C

Benjamin Anwasia
New York University Abu Dhabi
United Arab Emirates

Abstract:
In quantum kinetic theory, the Boltzmann-Fermi-Dirac equation is the model that governs the evolution of a gas of fermions. At extremely low temperatures, fermions transition into a superfluid phase called a fermionic condensate. This superfluid phase is characterized by an equilibrium state of the Boltzmann-Fermi-Dirac equation, where all particles occupy their lowest energy levels while obeying the Pauli exclusion principle. Our objective is to demonstrate how to derive the acoustic equations for fermionic condensates as a hydrodynamic limit of the Boltzmann-Fermi-Dirac equation. This is a joint work with Diogo Ars\`enio.

Optimal transport of measures via autonomous vector fields

Schedule: December 18 17:30-18:00 Capital Suite 21 C

Nicola N De Nitti
EPFL
Switzerland

Abstract:
We study the problem of transporting one probability measure to another via an autonomous velocity field. We rely on tools from the theory of optimal transport. In one space-dimension, we solve a linear homogeneous functional equation to construct a suitable autonomous vector field that realizes the (unique) monotone transport map as the time-1 map of its flow. Generically, this vector field can be chosen to be Lipschitz continuous. We then use Sudakov's disintegration approach to deal with the multi-dimensional case by reducing it to a family of one-dimensional problems. This talk is based on a joint work with Xavier Fern�ndez-Real.

Small inertia limit for coupled kinetic swarming models

Schedule: December 19 13:00-13:30   Capital Suite 21 C

Simone Fagioli
University of L`Aquila
Italy

Co-Author(s): Y-P. Choi, V. Iorio

Abstract:
We investigate various versions of multi-dimensional systems involving many species, modeling aggregation phenomena through nonlocal interaction terms. We establish a rigorous connection between kinetic and macroscopic descriptions by considering the small-inertia limit at the kinetic level. The results are proven either under smoothness assumptions on all interaction kernels or under singular assumptions for \emph{self-interaction} potentials. Utilizing different techniques in the two cases, we demonstrate the existence of a solution to the kinetic system, provide uniform estimates with respect to the inertia parameter, and show convergence towards the corresponding macroscopic system as the inertia approaches zero.

The mean-field Limit of sparse networks of integrate and fire neurons

Schedule: December 18 17:00-17:30   Capital Suite 21 C

Pierre-Emmanuel Jabin
Pennsylvania State University
USA

Co-Author(s): D. Zhou

Abstract:
We study the mean-field limit of a model of biological neuron networks based on the so-called stochastic integrate-and-fire (IF) dynamics. Our approach allows to derive a continuous limit for the macroscopic behavior of the system, the 1-particle distribution, for a large number of neurons with no structural assumptions on the connection map outside of a generalized mean-field scaling. We propose a novel notion of observables that naturally extends the notion of marginals to systems with non-identical or non-exchangeable agents. Our new observables satisfy a complex approximate hierarchy, essentially a tree-indexed extension of the classical BBGKY hierarchy. We are able to pass to the limit in this hierarchy as the number of neurons increases through novel quantitative stability estimates in some adapted weak norm. While we require non-vanishing diffusion, this approach notably addresses the challenges of sparse interacting graphs/matrices and singular interactions from Poisson jumps, and requires no additional regularity on the initial distribution.

Compactness and existence theory for a general class of stationary radiative transfer equations

Schedule: December 19 14:30-15:00 Capital Suite 21 C

Jin Woo Jang
POSTECH
Korea

Co-Author(s): Elena Dematte, Juan J. L. Velazquez

Abstract:
In this talk, I will introduce a recent proof for the existence of the steady-states of a large class of stationary radiative transfer equations in a C^1 convex bounded domain. The main difficulty in proving existence of solutions is to obtain compactness of the sequence of integrals along lines that appear in several exponential terms. Currently available averaging lemmas do not seem to provide sufficient compactness that we require, and I will introduce our new compactness result suitable to deal with such a non-local operator containing integrals on a line segment.

Kinetic and hydrodynamic flocking models with nonlocal velocity alignment

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Schedule: December 19 13:30-14:00 Capital Suite 21 C

Changhui Tan
University of South Carolina
USA

Co-Author(s): McKenzie Black

Abstract:
The Euler-alignment system describes the collective behaviors of animal swarms. In this talk, we introduce a new type of alignment interaction that depends nonlinearly on velocity. We explore the asymptotic flocking and alignment behaviors. Notably, the introduction of nonlinearity yields a spectrum of distinctive asymptotic behaviors. Moreover, we present a rigorous derivation of our system from a kinetic flocking model.

Non-uniqueness for continuous solutions to 1D hyperbolic systems

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Schedule: December 19 8:30-9:00 Capital Suite 21 C

Cheng Yu
University of Florida
USA

Co-Author(s): Ming Chen, Alexis Vasseur

Abstract:
In this talk, I will discuss a geometrical condition on 2×2 systems of conservation laws leads to non-uniqueness in the class of 1D continuous functions. This demonstrates that the Liu Entropy Condition alone is insufficient to guarantee uniqueness, even within the mono-dimensional setting. This is a joint work with M.Chen and A. Vasseur.

Landau damping, collisionless limit, and stability threshold for the Vlasov-Poisson equation with nonlinear Fokker-Planck collisions

Schedule: December 19 14:00-14:30 Capital Suite 21 C

Weiren Zhao
New York University Abu Dhabi
United Arab Emirates

Abstract:
In this talk, I will present a recent work about the asymptotic stability of the global Maxwellian for the Vlasov-Poisson-Fokker-Planck (VPFP) equation with a small collision frequency. Our main result establishes the Landau damping and enhanced dissipation phenomena under the condition that the perturbation of the global Maxwellian falls within the Gevrey-1/s class and obtains that the stability threshold for the Gevrey-1/s class with $s > s_k$ can not be larger than $\gamma = \frac{1-3s_k}{3-3s_k}$ for $s_k \in [0, 1/3]$.

Special Session 129 : Inverse problems for nonlocal / nonlinear PDEs

Introduction: Fractional operators as components of partial differential equations have been studied since the 1950’s. In the late 1960s it was realised that the use of fractional order derivative damping terms in the wave equation restored a dependence on frequency; a missing requirement from physical observations that is not possible with integer order derivatives. Also dating from this period was the concept of fractional powers of partial differential operators. All such fractional operators are nonlocal; the value at a point depends also on values in a domain that includes that point as opposed to the pure pointwise situation of integer order derivatives. This paradigm has enormous implications in modelling but in particular for inverse problems involving such operators, especially those for which the "usual" inverse problem with integer order derivatives is severely ill-conditioned. Due to work over the last decade there are now many known examples of both fractional space operators and fractional time operators where such a “history effect” reduces the ill-conditioning significantly leading to much more tractable inversions. However, there is often a price to be paid and the cost is in a more difficult analysis due to the absence of some classical tools. This also shows up in the difficulty of proving uniqueness of the inversion map. The purpose of the special session is to bring together people working on different aspects of this topic.

Inverse problems for subdiffusion with an unknown terminal time

Schedule: December 19 13:00-13:30 Capital Suite 12 A

Bangti Jin
The Chinese University of Hong Kong
Hong Kong

Abstract:

Inverse problems of recovering space-dependent parameters, e.g., initial condition, space-dependent source, or potential coefficient in a subdiffusion model from the terminal observation are classical. However, all existing studies have assumed that the terminal time at which one takes the observation is exactly known. In this talk, we present uniqueness and stability results for three canonical inverse problems, e.g., backward problem, inverse source, and inverse potential problems from the terminal observation at an unknown time. We show the uniqueness and stability of the inverse problems and also present numerical illustrations of the behavior of the inverse problem.

Inverse problems for parabolic and pseudo-parabolic equations with p-Laplacian diffusion and damping

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Schedule: December 19 14:30-15:00 Capital Suite 12 A

Khonatbek Khompysh
Institute of Mathematics and Mathematical Modeling
Kazakhstan

Co-Author(s): Kenzhebai Kh.

Abstract:

In this talk, we discuss on uniquely solvability of inverse problems for parabolic and pseudo-parabolic equations perturbed by p-Laplacian diffusion and damping. Inverse problems consist of recovering a time dependent source/potential under the measurement in the integral form over the space domain. Under the suitable assumptions on the data, we establish existence and uniqueness of weak solutions posed inverse problems. This work supported by the grants no AP19676624 and AP23486218 Ministry of Science and Higher Education of the Republic of Kazakhstan (Kazakhstan)

An inverse source problem for a two dimensional time fractional diffusion equation with nonlocal boundary conditions

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Schedule: December 19 16:45-17:15 Capital Suite 12 A

Mokhtar KIRANE
Khalifa University
United Arab Emirates

Co-Author(s): M. Al-Gwaiz, M. Kirane, S.A. Malik

Abstract:

We consider the inverse source problem for a time fractional diffusion equation. The unknown source term is independent of the time variable, and the problem is considered in two dimensions. A bi-orthogonal system of functions consisting of two Riesz bases of the space $L^2((0,1)\times(0,1))$, obtained from eigenfunctions and associated functions of the spectral problem and its adjoint problem, is used to represent the solution of the inverse problem. Using the properties of the bi-orthogonal system of functions, we show the existence and uniqueness of the solution of the inverse problem and its continuous dependence on the data.

Inverse problems for semilinear Schrodinger equations on Riemannian manifolds at large frequency

Schedule: December 19 17:30-18:00 Capital Suite 12 A

Katya Krupchyk
University of California, Irvine
USA

Abstract:
In this talk, we will discuss inverse boundary problems for semilinear Schrodinger equations on smooth compact Riemannian manifolds of dimension two and higher with smooth boundary, at a large fixed frequency. We will demonstrate that certain classes of cubic nonlinearities are uniquely determined from the knowledge of the nonlinear Dirichlet-to-Neumann map at a large fixed frequency on quite general Riemannian manifolds. In particular, in contrast to the previous results available, here the manifolds need not satisfy any product structure, may have trapped geodesics, and the geodesic ray transform need not be injective. Only a mild assumption about the geometry of intersecting geodesics is required. This is joint work with Shiqi Ma, Suman Kumar Sahoo, Mikko Salo, and Simon St-Amant.

Fixed angle inverse scattering and rigidity of the Minkowski spacetime

Schedule: December 19 18:00-18:30 Capital Suite 12 A

Lauri Oksanen
University of Helsinki
Finland

Co-Author(s): Rakesh, Mikko Salo

Abstract:
An acoustic medium occupying a compact domain with non-constant sound speed is probed by an impulsive plane wave, and the far-field response is measured in all directions for all frequencies. A longstanding open problem, called the fixed angle scattering inverse problem, is the recovery of the sound speed from this far-field response. In some situations, the acoustic properties of the medium are modeled by a Lorentzian metric and then the goal is the recovery of this metric from the far field measurements corresponding to a finite number of incoming plane waves. We consider a time domain, near field version of this problem and show that natural fixed angle measurements distinguish between a constant velocity (the Minkowski metric) medium and a non-constant velocity (a general Lorentzian metric) medium.

Mathematical models for nonlinear ultrasound contrast imaging with microbubbles

Schedule: December 19 15:15-15:45 Capital Suite 12 A

Teresa Rauscher
University of Klagenfurt
Austria

Co-Author(s): Vanja Nikolic

Abstract:
Ultrasound contrast imaging is a specialized imaging technique that applies microbubble contrast agents to traditional medical sonography providing real-time visualization of blood flow and vessels. Gas filled microbubbles are injected into the body where they undergo compression and rarefaction and interact nonlinearly with the ultrasound waves. Therefore, the propagation of sound through bubbly liquid is a strongly nonlinear problem that can be modeled by a nonlinear acoustic wave equation for the propagation of the pressure waves coupled with an ordinary differential equation for the bubble dynamics. We start by deriving different models and then focus on the coupling of the Westervelt equation and the Rayleigh-Plesset equation, where we show well-posedness locally in time under suitable conditions on the initial data. Finally, we present numerical experiments on the single bubble dynamics and the interaction of the microbubbles and ultrasound waves.

A policy iteration method for inverse mean field games

Schedule: December 19 16:15-16:45 Capital Suite 12 A

Kui Ren
Columbia University
USA

Abstract:
We propose a policy iteration method to solve an inverse problem for a mean-field game (MFG) model, specifically to reconstruct the obstacle function in the game from the partial observation data of value functions, which represent the optimal costs for agents. The proposed approach decouples this complex inverse problem, which is an optimization problem constrained by a coupled nonlinear forward and backward PDE system in the MFG, into several iterations of solving linear PDEs and linear inverse problems. This method can also be viewed as a fixed-point iteration that simultaneously solves the MFG system and inversion. We prove its linear rate of convergence. In addition, numerical examples in 1D and 2D, along with performance comparisons to a direct least-squares method, demonstrate the superior efficiency and accuracy of the proposed method for solving inverse MFGs. This is a joint work with Nathan Soedjak and Shahyin Tong of Columbia University.

Inverse problems for some attenuated wave equations

Schedule: December 19 15:45-16:15 Capital Suite 12 A

Cong Shi
University of Vienna
Austria

Co-Author(s): Barbara Kaltenbacher and Otmar Scherzer

Abstract:
In this talk we will introduce a general attenuated wave equation in the frequency domain using pseudo differential operator, which can be transformed into fractionally damped wave equations in the time domain. We will first explore how this general model relates to various fractionally damped wave equations and illustrate the connection among the initial conditions derived from physical principle. Next, we will establish the uniqueness of both direct and inverse problems associated with this framework. Additionally, we will discuss the ill-posedness of the inverse problem by analyzing the asymptotic behavior of the singular values of the forward operator.

Inverse problems for nonlinear parabolic equations in domains with moving boundaries

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Schedule: December 19 14:00-14:30 Capital Suite 12 A

Madi Yergaliyev
Institute of Mathematics and Mathematical Modeling
Kazakhstan

Co-Author(s): Muvasharkhan Jenaliyev, Medina Kassen

Abstract:
We will explore inverse problems for nonlinear parabolic equations in degenerate domains and domains with moving boundaries. It is important to note that a significant characteristic of such inverse problems is that they are studied in degenerate domains, which, in turn, leads to additional solvability conditions. For example, for one inverse problem, the conditions for unique solvability are derived as a connection between a known multiplier on the right-hand side of the equation and the functions governing the changes in the boundaries of the nonlinearly degenerate domain.

Numerical Reconstruction of Potential and Initial Data in Subdiffusion using Observations at Two Time Levels

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Schedule: December 19 13:30-14:00 Capital Suite 12 A

Zhi Zhou
The Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Xu Wu

Abstract:
In this talk, we will discuss the numerical recovery of both initial data and a spatially dependent potential in time-fractional subdiffusion models using observations at two different time levels. This problem is challenging because the coefficients-to-state map is more complex than for a single coefficient, and the decoupling method remains unclear. Our investigation addresses critical aspects of the numerical treatment and analysis of this inverse problem, including proving conditional stability, developing an efficient solver, and designing a discrete numerical scheme with a provable error estimate. We develop a fixed-point iterative algorithm to recover the initial data and potential together. By establishing novel \textsl{a priori} estimates for the discrete direct problem, we demonstrate the contraction mapping property of the fixed-point iteration, leading to both convergence of the iteration and error estimates for the fully discrete reconstruction.

The Calder\`{o}n problem for nonlocal wave equations with polyhomogeneous nonlinearities

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Schedule: December 19 18:30-19:00 Capital Suite 12 A

Philipp Zimmermann
Universitat de Barcelona
Switzerland

Abstract:
The main purpose of this talk is to present recent results on the Calder\`{o}n problem for nonlocal wave equations with polyhomogeneous nonlinearities. We start by discussing the unique determination of homogeneous nonlinearities from the Dirichlet to Neumann map. Then, we explain how this approach can be generalized to recover polyhomogeneous nonlinearities. On the way, we discuss an optimal Runge approximation result, which in turn relies on the existence of very weak solutions to linear nonlocal wave equations with sources in $L^2(0,T;H^{-s}(\Omega))$.

Special Session 130 : kinetic theory, analysis and application

Introduction: Kinetic theory is a body of theory that studies statistical behavior of interacting particles. The formulation has been widely applied in understanding problems raise from physical and biological sciences. Prominent examples include the Boltzmann equation and the chemotaxis equation. This special session gather together experts in various sub-disciplines within kinetic theory, and showcases the most recently achieved result, both on the analysis front, and on the computation and application fronts.

Fast spectral method for the linearized Boltzmann collision operator

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Schedule: December 18 8:00-8:30 Capital Suite 8

Zhenning Cai
National University of Singapore
Singapore

Abstract:
We develop a fast numerical method for the Boltzmann collision operator linearized about the local Maxwellian. The algorihtm is based on the Fourier spectral method, and the computational cost is $O(N^4 \log N)$ for all variable hard sphere models. To achieve better numerical stability, we couple the Fourier method and the Burnett spectral method to handle the tail of the distribution function. In this talk, we will also discuss the potential use of our method in solving the steady-state Boltzmann equation.

An asymptotic preserving scheme for kinetic models with singular limit

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Schedule: December 17 19:00-19:30 Capital Suite 8

Alina Chertock
North Carolina State University
USA

Co-Author(s): Yan Bokai and Changhui Tan

Abstract:
We propose a new class of asymptotic preserving schemes to solve kinetic equations with a mono-kinetic singular limit. The main idea in dealing with singularity is to transform the equations by appropriate scalings in velocity. In particular, we study two biologically related kinetic systems. We derive the scaling factors and prove that the rescaled solution does not have a singular limit under appropriate spatial non-oscillatory assumptions, which can be verified numerically by a newly developed asymptotic preserving scheme. We conducted a few numerical experiments demonstrating the schemes` accuracy, stability, efficiency, and asymptotic preserving properties.

Model Reduction for Multiscale Dynamics on Networks

Schedule: December 17 18:00-18:30 Capital Suite 8

Weiqi Chu
University of Massachusetts Amherst
USA

Co-Author(s): Weiqi Chu, Qin Li, Alina Chertock

Abstract:
Consider a complex system consisting of a large number of interacting agents, coupled through pairwise interactions with nonhomogeneous weights. Simulating the dynamics and identifying patterns of collective behavior can become computationally expensive, particularly as the system size grows, making most of the related algorithms unscalable. In this talk, I propose a model-reduction framework that transforms heterogeneous interacting particle systems into multi-community mean-field models by accounting for the network community structures for reduction. I will also introduce two structure-preserving numerical methods for solving these reduced mean-field equations.

Forward and inverse computation for radiative transfer via hp-adaptive mesh refinement

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Schedule: December 18 9:30-10:00 Capital Suite 8

Shukai Du
Syracuse University
USA

Co-Author(s): Shukai Du, Samuel N. Stechmann

Abstract:
The forward and inverse problems for radiative transfer are critical in many applications, such as climate modeling, optical tomography, and remote sensing. Both problems present major challenges, particularly large memory requirements and computational expense, due to the high dimensionality of the equation and the iterative nature of solving the inverse problem. To tackle these challenges, we investigate the hp-adaptive mesh refinement approach, which has proved effective in efficiently representing solutions where they are smooth with high-order approximations, while also providing the flexibility to resolve local features through adaptive refinements. For the forward problem, we demonstrate that exponential convergence with respect to degrees of freedom (DOFs) can be achieved even when the solution exhibits certain levels of sharp gradients. For the inverse problem, we introduce a goal-oriented hp-adaptive mesh refinement method that can blend the two optimization processes -- one for inversion and one for mesh adaptivity -- thereby reducing computational cost and memory requirements. Numerical tests are presented to validate the theoretical predictions.

A mean-field approach for the asymptotic tracking of continuum target clouds

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Schedule: December 17 14:45-15:15 Capital Suite 8

Seung Yeal Ha
Seoul National University
Korea

Co-Author(s): Seung Yeal Ha and Hyunjin Ahn

Abstract:
In this talk, we propose a new coupled kinetic system arising from the asymptotic tracking of a continuum target cloud, and study its asymptotic tracking property. For the proposed kinetic system, we present an energy functional which is monotonic and distance between particle trajectories corresponding to kinetic equations for target, and tracking ensembles tend to zero asymptotically under a suitable sufficient framework. The framework is formulated in terms of system parameters and initial data. This is a joint work with Hyunjin Ahn (Myongji Univ. Korea)

Unique identification for discretized inverse problems

Schedule: December 17 18:30-19:00 Capital Suite 8

Ruhui Jin
University of Wisconsin-Madison
USA

Co-Author(s): Qin Li, Anjali Nair, Sam Stechmann

Abstract:
Theoretical inverse problems are often studied in an ideal infinite-dimensional setting. The well-posedness theory provides a unique reconstruction of the parameter function, when an infinite amount of data is given. Through the lens of PDE-constrained optimization, this means one attains the zero-loss property of the mismatch function in this setting. This is no longer true in computations when we are limited to finite amount of measurements due to experimental or economical reasons. Consequently, one must compromise the goal, from inferring a function, to a discrete approximation. What is the reconstruction power of a fixed number of data observations? How many parameters can one reconstruct? Here we describe a probabilistic approach, and spell out the interplay of the observation size (r) and the number of parameters to be uniquely identified (m). The technical pillar here is the random sketching strategy, in which the matrix concentration inequality and sampling theory are largely employed. By analyzing a randomly subsampled Hessian matrix, we attain a well-conditioned reconstruction problem with high probability. Our main theory is validated in numerical experiments, using an elliptic inverse problem as an example.

On the dynamical low-rank numerical method for kinetic equations

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Schedule: December 17 17:30-18:00 Capital Suite 8

Christian Klingenberg
Wuerzburg University
Germany

Co-Author(s): Lena Baumann (Wuerzburg, Germany), Lukas Einkemmer (Innsbruck, Austria) and Jonas Kusch (As, Norway)

Abstract:
The numerical solution of kinetic equations often requires a high computational effort and memory cost due to the potentially six-dimensional phase space. One approach to overcome this difficulty is the reduced order method dynamical low-rank approximation. It has recently gained an increasing interest as it has been shown to provide accurate numerical solutions of kinetic PDEs in various applications while reducing the computational time significantly. This talk will focus on a research project that has the goal to devise an efficient numerical method for solving a BGK-type kinetic equation

$$\partial t f + v \cdot \nabla f = \sigma(M - f).$$

Our approach has the potential to bring about large savings in computational time. We build on the low-rank approximation technique used by Einkemmer, Jingwei Hu, Ying, SIAM J. Sci. Comput. (2021). We show how we have made progress in reducing the numerical effort even further by proving stability estimates for a related system of kinetic equations, see Baumann, Einkemmer, Klingenberg, Kusch, SIAM J. Sci. Comput. (2024). This is joint work with Lena Baumann (W\urzburg, Germany), Lukas Einkemmer (Innsbruck,Austria) and Jonas Kusch (As, Norway).

A Hybrid Finite-Difference-Particle Method for Chemotaxis Models

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Schedule: December 17 17:00-17:30 Capital Suite 8

Alexander Kurganov
Southern University of Science and Technology
Peoples Rep of China

Co-Author(s): Alina Chertock, Shumo Cui, Chenxi Wang

Abstract:
Chemotaxis systems play a crucial role in modeling the dynamics of bacterial and cellular behaviors, including propagation, aggregation, and pattern formation, all under the influence of chemical signals. One notable characteristic of these systems is their ability to simulate concentration phenomena, where cell density undergoes rapid growth near specific concentration points or along certain curves. Such growth can result in singular, spiky structures and lead to finite-time blowups. Our investigation focuses on the dynamics of the Patlak-Keller-Segel chemotaxis system and its two-species extensions. In the latter case, different species may exhibit distinct chemotactic sensitivities, giving rise to very different rates of cell density growth. Such a situation may be extremely challenging for numerical methods as they may fail to accurately capture the blowup of the slower-growing species mainly due to excessive numerical dissipation. We propose a hybrid finite-difference-particle (FDP) method, in which a sticky particle method is used to solve the chemotaxis equation(s), while finite-difference schemes are employed to solve the chemoattractant equation. Thanks to the low-dissipation nature of the particle method, the proposed hybrid scheme is particularly adept at capturing the blowup behaviors in both one- and two-species cases. The proposed hybrid FDP methods are tested on a series of challenging examples, and the obtained numerical results demonstrate that our hybrid method can provide sharp resolution of the singular structures even with a relatively small number of particles. Moreover, in the two-species case, our method adeptly captures the blowing-up solution for the component with lower chemotactic sensitivity, a feature not observed in other works.

From Schr\{o}dinger to diffusion- speckle formation of light in random media and the Gaussian conjecture

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Schedule: December 18 8:30-9:00 Capital Suite 8

Anjali Nair
University of Chicago
USA

Co-Author(s): Guillaume Bal

Abstract:
A well-known conjecture in physical literature states that high frequency waves propagating over long distances through turbulence eventually become complex Gaussian distributed. The intensity of such wave fields then follows an exponential law, consistent with speckle formation observed in physical experiments. Though fairly well-accepted and intuitive, this conjecture is not entirely supported by any detailed mathematical derivation. In this talk, I will discuss some recent results demonstrating the Gaussian conjecture in a weak-coupling regime of the paraxial approximation. The paraxial approximation is a high frequency approximation of the Helmholtz equation, where backscattering is ignored. This takes the form of a Schr\{o}dinger equation with a random potential and is often used to model laser propagation through turbulence. The proof relies on the asymptotic closeness of statistical moments of the wavefield under the paraxial approximation, its white noise limit and the complex Gaussian distribution itself. I will describe two scaling regimes, one is a kinetic scaling where the second moment is given by a transport equation and a second diffusive scaling, where the second moment follows an anomalous diffusion. In both cases, the limiting complex Gaussian distribution is fully characterized by its first and second moments. An additional stochastic continuity/tightness criterion allows to show the convergence of these distributions over spaces of H\{o}lder-continuous functions. This is joint work with Guillaume Bal.

The sticky particle dynamics with alignment interactions

Schedule: December 17 15:15-15:45 Capital Suite 8

Changhui Tan
University of South Carolina
USA

Co-Author(s): Trevor Leslie

Abstract:
In this talk, I will introduce the Euler-alignment system in collective dynamics, which models flocking behavior. The discussion will center on weak solutions, with the goal of isolating a unique solution through the use of an entropic selection principle. Notably, this selection principle aligns with the sticky particle rules applied in the agent-based Cucker-Smale dynamics. I will present an analytical convergence result and discuss the formation of both finite- and infinite-time clusters.

On the exponential weak flocking for the kinetic Cucker-Smale model with non-compact support

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Schedule: December 18 13:30-14:00 Capital Suite 8

XINYU WANG
Seoul National University
Peoples Rep of China

Co-Author(s): Seung-Yeal Ha, Xinyu Wang,Xiaoping Xue

Abstract:
We study the propagation of the second spatial-velocity moments for the kinetic Cucker-Smale model with non-compact spatial support. In contrast to compact support, non-compact support leads to a lower bound of zero for the communication weight, which makes the previous approach break down. To address this challenge, we consider two types of initial distributions: exponential decay distributions and polynomial decay distributions. Moreover, our approach uses the infinite-particle mean-field approximation as an intermediary step to analyze the kinetic Cucker-Smale model, with conservation laws of mass and momentum. When initial distributions belong to the aforementioned types of decaying classes and coupling strength exceeds a certain threshold, we show the weak flocking behavior of the kinetic Cucker-Smale model. Specifically, the second velocity moment of the solution centered around the initial average velocity converges to zero, and the second spatial moment around the position of the center of mass remains uniformly bounded in time. The emergence of weak flocking behavior illustrates that even for non-compact support, a certain degree of aggregation can be maintained for the kinetic Cucker-Smale model, as long as the initial distribution exhibits relative concentration.

Shock Profiles for the Long-Range Boltzmann Equation

Schedule: December 17 16:15-16:45 Capital Suite 8

Dominic L Wynter
University of Texas at Austin
USA

Abstract:
The Boltzmann equation models gas dynamics in the low density or high Mach number regime, using a statistical description of molecular interactions. Shock wave solutions have been constructed for the Boltzmann equation with hard-sphere particle interactions, and more recently for the related Landau equation of plasma dynamics by Albritton, Bedrossian, and Novack. Along similar lines as these works, we construct traveling shock solutions for the Boltzmann equation when molecular interactions are long-range. We prove existence and uniqueness up to translation near compressible Navier-Stokes shock profiles, using stability estimates for the Boltzmann equation and the stability theory of viscous shocks.

Dimension-free ergodicity of path integral molecular dynamics: a generalized Gamma calculus approach

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Schedule: December 18 14:00-14:30 Capital Suite 8

Xuda Ye
Peking University
Peoples Rep of China

Co-Author(s): Zhennan Zhou

Abstract:
Path integral molecular dynamics (PIMD) is a standard method for computing thermal averages in quantum canonical ensembles, with its accuracy depending on the number of beads, D, representing the discretization size of the Feynman path integral. Despite its widespread use in computational physics, the ergodicity of PIMD, particularly the dependence of the convergence rate on D, is not well understood. In this talk, I will present a rigorous analysis proving the uniform-in-D ergodicity of PIMD, meaning that the convergence rate toward equilibrium is independent of the bead count D. This result is established for both overdamped and underdamped Langevin dynamics. Our approach relies on the generalized Gamma calculus, an advanced technique related to hypocoercivity, developed by Pierre Monmarch\`{e}, which provides deeper insight into the long-time behavior of these stochastic systems.

Random Winfree dynamics with high-order couplings

Schedule: December 18 9:00-9:30 Capital Suite 8

Jaeyoung Yoon
Technical University of Munich
Germany

Co-Author(s): Seung-Yeal Ha, Myeongju Kang, Jaeyoung Yoon and Mattia Zanella

Abstract:
Recently, Winfree dynamics with high-order couplings was studied for better description of nature communications. Of particular interest in this work is the random order, which means order of coupling is regarded as a random variable. We derive the sufficient conditions under which the random Winfree dynamics converges to death-state stably and compare the theoretical results with numeric simulations.

Infinitely many solutions to the isentropic system of gas dynamics

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Schedule: December 17 15:45-16:15 Capital Suite 8

Cheng Yu
University of Florida
USA

Abstract:
In this talk, I will discuss the non-uniqueness of global weak solutions to the isentropic system of gas dynamics. In particular, I will show that for any initial data belonging to a dense subset of the energy space, there exists infinitely many global weak solutions to the isentropic Euler equations for any $1 < \gamma \leq 1 + 2/n$. The proof is based on a generalization of convex integration techniques and weak vanishing viscosity limit of the Navier-Stokes equations. This talk is based on a joint work with M. Chen and A. Vasseur.

Fokker-Planck equations of neuron networks: numerical simulation and dilating the blowup solution

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Schedule: December 18 13:00-13:30 Capital Suite 8

Zhennan Zhou
Westlake University
Peoples Rep of China

Abstract:
In this talk, we are concerned with the Fokker-Planck equations associated with the Nonlinear Noisy Leaky Integrate-and-Fire model for neuron networks. Due to the jump mechanism at the microscopic level, such Fokker-Planck equations are endowed with an unconventional structure: transporting the boundary flux to a specific interior point. In the first part of the talk, we present a conservative and positivity-preserving scheme for these Fokker-Planck equations, and we show that in the linear case, the semi-discrete scheme satisfies the discrete relative entropy estimate, which essentially matches the only known long-time asymptotic solution property. We also provide extensive numerical tests to verify the scheme properties, and carry out several sets of numerical experiments, including finite-time blowup, convergence to equilibrium and capturing time-period solutions of the variant models. Secondly, we introduce a new notion of genealized solutions for this model with a dynamical time rescaling, so that the extension of solutions after blowups become possible.

A PDE-based model-free algorithm for Continuous-time Reinforcement Learning

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Schedule: December 18 12:30-13:00 Capital Suite 8

Yuhua Zhu
University of California, Los Angeles
USA

Abstract:
This talk addresses the problem of continuous-time reinforcement learning (RL). When the underlying dynamics remain unknown and only discrete-time observations are available, how can we effectively conduct policy evaluation and policy iteration? We first highlight that while model-free RL algorithms are straightforward to implement, they are often not a reliable approximation of the true value function. On the other hand, model-based PDE approaches are more accurate, but the inverse problem is not easy to solve. To bridge this gap, we introduce a new Bellman equation, PhiBE, which integrates discrete-time information into a PDE formulation. PhiBE allows us to skip the identification of the dynamics and directly evaluate the value function using discrete-time data. Additionally, it offers a more accurate approximation of the true value function, especially in scenarios where the underlying dynamics change slowly. Moreover, we extend PhiBE to higher orders, providing increasingly accurate approximations.

Special Session 131 : Recent progress on singularities formations of some evolution partial differential equations

Introduction: Introduction: This special session delves into the latest advancements concerning the formation of singularities and the dynamics of solutions near singularity for several different mathematical models that involve partial differential equations (PDEs). The wide scope of this session may provide a valuable opportunity for sharing ideas and problems among specialists.

Blow-Up Dynamics for the L^2 critical case of the 2D Zakharov-Kuznetsov equation

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Schedule: December 18 9:30-10:00 Capital Suite 1

Francisc Bozgan
NYUAD
United Arab Emirates

Co-Author(s): Tej-Eddine Ghoul, Nader Masmoudi

Abstract:
We investigate the blow-up dynamics for the L^2 critical two-dimensional Zakharov-Kuznetsov equation with initial data u_0 slightly exceeding the mass of the soliton solution Q, which satisfies $-\Delta Q + Q - Q^3 = 0$. Employing methodologies analogous to those used in the study of the gKdV equation of Martel, Merle and Raphael, we categorize the behavior of the solution into three outcomes: asymptotic stability, finite-time blow-up, or divergence from the soliton`s vicinity. The universal blow-up behavior that we find is slightly different from the conjecture of Klein, Roudenko and Stoilov, by deriving a non-trivial, computationally determinable constant for the blow-up rate, dependent on the two-dimensional soliton`s behavior. The construction of blow-up solution involves the bubbling of the solitary wave which ensures that it is stable.

Singularity of the 2d Keller-Segel system formed by the collision of two collapsing solitons in interaction

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Schedule: December 18 14:45-15:15 Capital Suite 1

Charles Collot
CY Cergy Paris Universite
France

Co-Author(s): Tej-Eddine Ghoul, Nader Masmoudi, Van Tien Nguyen

Abstract:
The two-dimensional Keller-Segel system admits finite time blowup solutions, which is the case if the initial density has a total mass greater than 8pi and a finite second moment. Several constructive examples of such solutions have been obtained, where for all of them a perturbed stationary state undergoes scale instability and collapses at a point, resulting in a 8pi-mass concentration. It was conjectured that singular solutions concentrating simultaneously more than one solitons could exist. We construct rigorously such a new blowup mechanism, where two stationary states are simultaneously collapsing and colliding, resulting in a 16pi-mass concentration at a single blowup point, and with a new blowup rate which corresponds to the formal prediction by Seki, Sugiyama and Velazquez. We develop for the first time a robust framework to construct rigorously such blowup solutions involving simultaneously the non-radial collision and concentration of several solitons, which we expect to find applications to other evolution problems.

Nonlinear wave equations in Cosmology: Some results, but mostly open problems

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Schedule: December 18 18:00-18:30 Capital Suite 1

Jean-Pierre Eckmann
University of Geneva
Switzerland

Co-Author(s): Farbod Hassani, Hatem Za`ag

Abstract:
In certain cosmological models (effective field theories) one encounters a non-linear wave equation of the form

$$u_{tt} = \alpha u_{xx} + \beta (u_x)^2$$

with $\alpha > 0$ and $\beta > 0$ in ≥ 1 dimension. While cosmologists believed that solutions stay bounded for large enough α, it has been known for some time that nontrivial initial conditions lead to divergence in finite time. After explaining some of these results, I will focus also on the scaling of the diverging solutions. (For the experts: In the cosmological context, one is not allowed to scale the initial condition, since it is given by background conditions.)

Stable self-similar blowup for the Keller-Segel model in three dimensions

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Schedule: December 18 15:15-15:45 Capital Suite 1

Irfan Glogic
Bielefeld University
Germany

Co-Author(s): Birgit Schorkhuber

Abstract:
We consider the three-dimensional parabolic-elliptic Keller-Segel model for bacterial chemotaxis. From the work of Brenner et al. in 1999, it is known that this model admits an explicit radial imploding self-similar solution. We prove the nonlinear radial asymptotic stability of this blowup profile. For this, we develop a stability analysis framework that applies to a large class of semilinear parabolic equations. In particular, we outline a robust technique to treat the underlying spectral problems. This is joint work with Birgit Schorkhuber (Innsbruck).

Blow-up Dynamics in Coupled Wave Systems with Tricomi Effects and Scale-Invariant Damping

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Schedule: December 18 8:30-9:00 Capital Suite 1

Makram Hamouda
Imam Abdlrahman Bin Faisal University
Saudi Arabia

Co-Author(s): M.F. Ben Hassen, M. A Hamza,

Abstract:
We present some results on the blow-up of systems of semilinear coupled waves with scale-invariant damping and time-derivative nonlinearities, examining various scenarios that include mass terms and time-dependent propagation speeds. A key novelty lies in a more refined characterization of the blow-up region, with a particular focus on the impact of the Tricomi term, which significantly alters the dynamics of the system. These findings relate to the well-known Glassey exponent. From a numerical perspective (Lattice Boltzmann methods and PINNs), we explore a tentative of blow-up time detection for some toy models. The determination of the threshold between blow-up and global existence regions is an interesting problem, but here we intend to provide some numerical insights for proving the conjectures on the critical nonlinearity exponent.

The blow-up rate for some nonlinear evolution equations in the log non-scaling invariance case

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Schedule: December 17 18:00-18:30 Capital Suite 1

Mohamed Ali Hamza
Imam Abdulrahman Bin Faisal University
Saudi Arabia

Co-Author(s): Hatem Zaag

Abstract:
In this talk, we discuss some evolution equations with logarithmic nonlinearity in the subconformal case. We show that the blow-up rate of any singular solution to the problem is like the ODE solution associated. In other terms, all blow-up solutions in the subconformal range are Type I solutions. This will constitute a good start in proving that the scale invariance property is not crucial in deriving the blow-up rate.

Blow-up phenomena in an integrable system with a singular integral and its application to traffic flow

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Schedule: December 18 16:15-16:45 Capital Suite 1

Kohei Higashi
Musashino University
Japan

Co-Author(s): Kohei Higashi

Abstract:
We investigate blow-up phenomena in an integrable system with a singular integral, which is described by the equation $u_t = -2Au_xTu_x - Vu_x + Du_{xx}$. Here, T is a singular integral operator with a $\coth$-type kernel, which incorporates nonlocal effects. A, V, and D are constants. By utilizing exact solutions, we examine four aspects: (1) determining the conditions under which blow-up occurs; (2) identifying the locations of blow-up points; (3) analyzing the form of the blow-up solution; and (4) exploring the system`s behavior after blow-up. Furthermore, we apply these findings to a traffic flow model, where blow-up corresponds to complete congestion in high-density regions.

Mathematical and Numerical Studies on Blow-up Rate of Solutions to Some Quasilinear Parabolic Equation

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Schedule: December 17 17:30-18:00 Capital Suite 1

Tetsuya Ishiwata
Shibaura Institute of Technology
Japan

Co-Author(s): Koichi Anada, Takeo Ushijima

Abstract:
In this talk, we discuss the blow-up rate of solutions to some quasilinear parabolic equations. In particular, we focus on type II blow-up solutions and show the mathematical results and the numerical observations. We also introduce our numerical estimation method for blow-up rate using the scale invariance.

Hyperbolic inequalities in an exterior domain: A general blow-up result for degenerate hyperbolic inequalities in an exterior domain

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Schedule: December 18 8:00-8:30 Capital Suite 1

Mokhtar KIRANE
Khalifa University
United Arab Emirates

Co-Author(s): M. Jleli, M. Kirane, B. Samet

Abstract:
We consider a degenerate hyperbolic inequality in an exterior domain under three types of boundary conditions: Dirichlet-type, Neumann-type, and Robin-type boundary conditions. Using a unified approach, we show that all the considered problems have the same Fujita critical exponent. Moreover, we answer some open questions from the literature regarding the critical case.

Blow-up phenomena in one-dimensional derivative nonlinear wave equations

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Schedule: December 18 17:30-18:00 Capital Suite 1

Jie Liu
New York University Abu Dhabi
United Arab Emirates

Co-Author(s): Tej-eddine Ghoul, Jie Liu, Nader Masmoudi

Abstract:
In this talk, we construct explicit smooth blow-up solutions for the one-dimensional derivative nonlinear wave equation, for which no smooth self-similar solutions exist. Additionally, we establish the stability of these blow-up solutions.

Representation formulas for eigenvalues and eigenfunctions concerning a phase-field model

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Schedule: December 17 15:45-16:15 Capital Suite 1

Tatsuki Mori
Musashino University
Japan

Co-Author(s): Tatsuki Mori, Yasuhito Miyamoto, Sohei Tasaki, Tohru Tsujikawa, Shoji Yotsutani

Abstract:
We have been investigating the global bifurcation diagrams of stationary solutions for a phase field model proposed by Fix and Caginalp in a one-dimensional case. It has recently been shown that there exists a secondary bifurcation with a symmetry-breaking phenomenon from a branch consisting of symmetric solutions in the case where the total enthalpy equals zero. In this talk, we determine the stability/instability of all symmetric solutions and asymmetric solutions near the secondary bifurcation point. Moreover, we show representation formulas for all eigenvalues and eigenfunctions for the linearized eigenvalue problem around the symmetric solutions.

Blowup solutions to the complex Ginzburg-Landau equation

Schedule: December 18 13:00-13:30 Capital Suite 1

Van Tien Nguyen
National Taiwan University
Taiwan

Co-Author(s): Jiajie Chen, Thomas Y. Hou, Yixuan Wang

Abstract:
We develop a so-called generalized dynamical rescaling method to study singularity formation in the complex Ginzburg-Landau equation (CGL). This innovative technique enables us to capture all relevant symmetries of the problem, allowing us to directly demonstrate a full stability of constructed blowup solutions. One of the advantages of our approach is its ability to circumvent spectral decomposition, which is often complex for problems involving non-self- adjoint operators. Additionally, the (CGL) system lacks a variational structure, making standard energy-type methods difficult to apply. By employing the amplitude-phase representation, we establish a robust analysis framework that enforces vanishing conditions through a carefully chosen normalization and utilizes weighted energy estimates.

Construction of type I-Log blowup for the Keller-Segel system in dimensions 3 and 4

Schedule: December 18 15:45-16:15 Capital Suite 1

Nejla Nouaili
CEREMADE Univesite Paris Dauphine PSL
France

Co-Author(s): Van Tien Nguyen and Hatem Zaag

Abstract:
We construct finite time blowup solutions to the parabolic-elliptic Keller-Segel system

$$\pa_t u = \Delta u - \nabla \cdot (u \nabla \mathcal{K}_u), \quad -\Delta \mathcal{K}_u = u \quad \textup{in} \ \mathbb{R}^d, \ d = 3, 4,$$

and derive the final blowup profile

$$u(r, T) \sim c_d \frac{|\log r|^{\frac{d-2}{d}}}{r^2} \quad \textup{as} \ \ r \to 0, \ \ c_d > 0.$$

To our knowledge this provides a new blowup solution for the Keller-Segel system, rigorously answering a question by Brenner, Constantin, Kadanoff, Schenkel, and Venkataramani (Nonlinearity, 1999).

Orbital stability for the vortex pair of the Gross-Pitaevskii equation

Schedule: December 18 9:00-9:30 Capital Suite 1

Eliot Pacherie
CNRS & Cergy University
France

Abstract:
The Gross-Pitaevskii equation admits small speed travelling wave solutions behaving like two well-separated vortices. We show that this solution is orbitally stable for the natural metric of the energy space. The proof is based on two main ingredients : a nonlinear coercivity result for small perturbations of the travelling waves, which generalizes a similar result for a single vortex, as well as a new formulation of the momentum using the coaera formula. This is a joint work with Philippe Gravejat and Frederic Valet

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A priori estimates of solutions of local and nonlocal superlinear parabolic problems

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Schedule: December 17 14:45-15:15 Capital Suite 1

Pavol Quittner
Comenius University, Bratislava
Slovak Rep

Abstract:
We consider a priori estimates of possibly sign-changing solutions to superlinear parabolic problems and their applications (blow-up rates, continuity of the blow-up time, existence of nontrivial steady states etc.). Our estimates are based on energy, interpolation and bootstrap arguments. We first discuss known results on local problems and then provide new results for problems with nonlocal nonlinearities or nonlocal differential operators. In particular, we deal with nonlocal nonlinearities occuring in the Choquard equation or the Schr\odinger-Poisson-Slater problem, and we also consider problems involving the fractional Laplacian.

The lifespan of classical solutions of one dimensional wave equations with semilinear terms of the spatial derivative

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Schedule: December 18 17:00-17:30 Capital Suite 1

Takiko Sasaki
Musashino Unversity
Japan

Co-Author(s): Shu Takamatsu, Hiroyuki Takamura

Abstract:
This talk is devoted to the lifespan estimates of small classical solutions of the initial value problems for one dimensional wave equations with semilinear terms of the spatial derivative of the unknown function. It is natural that the result is same as the one for semilinear terms of the time⊠derivative. But there are so many differences among their proofs. Moreover, it is meaningful to study this problem in the sense that it may help us to investigate its blow-up boundary in the near future.

General theory and its optimality for nonlinear wave equations in one apace dimension

Schedule: December 17 17:00-17:30 Capital Suite 1

Hiroyuki Takamura
Tohoku University
Japan

Co-Author(s): T.Sasaki, K.Morisawa, R.Kido, S.Takamatsu

Abstract:
In this talk, the recent progress on nonlinear wave equations in one space dimension will be presented. More precisely, the so-called combined effect plays a key role in the analysis on model equations which improves the general theory for nonlinear wave equations, expected complete more than 30 years ago.

Life-span of solutions for some nonlinear parabolic problems

Schedule: December 17 15:15-15:45 Capital Suite 1

Slim Tayachi
University of Tunis El Manar
Tunisia

Abstract:
In this talk, we present lower and upper bound estimates for the maximal existence time of solutions to the nonlinear heat equation, and solutions to a nonlinear parabolic system. We improve and extend some known results by considering a large class of initial data. Part of the results presented in this talk are from joint work with Fred B. Weissler.

A Blow-up theorem for discrete semilinear wave equation

Schedule: December 18 13:30-14:00 Capital Suite 1

Tetsuji Tokihiro
Musashino University
Japan

Co-Author(s): Kohei Higashi, Keisuke Matsuya, Takiko Sasaki, Ryosuke Tsubota

Abstract:
In this talk, we evaluate lifespan of the solution of the equation obtained by discretising a semilinear wave equation with a power-type nonlinear term. The discrete equation was first proposed by Matsuya(2013) and has the following form.
$u_n^{t+1} + u_n^{t-1} = \frac{4v_n^t}{2 - \delta^2 v_n^t |v_n^t|^{p-2}} \; (n \in \mathbb{Z}^d,\, t \in \mathbb{Z}_{\geq 0}) \; v_n^t \quad := \frac{1}{2d} \sum_{i=1}^{d} \left(u_{n+e_i}^t + u_{n-e_i}^t \right)$ In continuous limit, this discrete equation turns to the semiliniar wave equation: $u_{tt} = \Delta u + |u|^p$ This semiinear wave equation is known to explode if the exponent p appearing in the nonlinear term is smaller than a certain value when the initial conditions are sufficiently small, and the discrete equation has been proved to have similar behaviour to the original wave equation. We show that the discrete equation also has similar lifesapn to that of the semilinear wave equation.

Reference: Keisuke Matsuya (2013), A blow-up theorem for a discrete semilinear wave equation, Journal of Difference Equations and Applications, 19:3, 457-465

Critical exponents for the quasilinear heat equations with combined nonlinearities

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Schedule: December 18 14:00-14:30 Capital Suite 1

Berikbol T. Torebek
Ghent University
Belgium

Abstract:
This work studies the global behavior of solutions to the quasilinear inhomogeneous parabolic equation with combined nonlinearities. Firstly, we focus on an interesting phenomenon of discontinuity of the Fujita-type critical exponents. In particular, we will fill the gap in the results of Jleli-Samet-Souplet (Proc Am Math Soc 148:2579-2593, 2020) for the critical case. We are also interested in the influence of the forcing term on the critical behavior of the considered problem, so we will define the second critical exponent in the sense of Lee-Ni, depending on the forcing term.

Blow-up of solutions of semilinear wave equations in Friedmann-Lemaitre-Robertson-Walker spacetime

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Schedule: December 17 16:15-16:45 Capital Suite 1

Yuta Wakasugi
Hiroshima University
Japan

Co-Author(s): Kimitoshi Tsutaya

Abstract:
Consider semilinear wave equations in the spatially flat Friedmann-Lemaitre-Robertson-Walker (FLRW) spacetimes. We show some blow-up results obtained in recent years, including decelerating and accelerating expansion cases and power-type and derivative-type nonlinearities. Our approach is based on a generalized Kato`s lemma on ordinary differential inequalities and the test function method.

On optimal blowup stability for wave equations

Schedule: December 17 18:30-19:00 Capital Suite 1

David Wallauch-Hajdin
EPFL
Switzerland

Abstract:
This talk reports on the recent development of a unified approach to derive Strichartz estimates for radial wave equations with self-similar potentials in similarity variables.To illustrate the usefulness of these estimates we will derive an optimal blowup stability result for a nonlinear wave equation.

Numerical and analytical approaches for the blow-up dynamics for some nonlinear dispersive equations

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Schedule: December 17 19:00-19:30 Capital Suite 1

Kai Yang
Chongqing University
Peoples Rep of China

Abstract:
We discuss some results about the existence and stable blow-up solutions and their dynamics for the L2 critical and super-critical nonlinear Schrodinger type and the KdV type equations. These results are obtained from both numerical and analytical approaches. This is joint work with Luiz Farah, Justin Holmer, Annie Millet, Svetlana Roudenko and Yanxiang Zhao.

Critical and subcritical blow-up for the nonlocal shadow limit of the Gierer-Meinhardt system

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Schedule: December 18 12:30-13:00 Capital Suite 1

Hatem Zaag
CNRS and Universite Sorbonne Paris Nord
France

Abstract:

The Gierer-Meinhardt system is a model for pattern formation based on Turing`s mechanism. Under some conditions, it reduces to a scalar heat equation, with a nonlinearity showing a pure power divided by some non-local term. Depending on parameters, that equation shows two different types of blow-up behavior: - in some subcritical range of parameters, the non-local term converges to a positive constant, leading to some blow-up behavior similar to the classical semilinear heat equation, with power nonlinearity ; - in the critical case, the non-local term converges to infinity, weakening the effect of the pure power nonlinearity. This leads to a new type of blow-up behavior, unknown in earlier literature. In this talk, we construct examples for the two types of behaviors, and give their blow-up profiles. Our method happens to be a non-trivial adaptation of the classical construction method for the semilinear heat equation.

Special Session 132 : Advances in Nonlinear PDE-based Models for Artificial Intelligence and Computer Vision

Introduction: The nonlinear partial differential equations (PDE), that have long been used to formulate various dynamical phenomena, have been applied successfully in many important sub-domains of Artificial Intelligence (AI) in the last four decades. They include image and video processing and analysis and computer vision fields, such as image/video filtering, inpainting, segmentation, compression, decomposition, registration and motion estimation. The PDEs can be also used successfully to create scale-space representations that are used for various multi-scale image analysis tasks. An important AI sub-domain, Deep Learning, represents an application area of the PDEs, too. The neural partial differential equations (NPDE) could describe AI systems and the architectures of some deep models, like recurrent neural networks (RNN), may be interpreted as nonlinear PDEs. Some evolution partial differential equation could be learned from certain datasets using deep neural networks, that also predict their dynamical behavior. The Convolutional Neural Networks (CNN) are increasingly used for solving nonlinear diffusion-based models and are also used in connection to PDEs to solve many computer vision tasks. This special session aims to disseminate advanced and original research in these PDE-based AI and CV areas, bring together researchers working in these fields and promote exchange of valuable ideas between them.

Active Contour-based Image Segmentation Framework using a Nonlinear Second-order Diffusion-based Model

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Schedule: December 19 15:15-15:45 Conference Hall B (C)

Tudor Barbu
Institute of Computer Science of the Romanian Academy
Romania

Abstract:
Active contour models represent well-known computer vision techniques for image segmentation. They are divided into parametric and geodesic active contours (GAC). In this work we introduce a novel PDE-based segmentation approach inspired by the GAC models and level-set method. The proposed segmentation scheme evolves level-set based active contours toward the boundaries of some certain objects in the analyzed image. A second-order nonlinear anisotropic diffusion model is introduced here for this task. Its curve evolution equation is based on a level-set function u, representing the evolving function, and image function v. It uses a properly chosen stopping function whose arguments are based on v, and a positive monotonically decreasing diffusivity conductance function receiving combinations of gradients and Laplacians of u as arguments. A rigorous mathematical treatment is performed on this nonlinear parabolic PDE model, its validity being investigated. We demonstrate that it admits a unique weak solution under some certain assumptions. Then it is solved numerically applying a finite difference-based approximation algorithm developed by us. That algorithm provides successful results when applied to image objects. The discrete u is initialized as a square contour covering almost the entire image and evolves to objects` edges in few iterations (less than 100). The proposed active contour-based segmentation solution can be applied successfully to important computer vision tasks, like object detection and tracking.

The optical flow problem: an optimal control approach

Schedule: December 19 16:15-16:45 Conference Hall B (C)

Gabriela Marinoschi
Gheorghe Mihoc-Caius Iacob Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy
Romania

Co-Author(s): Gabriela Marinoschi

Abstract:
The optical flow problem consists in determining the motion, or more exactly the velocity field, of an object function representing the brightness pattern in an image. The optical flow problem is reduced to an optimal control problem governed by a linear parabolic equation having the unknown velocity field (the optical flow) as drift term. This model is derived from a new assumption, that is, the brightness intensity is conserved on a moving pattern driven by a Gaussian stochastic process. The optimality conditions are deduced by a passage to the limit technique in an approximating optimal control problem introduced for a regularization purpose. Finally, the controller uniqueness is addressed. This optical flow estimation solution can be applied successfully in AI and CV-based domains like the video object detection and tracking. This is a joint work with V. Barbu.

Deep Ridgelet Transform: Harmonic Analysis for Deep Neural Network

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Schedule: December 19 15:45-16:15 Conference Hall B (C)

Sho Sonoda
RIKEN
Japan

Abstract:
The ridgelet transform has been developed to study neural network parameters, and it can describe the distribution of parameters. Mathematically, it is defined as a pseudo-inverse operator of neural networks. Namely, given a function f, and network $NN[\gamma]$ with parameter γ, the ridgelet transform $R[f]$ for the network NN satisfies the reconstruction formula $NN[R[f]] = f$. For depth-2 fully-connected networks on a Euclidean space, the ridgelet transform has been discovered up to the closed-form expression, thus we could describe how the parameters are distributed. However, for a variety of modern neural network architectures, the closed-form expression has not been known. In this talk, I will introduce a systematic method to induce the generalized neural networks and their corresponding ridgelet transforms from group equivariant functions, and present an application to deep neural networks.

Special Session 134 : Recent advances in wavelet analysis, PDEs and dynamical systems - part II

Introduction: This session is a follow-up of the SS90 - AIMS WILMINGTON 2023. We focus our attention on recent interconnections between wavelet analysis, PDEs and dynamical systems -- including pure analysis and applications. In particular, this Special Session is dedicated to the analysis of both PDEs and dynamical systems by wavelet-fractal analysis and vice versa. Our main goal is to bring together scholars working in wavelet analysis, PDEs and dynamical systems, in order to report the newest progress, exchange ideas, forge new cooperation and to discuss both classical and merging open problems. The following is a non-exhaustive list of topics to be discussed in this session. - Wavelet methods for PDEs - Fractal-wavelet characterization of dynamical systems - Multiresolutional algorithms for operator equations - Hamiltonian systems, Lyapunov functions and stability - Dynamical systems and fractal sets - Variational methods

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HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS WITH DISCRETE EFFECT MEMORY AND BOUNDARY VALUE PROBLEMS FOR ITS

Schedule: December 17 8:00-8:30 Capital Suite 7

Anar Assanova
Institute of Mathematics and Mathematical Modeling
Kazakhstan

Abstract:
In the present communication we study a questions for existence and uniqueness of solution to the boundary value problem for the system of hyperbolic partial differential equations with discrete effect memory on the rectangular domain. Considered problem is transferred to family of problems for differential equations with discrete effect memory and integral condition by introducing a new functions. Further, introducing functional parameters as the values of the desired solution along the lines of the domain partition with respect to the time variable, we obtain an equivalent problem for the system of differential equations with initial conditions and functional relations with respect to the introduced parameters. We have developed a two-stage procedure to approximately solve the latter problem. We have obtained some conditions for the convergence of approximate solutions to the exact solution of the problem under study in terms of input data and proved that these conditions guarantee the existence of a unique solution of the equivalent problem. Finally, we have established coefficient conditions for the unique solvability of the problem for the system of hyperbolic partial differential equations with discrete effect memory subject initial and integral conditions. This research is funded by the Science Committee of the Ministry of Science and Higher Education of Republic of Kazakhstan (Grant no. AP19675193).

Perturbations of non-autonomous second-order abstract Cauchy problems

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Schedule: December 17 8:30-9:00 Capital Suite 7

Christian Budde
University of the Free State
So Africa

Co-Author(s): Christian Seifert

Abstract:
In this talk we present time-dependent perturbations of second-order non-autonomous abstract Cauchy problems associated to a family of operators with constant domain. We make use of the equivalence to a first-order non-autonomous abstract Cauchy problem in a product space, which we elaborate in full detail. As an application we provide a perturbed non-autonomous wave equation. Autonomous second-order abstract Cauchy problems which often occur in the context of wave equations, have been studied intensively by several authors in the past. In contrast to the first-order problem, where (classical) solutions are given by C0-semigroups, one needs another solution concept for the second-order case, the so-called cosine and sine families. Similar to the Hille-Yosida generation theorem for strongly continuous semigroups, one can also characterize generators of cosine families. Non-autonomous second-order abstract Cauchy problems have been studied first by Kozak and later on by Bochenek, Winiarska and Lan, just to mention a few. The classical idea helps to reduce the non-autonomous second-order abstract Cauchy problem again to a first-order problem. The goal is to establish a bounded perturbation result for non-autonomous second-order abstract Cauchy problems. As mentioned above, we also discuss the non-autonomous wave equation as an example.

Support Vector Regression Estimator with Kalman Filtering for Testing Chaotic dynamic System via lyapunov Exponents

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Schedule: December 17 16:15-16:45 Capital Suite 7

Slim cho Chokri
Mocfine laboratory ISCAE Manouba University
Tunisia

Abstract:
Support vector machines (SVMs) are a recent supervised learning approach towards function estimation. They combine several results from statistical learning theory, optimisation theory, and machine learning, and employ kernels as one of their most important ingredients. In this regard we propose a novel methodologie to derives a formal test from the nonparametric support vector regression estimator of the Lyapunov exponent in a noisy system with Kalman filtering (SVREKF). Amongst others the advantage of SVREKF compared to the widely used estimators (which is implemented using Artifcial Neural Network (ANN)) is, implicit nonlinear mapping and better regularization capability. In this work, we make use of Kalman recursions instead of quadratic programming which is generally used in kernel methods. We introduce a statistical framework for testing the chaotic hypothesis based on the estimated Lyapunov exponents and a consistent variance estimator. We apply our test to some of the standard chaotic systems and the financial time series. The performance of the test is very satisfactory in the presence of noise as well as with limited number of observations.We also discuss some of the limitations of our fndings.

Fractality in prime distribution

Schedule: December 16 17:00-17:30 Capital Suite 7

Emanuel Guariglia
Wenzhou-Kean University
Peoples Rep of China

Co-Author(s): Shengyi Qi

Abstract:
This work concerns the fractal-like behavior of prime subsets. Numerical simulations indicate that some prime subsets (e.g., Chen primes, Gaussian primes) resemble a fractal-like behavior. Our simulations are based on the construction of binary images based on prime numbers. Indeed, two-integer sequences can easily be converted into a two-color image. In particular, the Cantor set seems to cover a relevant role in our analysis. It seems that the Cantor set has a sort of relevant role in prime number theory. In addition, our results have potential applications in chaotic dynamical systems and cryptography.

Global dynamics of a tumor growth model with three mechanisms

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Schedule: December 17 12:30-13:00 Capital Suite 7

Mahmoud A. Ibrahim
Bolyai Institute, university of Szeged
Hungary

Co-Author(s): Attila D\`enes and Gergely R\ost

Abstract:
Understanding the emergence of chemotherapy resistance in cancer patients, whether driven by Darwinian evolution, gene expression changes, or the transfer of microvesicles from resistant to sensitive cells, is crucial as it significantly impacts treatment outcomes by promoting the survival and spread of resistant cells. We have developed a mathematical model to describe the evolution of tumor cells that are either sensitive or resistant to chemotherapy and to make it more realistic by including a separate equation for the number of microvesicles. This model accounts for three resistance mechanisms: Darwinian selection, Lamarckian induction, and resistance via microvesicle transfer, mimicking infectious spread. Our analysis identifies three key threshold parameters that determine the stability and existence of different equilibria within the system. We provide a comprehensive description of the global dynamics, including the existence of global attractors, depending on these threshold values. Additionally, we explore the effects of varying drug concentrations and characterize potential bifurcation sequences that lead to either successful treatment or therapeutic failure. Lastly, we identify the factor that exerts the most significant influence on cancer cell growth.

Vortex dynamics for the Gross-Pitaevskii equation

Schedule: December 16 17:30-18:00 Capital Suite 7

Rowan Juneman
University of Bath
England

Co-Author(s): Manuel del Pino, Monica Musso

Abstract:
The Gross-Pitaevskii equation in the plane arises as a physical model for an idealized, two-dimensional superfluid. We construct solutions to this equation with multiple vortices of degree ± 1, corresponding to concentration points of the associated fluid vorticity. The vortex dynamics is described on any finite time interval, and at leading order is governed by the classical Helmholtz-Kirchhoff system. Compared to previous rigorous results of Bethuel-Jerrard-Smets and Jerrard-Spirn, we use a different method based on linearization around an approximate solution. This approach provides a very precise description of the solutions near the vortex set and information on lower order corrections to the vortex dynamics. Moreover, our analysis of the linearized problem is potentially of independent interest in the study of long-time dynamics. This is joint work with Manuel del Pino and Monica Musso.

Geometrical equivalence of global attractors of reaction diffusion equations under Lipschitz perturbations

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Schedule: December 16 14:45-15:15 Capital Suite 7

Jihoon Lee
Chonnam National University
Korea

Abstract:
In this talk, we explore the geometrical equivalence among the global attractors of reaction diffusion equations under Lipschitz perturbations of the domain and equation. Using the facts, we obtain the continuity of the global attractors of reaction diffusion equations if every equilibrium point of the system is hyperbolic. These extend the recent results L.Pires. {\it Joint work with N.Nguyen and L.Pires.}

On the generalization of IFSs

Schedule: December 17 13:30-14:00 Capital Suite 7

Lianglin Li
Wenzhou-Kean University
Peoples Rep of China

Co-Author(s): Emanuel Guariglia, Jiayi Wei

Abstract:
This talk concerns the generalization of iterated function systems. In fractal geometry, iterated function systems have already been generalized for superfractals by the concept of superIFS. Here, we propose another generalization of iterated function systems with an application in signal theory.

Global existence for the 2D Kuramoto-Sivashinsky equation

Schedule: December 16 13:30-14:00 Capital Suite 7

Anna L Mazzucato
Penn State University
USA

Co-Author(s): David Ambrose

Abstract:
I will present recent results concerning global existence for the Kuramoto-Sivashinsky equation in 2 space dimensions in the presence of growing modes. The KSE is a model of long-wave instability in dissipative systems.

Extension of wavelets/PDEs to topologically complicated domains

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Schedule: December 17 13:00-13:30 Capital Suite 7

Mani Mehra
Department of Mathematics, Indian Institute of Technology Delhi, IITD, India
India

Abstract:

Differential equations on topologically complicated domains is a relatively new branch in the theory of differential equations. Some of the examples include differential equations on manifolds or irregularly shaped domains and differential equation on network-like structure. Differential equations on manifolds arises in the areas of mathematical physics, fluid dynamics, image processing, medical imaging etc.. Differential equations on network-like structure also play a fundamental role in many problems in science and engineering. The aim of this talk is to show how wavelets could be extended to network to solve partial differential equations on network like structure using spectral graph wavelet.

Incompressible MHD Without Resistivity: Structure and regularity

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Schedule: December 17 9:30-10:00 Capital Suite 7

Ronghua Pan
Georgia Institute of Technology
USA

Abstract:

We study the global existence of classical solutions to the incompressible MHD system without magnetic diffusion in 2D and 3D. The lack of resistivity or magnetic diffusion poses a major challenge to a global regularity theory even for small smooth initial data. However, the interesting nonlinear structure of the system not only leads to some significant challenges, but some interesting stabilization properties. This helps the establishment of the global regularity and the existence of global strong solutions.

Dynamics of the Navier-Stokes equations in critical spaces

Schedule: December 16 19:00-19:30 Capital Suite 7

Gabriela Planas
Universidade Estadual de Campinas
Brazil

Co-Author(s): M. Ikeda, L. Kosloff, C. Niche

Abstract:

We discuss the large-time dynamics for the Navier-Stokes equations in the critical space $\dot{H}^{1/2}$. Known decay estimates merely provide decay to zero with no explicit rates. We show an algebraic upper bound for the decay rate of solutions.

Regularity procedure for solutions of PDEs having discontinous coefficients

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Schedule: December 16 12:30-13:00 Capital Suite 7

Maria Alessandra Ragusa
University of Catania
Italy

Abstract:
Sharp inequalities have a rich tradition in harmonic analysis, going back to the epoch-making works of Hardy--Littlewood--Sobolev inequalities. In this talk, we survey selected highlights from the past decades, describe some of our own contributions, and pose a few open problems which lie at the interface of euclidean harmonic analysis, regularity of solutions of PDEs and systems.

Algorithmic detection of conserved quantities for finite- difference schemes

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Schedule: December 17 14:45-15:15 Capital Suite 7

Ricardo L Ribeiro
KAUST
Saudi Arabia

Co-Author(s): Diogo A. Gomes, Friedemann Krannich, Bashayer Majrashi

Abstract:
Many partial differential equations (PDEs) admit conserved quantities such as mass for the heat equation or energy for the advection equation. These are often essential for establishing well-posedness results. When approximating a PDE with a finite-difference scheme, it is crucial to determine whether related discretized quantities remain conserved by the scheme. Such conservation may ensure the stability of the numerical scheme. We present an algorithm for verifying the preservation of a polynomial quantity under a polynomial finite-difference scheme. Our schemes can be explicit or implicit, have higher-order time and space derivatives, and have an arbitrary number of variables. Additionally, we introduce an algorithm for finding conserved quantities. We illustrate our algorithm in several finite-difference schemes. Our approach incorporates a naive implementation of Comprehensive Grobner Systems to handle parameters, ensuring accurate computation of conserved quantities.

Interior estimates for elliptic equations in Morrey-type spaces

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Schedule: December 16 13:00-13:30 Capital Suite 7

Andrea Scapellato
University of Catania
Italy

Abstract:
The talk deals with some interior estimates for the solutions of elliptic equations in Morrey-type spaces. We collect some results related to the boundedness of fractional integral operators in several Morrey-type spaces and we show some applications related to the regularity theory for elliptic equations with discontinuous coefficients both in non-divergence and divergence form.

Homogenization of elliptic operators with coefficients in variable exponent Lebesgue spaces

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Schedule: December 16 16:15-16:45 Capital Suite 7

Adisak Seesanea
Sirindhorn International Institute of Technology, Thammasat University
Thailand

Abstract:
We shall discuss homogenization problems involving second-order elliptic operators in the divergence form whose drift and potential terms belong to variable exponent Lebesgue spaces $L^{p(\cdot)}$. Our techniques rely on a study of the periodic unfolding method in the $L^{p(\cdot)}$ setting. This is a joint work with Mya Hnin Lwin.

Axisymmetric flows with swirl for Euler and Navier-Stokes equations

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Schedule: December 16 15:45-16:15 Capital Suite 7

Athanasios Tzavaras
King Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): Theodoros Katsaounis and Ioanna Mousikou

Abstract:
We consider the incompressible axisymmetric Navier-Stokes equations with swirl as an idealized model for tornado-like flows. Assuming an infinite vortex line which interacts with a boundary surface resembles the tornado core, we look for stationary self-similar solutions of the axisymmetric Euler and axisymmetric Navier-Stokes equations. We are particularly interested in the connection of the two problems in the zero-viscosity limit. First, we construct a class of explicit stationary self-similar solutions for the axisymmetric Euler equations. Second, we consider the possibility of discontinuous solutions and prove that there do not exist self-similar stationary Euler solutions with slip discontinuity. This nonexistence result is extended to a class of flows where there is mass input or mass loss through the vortex core. Third, we consider solutions of the Euler equations as zero-viscosity limits of solutions to Navier-Stokes. Using techniques from the theory of Riemann problems for conservation laws, we prove that, under certain assumptions, stationary self-similar solutions of the axisymmetric Navier-Stokes equations converge to stationary self-similar solutions of the axisymmetric Euler equations as the viscosity tends to zero. This allows to characterize the type of Euler solutions that arise via viscosity limits.

Blow up solutions on critical problems

Schedule: December 16 14:00-14:30 Capital Suite 7

Giusi Vaira
University of Bari Aldo Moro
Italy

Abstract:
In this talk I will consider some critical problems on domans and on manifold with boundary discussing the existence and qualitative properties of solutions.

Generalized eigenvalue problem of quantum walks in 1-dimension

Schedule: December 16 15:15-15:45 Capital Suite 7

Kazuyuki Wada
Hokkaido University of Education
Japan

Co-Author(s): Masaya Maeda, Akito Suzuki

Abstract:
This talk is concerned with the discrete-time quantum walks in 1-dimension. This model is corresponding to the space-time discretized Dirac equation. We consider the generalized eigenvalue problem under long-range perturbations and construct Jost solutions. After that, we apply it to spectral theory.

Exponential spectral process (ESP): High order temporal discretization for semilinear PDEs

Schedule: December 17 15:15-15:45 Capital Suite 7

Xiang Wang
Jilin University
Peoples Rep of China

Abstract:
We propose an exponential spectral process (ESP) method for time discretization of spatial-temporal equations. The proposed ESP method uses explicit iterations at each time step, which allows us to use simple initializations at each iteration. This method has the capacity to obtain high accuracy (up to machine precision) with reasonably large time step sizes. Theoretically, the ESP method has been shown to be unconditionally energy stable for arbitrary number of iteration steps for the case where two spectral points are used. To demonstrate the advantages of the ESP approach, we consider two applications that have stability difficulties in large-time simulations. One of them is the Allen-Cahn equation with the symmetry breaking problem that most existing time discretizations face, and the second one is about the complex Ginzburg-Landau equation, which also suffers from large-time instabilities.

Chaos and convergence in 3D H\`{e}non maps

Schedule: December 17 14:00-14:30 Capital Suite 7

Jiayi Wei
Wenzhou-Kean University
Peoples Rep of China

Co-Author(s): Emanuel Guariglia, Lianglin Li

Abstract:
This work concerns the chaotic behavior in H\`{e}non maps. More precisely, we deal with its aperiodic orbits. We thus remove these points from the dynamics of the 3D H\`{e}non map. Our results are based on a perturbation technique so that the perturbed map has the same fixed points of the 3D H\`{e}non map.

Stability of the Caffarelli-Kohn-Nirenberg inequality

Schedule: December 16 18:00-18:30 Capital Suite 7

Yuanze Wu
China University of Mining and Technology
Peoples Rep of China

Co-Author(s): Juncheng Wei

Abstract:
In this talk, I will report our recent results on the stability of the Caffarelli-Kohn-Nirenberg inequality both in the functional inequality setting and in the critical point setting. In these results, we establish the sharp Bianchi-Egnell stability in the functional inequality setting under the nondegenerate assumption and discuss the existence of minimizers of the variational problem related to the optimal constant. We also establish the sharp Figalli-Glaudo stability in the critical point setting both under the nondegenerate assumption and the degenerate assumption. Rather surprisingly, the optimal power of the stability under the degenerate assumption is an absolute constant which is independent of the power of the nonlinearity and the number of bubbles.

Parabolic-scalings on asymptotic expansion of the incompressible Navier-Stokes flow

Schedule: December 16 18:30-19:00 Capital Suite 7

Masakazu Yamamoto
Niigata University
Japan

Abstract:
In this talk, large-time behavior of the incompressible Navier-Stokes flow in n-dimensional whole space is discussed. For this theme, Carpio (1996) and Fujigaki and Miyakawa (2001) derived the asymptotic expansion up to n-th order by employing the theory via Escobedo and Zuazua (1991). In those expansion, integrability of the moments of solution is required. However, on the next profile, the moment is growing logarithmically in time. Not only that, but there is also a problem with spatial integrability since the nonlinear effect contains the nonlocal operator. More precisely it contains the Riesz transform which is coming from the solenoidal conditions. To omit those difficulties, we employ the renormalization together with Biot-Savart law. By employing this method, asymptotic expansion up to 2n-th order is derived. Any terms on the expansion have their own parabolic-scalings. The parabolic scaling guarantees uniqueness of the expansion. Furthermore the above logarithmic evolution is specified on this expansion.

Optimistic Sample Size Estimate for Deep Neural Networks

Schedule: December 17 15:45-16:15 Capital Suite 7

Yaoyu Zhang
Shanghai Jiao Tong University
Peoples Rep of China

Abstract:
Estimating the sample size required for a deep neural network (DNN) to accurately fit a target function is a crucial issue in deep learning. In this talk, we introduce a novel sample size estimation method inspired by the phenomenon of condensation, which we term the optimistic estimate. This method quantitatively characterizes the best possible performance achievable by neural networks. Our findings suggest that increasing the width and depth of a DNN preserves its sample efficiency. However, increasing the number of unnecessary connections significantly deteriorates sample efficiency. This analysis provides theoretical support for the commonly adopted strategy in practice of expanding network width and depth rather than increasing the number of connections.

Singularity formation for the heat flow of the H-system

Schedule: December 17 9:00-9:30 Capital Suite 7

Yifu Zhou
Wuhan University
Peoples Rep of China

Co-Author(s): Yannick Sire, Juncheng Wei, and Youquan Zheng

Abstract:
In this talk, we shall briefly report a recent gluing construction of finite-time blow-up for the heat flow of the H-system, describing the evolution of surfaces with constant mean curvature. One key observation is a decoupling property of the system at linear level, and as a by-product, non-degeneracy of H-bubbles with higher degree is shown.

Special Session 135 : Latest Developments in Computational Methods for Differential Equations Arising in Fluid Dynamics with Multi-scale and Boundary Layer Behaviour

Introduction: Several real-life problems are modeled by ordinary and partial differential equations. In particular, several differential equations arising in fluid dynamics are nonlinear in nature. Obtaining closed form analytical solutions to these problems are very difficult and almost impossible in some cases. Therefore, one has to seek numerical approximate solutions to these problems. When the solutions of these differential equations have multi-scale behavior or exhibit boundary layers, then the classical methods fail to yield satisfactory numerical approximate solutions, and one has to use certain layer-adapted nonuniform meshes. In addition, we will discuss efficient numerical and analytical solution techniques to various types of differential equations arising in real-life applications. In this special session, several researchers across the globe, will present their latest contributions in this direction.

Singularly Perturbed Differential Equations on a Graph Domain

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Schedule: December 16 15:15-15:45 Capital Suite 12 A

Vivek Kumar Aggarwal
Delhi Technological University
India

Abstract:
In this talk, singularly perturbed convection dominant and reaction diffusion problems will be discussed on a graph domain. Challenges (such as Kirchhoff`s conditions, continuity conditions) related to the graph domain will be taken care. Some problems on a tripod is solved numerically and in closed form for the validation of the proposed method. A general graph is also discussed along with a diamond graph for singularly perturbed problems. Error estimated have also been done.

Data Driven Approach to Estimate Perturbation Parameter for Singularly Perturbed Problems using Differential Evolution

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Schedule: December 16 18:00-18:30 Capital Suite 12 A

Vivek Kumar Aggarwal
Delhi Technological University
India

Abstract:

This paper introduces a machine learning framework using differential evolution algorithm to learn the perturbation parameter (ϵ^{α}) involved in the singularly perturbed problems. Perturbation parameter plays a vital role in the field of the perturbation theory and is responsible for generating boundary/interior layers. Initially, random data is being used as an population for the estimation of the parameter (α). Two types of problems: convection diffusion and reaction diffusion, have been tested for the estimation of the parameter. For comparison, the same test problems have also been solved using the particle swarm optimization method. For the values of the various parameters, results have been shown in the tables along with best cost figures.

Stiff Order Conditions in Runge-Kutta Methods for Linear and Semi-Linear Problems

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Schedule: December 16 17:00-17:30 Capital Suite 12 A

Abhijit Biswas
king Abdullah University of Science and Technology
Saudi Arabia

Co-Author(s): David Ketcheson, Steven Roberts, Benjamin Seibold, David Shirokoff

Abstract:

Runge-Kutta (RK) methods may demonstrate order reduction when applied to stiff problems. This talk explores the issue of order reduction in Runge-Kutta methods specifically when dealing with linear and semi-linear stiff problems. First, I will introduce Diagonally Implicit Runge-Kutta (DIRK) methods with high Weak Stage Order (WSO), capable of mitigating order reduction in linear problems with time-independent operators. On the theoretical front, I will present order barriers relating the WSO of an RK scheme to its order and the number of stages for fully-implicit RK and DIRKmethods, serving as a foundation to construct schemes with high WSO. I will conclude by presenting stiff order conditions for semilinear problems, essential to extend beyond the limitations of WSO, which primarily focused on linear problems.

A parameter uniform hybrid approach for singularly perturbed two-parameter parabolic problem with discontinuous data

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Schedule: December 16 15:45-16:15 Capital Suite 12 A

Anuradha Jha
Indian Institute of Information Technology Guwahati
India

Co-Author(s): Nirmali Roy, Anuradha Jha

Abstract:
In this talk, we discuss singularly perturbed two-parameter 1D parabolic problem of the reaction-convection-diffusion type. These problems exhibit discontinuities in the source term and convection coefficient at particular domain points, which results in the interior layers. Presence of perturbation parameters give rise to the boundary layers too. To resolve these layers a hybrid monotone difference scheme is used on a piece-wise uniform Shishkin mesh in the spatial direction and Crank-Nicolson scheme is used on a uniform mesh in the temporal direction. The resulting scheme is proven to be almost second order convergent in spatial direction and order two in temporal direction. Numerical experiments corroborate the theoretical claims made.

Layer-Resolving Numerical Methods for Degenerate Singular Perturbations Problems with Two Parameters

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Schedule: December 16 16:15-16:45 Capital Suite 12 A

Anirban Majumdar
Indian Institute of Information Technology Design and Manufacturing Kurnool
India

Co-Author(s): Mrityunjoy Barman, Natesan Srinivasan, Anirban Majumdar

Abstract:
This work addresses a class of steady-state and time-dependent degenerate singular perturbation problems with two parameters affecting the convection and diffusion terms. Due to the presence of degeneracy and multiple perturbation parameters, the continuous solution exhibits boundary layers with different widths at the boundaries of the spatial domain. To effectively capture these layers, we utilize a piecewise uniform Shishkin grid for spatial discretization and a uniform grid for time discretization. The time derivative is approximated using an implicit Euler method on the equispaced temporal grid, while upwind finite difference schemes are applied to the Shishkin mesh for spatial derivatives. To enhance solution accuracy, we incorporate the Richardson extrapolation technique. Our theoretical analysis establishes an error bound, demonstrating almost second-order convergence. Numerical experiments are conducted to corroborate the theoretical findings, confirming the predicted convergence rates.

An Efficient Robust Computational Method for Singularly Perturbed 1D Parabolic PDEs

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Schedule: December 16 14:45-15:15 Capital Suite 12 A

Natesan Srinivasan
Indian Institute of Technology Guwahati
India

Co-Author(s): Suraj Kumar

Abstract:
Here, we study the numerical solution of singularly perturbed 1D parabolic PDE exhibiting boundary layers. Crank-Nicolson scheme is used to discretize the time derivative on uniform mesh and Non-symmetric Interior Penalty Galerkin (NIPG) is used for the spatial derivatives on the exponentially-graded mesh. Stability, convergence and superconvergence are studied and numerical experiments are provided.

Numerical Solution of Two-Parameter Singularly Perturbed Differential Equations by Efficient Physics-Informed Neural Networks

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Schedule: December 16 18:30-19:00 Capital Suite 12 A

Natesan Srinivasan
Indian Institute of Technology Guwahati
India

Co-Author(s): Aayushman Raina and Pradanya Boro

Abstract:
In recent years, machine learning techniques, namely, physics informed neural networks (PINNs) are becoming popular to solve various types of differential equations modelling several physical phenomena. Here, we focus the fundamentals of PINNs, and, their performance to solve 1D and 2D singularly perturbed differential equations having two small parameters in the diffusion and convection terms. Further, we study the shortfalls of classical PINNs in solving two-parameter singular perturbation problems, and how to overcome these difficulties through other variants of PINNs. Several numerical experiments are carried out to see their performance.

Robust conservative finite element methods for incompressible flows: with lower degrees

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Schedule: December 16 17:30-18:00 Capital Suite 12 A

Shuo Zhang
Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Peoples Rep of China

Abstract:
The strict preservation of the conservation property is important in the design of numerical schemes for various model problems. I will firstly talk about why we would like to study low-degree strictly conservative finite element method for incompressible flows. Then I will talk about a nonstandard approach for designing finite element schemes for fluid computation, which can preserve strictly the divergence free condition for incompressible fluid flows. The schemes work on general triangulations with lower degree of polynomials than known results, and its superiority with respect to some existing schemes are partially illustrated with numerical experiments, including ones with boundary layers. The theoretical analysis depends on a careful application of Stokes complex. Both boundary value problems and eigenvalue problems will be mentioned, in case the time permits.

Special Session 136 : Analysis and Applications of the Boltzmann equation

Introduction: The Boltzmann equation is a fundamental model that governs the motion of rarefied gas flow, with notable applications in statistical physics. This special session will focus on both the theoretical analysis and practical applications of the Boltzmann equation and its variants. We aim to bring together the experts in this field to present their latest research results, facilitate the exchange of new ideas, and explore prospective directions for future work.

Thermalization rate for solutions to the Landau-Fermi-Dirac equation

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Schedule: December 18 17:00-17:30 Capital Suite 8

Ricardo Alonso
Texas A&M
USA

Co-Author(s): V. Bagland, L. Desvillettes, B. Lods

Abstract:
In this talk we discuss the essential properties of the LFD equation with focus on the thermal convergence of solutions to the Fermi Dirac distribution for moderately soft potentials. The key point of the analysis, valid only under a weak saturation regime, is to obtain estimates free of the Planck`s quantum parameter. Using such estimates, algebraic rate of convergence is obtained after applying a recent entropy - entropy dissipation inequality for the equation.

Short- and long-time behavior in evolution equations: the role of the hypocoercivity index

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Schedule: December 18 14:45-15:15 Capital Suite 8

Anton Arnold
Vienna University of Technology
Austria

Abstract:
The index of hypocoercivity is defined via a coercivity-type estimate for the self-adjoint/skew-adjoint parts of the generator, and it quantifies `how degenerate` a hypocoercive evolution equation is, both for ODEs and for evolutions equations in a Hilbert space. We show that this index characterizes the polynomial decay of the propagator norm for short time and illustrate these concepts for the Lorentz kinetic equation on a torus. This talk is based on joint work with F. Achleitner, E. Carlen, E. Nigsch, and V. Mehrmann.

Well/Ill-posedness separation of the Boltzmann equation with cut-off

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Schedule: December 18 15:15-15:45 Capital Suite 8

Xuwen Chen
University of Rochester
USA

Co-Author(s): Justin Holmer, Shunlin Shen, Zhifei Zhang

Abstract:
We report the finding of the sharp separation of well/ill-posedness for the Boltzmann equation with cut-off using dispersive PDE techniques. The separation is unexpectly 1/2-derivative above scaling and the illposedness is represented by forward in time norm deflation.

The Non-cutoff Boltzmann Equation in Bounded Domains

Schedule: December 18 16:15-16:45 Capital Suite 8

Dingqun Deng
Pohang University of Science and Technology
Korea

Abstract:
In this talk, we will investigate the existence of the non-cutoff Boltzmann equation near a global Maxwellian in a general C^3 bounded domain Ω. This includes convex and non-convex cases with inflow or Maxwell reflection boundary conditions. We obtain global-in-time existence, which has an exponential decay rate for both hard and soft potentials. The crucial method is to extend the boundary problem in a bounded domain to the whole space without regular velocity dissipation and to construct an extra damping from the advection operator, followed by the De Giorgi iteration and the L^2--L^∞ method.

Polynomial tail solutions for Boltzmann equation in the whole space

Schedule: December 18 18:00-18:30 Capital Suite 8

Zongguang Li
The Hong Kong Polytechic University
Hong Kong

Abstract:
We are concerned with the Cauchy problem on the Boltzmann equation in the whole space. The goal is to study solutions near Maxwellians with the perturbation admitting a polynomial tail in large velocities. We obtain global-in-time bounded mild solutions near global Maxwellians and construct solutions up to any finite time around local Maxwellians whose fluid quantities are classical solutions to the corresponding compressible Euler system around constant states. The main difficulty to be overcome in case of the whole space is the polynomial time decay of solutions which is much slower than the exponential rate in contrast with the torus case.

Analysis and numerical methods for the Boltzmann equation with uncertainties

Schedule: December 19 13:30-14:00 Capital Suite 8

Liu Liu
Chinese University of Hong Kong
Peoples Rep of China

Co-Author(s): Kunlun Qi, Xueyu Zhu, Shi Jin

Abstract:
In this talk, we will first discuss the hypocoercivity analysis for general space-inhomogeous collisional kinetic problems with uncertainties, on the regularity and long-time behavior of the solution in the random space, proved spectral accuracy and long time (exponential decay) error estimates for the stochastic Galerkin method. For the spatially homogenous Boltzmann equation, we will show the spectral convergence for the numerical system with discrete velocity and uncertainty variables. Regarding numerical simulations for kinetic models with uncertainties, we will introduce the multi-fidelity method and asymptotic-preserving neural network approach, then discuss about how to apply the above analyses to obtain convergence and error estimates for the numerical methods.

The spatially inhomogeneous Vlasov-Nordstr\{o}m-Fokker-Planck system in the intrinsic weak diffusion regime

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Schedule: December 19 8:00-8:30 Capital Suite 8

Shuangqian Liu
Central China Normal University
Peoples Rep of China

Abstract:
The spatially homogeneous Vlasov-Nordstr\{o}m-Fokker-Planck system is known to exhibit nontrivial large time behavior, naturally leading to weak diffusion of the Fokker-Planck operator. This weak diffusion, combined with the singularity of relativistic velocity, present a significant challenge for the spatially inhomogeneous counterpart. In this talk, we demonstrate that the Cauchy problem for the spatially inhomogeneous Vlasov-Nordstr\{o}m-Fokker-Planck system, without friction, maintains dynamic stability relative to the corresponding spatially homogeneous system. Our results are twofold: (1) we establish the existence of a unique global classical solution and characterize the asymptotic behavior of the spatially inhomogeneous system using a refined weighted energy method; (2) we directly verify the dynamic stability of the spatially inhomogeneous system within the framework of self-similar solutions.

Precise boundary behavior of the kinetic Fokker-Planck equation

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Schedule: December 18 15:45-16:15 Capital Suite 8

Giacomo Lucertini
University of Bologna
Italy

Co-Author(s): Christopher Henderson, Weinan Wang

Abstract:
We present a study on the boundary behavior of a kinetic Fokker-Planck equation in the half-space with absorbing boundary condition. This equation can be seen as a base model for the study of Boltzmann equations: although the kinetic equation that we are taking into account is linear and present a local diffusion, it shares with the Boltzmann equation an analogue hypoelliptic structure. Our main result is the sharp regularity of the solution at the absorbing boundary and grazing set. The technique is based on a new kinetic Nash-type inequality. This talk is based on a joint work with Christopher Henderson (University of Arizona) and Weinan Wang (University of Oklahoma).

Global regularity for the Rayleigh-Taylor unstable Muskat bubble problem with critical regularity

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Schedule: December 19 8:30-9:00 Capital Suite 8

Robert Strain
University of Pennsylvania
USA

Abstract:
This talk concerns the Muskat problem with surface tension, modeling the filtration of two incompressible immiscible fluids in porous media. This non-local and non-linear partial differential equation is a basic mathematical model in petroleum engineering; it was formulated by the petroleum engineer M. Muskat in 1934 to describe the mixture of water into an oil sand. Given its origins and its equivalence with Hele-Shaw flows, the Muskat problem has received a lot of attention from the physics community. We consider the case in which the fluids have different constant densities together with different constant viscosities. The Rayleigh-Taylor condition cannot hold for a closed curve, which makes this situation unstable. In this case the equations are non-local, not only in the evolution system, but also in the implicit relation between the amplitude of the vorticity and the free interface. Among other extra difficulties, no maximum principles are available to bound the amplitude and the slopes of the interface. We prove global in time existence and uniqueness results for medium size initial stable data in critical functional spaces. In particular we prove for the first time the global in time stability of star shaped bubbles influenced by Gravity. This is joint work with Gancedo, Garcia-Juarez, and Patel.

Interplay of inertia and rarefaction in weakly nonlinear rarefied gas flow

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Schedule: December 19 13:00-13:30 Capital Suite 8

Satoshi Taguchi
Kyoto University
Japan

Abstract:
In this talk, we discuss the asymptotic behavior of a rarefied flow, governed by the Boltzmann equation, in the weakly nonlinear regime where both the Reynolds number and the Knudsen number are small. Specifically, we first address boundary-value problems of the Boltzmann equation and apply the Hilbert expansion for small Knudsen numbers (i.e., scaled mean free path) to derive a fluid-dynamic system in the case where the Reynolds number is of the same order as the Knudsen number. Using the matched asymptotic expansion, this system is then applied to analyze the flow past a sphere, providing insights into gas behavior around the sphere. In particular, we derive a drag formula that accounts for both rarefaction and inertia effects as well as their coupling. The work is in collaboration with Yuki Tatsudani and Tetsuro Tsuji.

Convergence to self-similar solution of the Boltzmann equation with shear flow

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Schedule: December 19 14:00-14:30 Capital Suite 8

Shuaikun WANG
Shandong University
Peoples Rep of China

Abstract:
In this report, we consider the wellposeness of the measure valued solution to the solutions to the Boltzmann equation with shear flow under the non-cutoff collision kernel and discuss the long time behavior of the solution. We show that the strong convergence rate to the self-similar solution is exponentially for the asymmetrical initial data.

Classical limit of the relativistic Cucker-Smale model

Schedule: December 19 9:00-9:30 Capital Suite 8

Qinghua Xiao
Innovation Academy for Precision Measurement Science and Technology, CAS
Peoples Rep of China

Co-Author(s): Seung-Yeal Ha; Tommaso Ruggeri

Abstract:
We study quantitative estimates for the flocking and uniform-in-time classical limit to a relativistic Cucker-Smale model (in short RCS) with non-zero pressure, which is a subsystem of the relativistic thermomechanical Cucker-Smale model. For this RCS model, we provide its uniform-in-time classical limit with optimal convergence rate which is the same as in finite-in-time classical limit. As its direct application, for the corresponding mean-field limit equation, relativistic kinetic Cucker-Smale equation (in short RKCS), the uniform-in-time classical limit is also obtained.

The stability of the Boltzmann equation with deformation

Schedule: December 19 16:15-16:45 Capital Suite 8

Anita Yang
The Chinese University of Hong Kong
Hong Kong

Co-Author(s): Shuangqian Liu, Yating Wang, Xueying Zhang

Abstract:
In this talk, we will present the existence and long-time behavior of the Boltzmann equation with a deformation matrix A, which describes the shear flow. Assuming the shear rate is small, we will study the corresponding Cauchy problem under the cutoff assumption. We will consider two cases. In the case where $trA < 0$, we will prove the well-posedness in the case of hard potentials. In the case where $trA \geq 0$, we will specifically consider the planar shear flow case and establish the stability of the stationary solution when the collision kernel is limited to the Maxwell molecules. This is a joint work with Prof. Shuangqian Liu, Yating Wang and Xueying Zhang.

KdV limit for the Vlasov-Poisson-Landau system

Schedule: December 19 14:30-15:00 Capital Suite 8

Dongcheng Yang
South China University of Technology
Peoples Rep of China

Abstract:
In this talk, we are concerned with the fluid limit to KdV equations for the one-dimensional Vlasov-Poisson-Landau system which describes the dynamics of ions in plasma with the electron density determined by the self-consistent electric potential through the so-called Boltzmann relation. Formally, it is well known that as the Knudsen number $\varepsilon \to 0$ the Vlasov-Poisson-Landau system in the compressible scaling converges to the Euler-Poisson equations which further under the Gardner-Morikawa transformation

$$(t,x) \to (\delta^{\frac{3}{2}} t, \delta^{\frac{1}{2}}(x - \sqrt{\frac{8}{3}} t))$$

converge to the KdV equations as the parameter $\delta \to 0$. Our goal of this paper is to construct smooth solutions of the correspondingly rescaled Vlasov-Poisson-Landau system over an arbitrary finite time interval that can converge uniformly to smooth solutions of the KdV equations as $\varepsilon \to 0$ and $\delta \to 0$ simultaneously under an extra condition $\varepsilon^{\frac{2}{3}} \leq \delta \leq \varepsilon^{\frac{2}{5}}$. Moreover, the explicit rate of convergence in δ is also obtained. The proof is established by an appropriately chosen scaling and an intricate weighted energy method through the macro-micro decomposition around local Maxwellians. We design a ε-δ-dependent high order energy functional to capture the singularity of such fluid limit problem.

The solution of the steady Boltzmann equation

Schedule: December 18 17:30-18:00 Capital Suite 8

Hongjun Yu
School of Mathematical Sciences, South China Normal University
Peoples Rep of China

Abstract:
In this talk, we will talk about some existence and stability results of the solution to the one-dimension steady Boltzmann equation.

Diffusive limit of one-species VPB and VMB with angular cutoff

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Schedule: December 19 15:45-16:15 Capital Suite 8

Fujun Zhou
South China University of Technology
Peoples Rep of China

Abstract:
In this talk, we give recent progress on diffusive limit of one-species VPB and VMB with angular cutoff. For one-species VPB, by a newly H^2-W^{2,\infty} framework, the time decay estimate and the weighted energy estimate, we justify the incompressible Navier-Stokes-Fourier Poisson (NSFP) limit for all potentials \gamma>-3. For one-species VMB, by employing the weighted energy method with two newly introduced weight functions, we justify the incompressible Navier-Stokes-Fourier-Maxwell (NSFM) limit for hard potentials \gamma \geq 0.

Special Session 138 : Recent advances in Fractal Geometry, Dynamical Systems, and Positive Operators

Introduction: In nature and finance, we usually see functions with high irregularity/non smoothness. Approximating and studying such nonsmooth functions may be better via fractal geometry and dynamical systems' tools such as fractal functions and attractors/repellers, which is an active research area in mathematics. In this special session, we will focus on some recent advances in these topics along with applications of positive operators such as Perron Frobenius, Ruelle, and transfer operators in dimension estimates for attractors and fractals. The main target of this session is to bring together scientists including young researchers to discuss and exchange ideas in the areas of fractal geometry, dynamical systems, positive operators and their recent advances and emerging applications.

Dimension of set-valued functions and their distance sets

Schedule: December 17 8:00-8:30 Capital Suite 4

Ekta Agrawal
Indian Institute of Information Technology Allahabad
India

Co-Author(s): Dr. Saurabh Verma

Abstract:
Barnsley introduced the theory of non-smooth interpolation for finite data in his seminal work ``Fractal Functions and Interpolation, Constr. Approx 2 (1986) 303-329 by exploiting an iterated function system concept. After that, numerous fractal functions are constructed corresponding to real/vector-valued functions. Recently, fractal interpolation functions corresponding to a set-valued function on a compact interval of the real line have been constructed. Set-valued functions played a significant role in applied areas such as mathematical modeling, game theory, control theory, and many more. Dimension estimation of any set or the graph of a function remains a vibrant area of research in the literature. In this talk, we first construct the set-valued fractal function corresponding to any continuous set-valued function defined on the compact subset of the real line using the metric sum of sets. Subsequently, some results are obtained for the bounds estimation of fractal dimensions, such as the Hausdorff and box dimension for the graphs of constructed fractal functions. Further, some bounds on the dimension of the distance sets of graphs of these functions are also discussed. In the end, we shed some light on the celebrated Falconer`s distance-set conjecture regarding the graphs of set-valued functions.

Fractals in sea ice dynamics

Schedule: December 17 9:00-9:30 Capital Suite 4

Ken Golden
University of Utah
USA

Co-Author(s): Kenneth M. Golden

Abstract:
Polar sea ice is a critical component of Earth`s climate system. As a material it displays composite structure over a vast range of length scales. In fact, fractals appear naturally throughout the sea ice system, from brine inclusions inside the ice and labyrinthine melt ponds on its surface, to the ice pack itself on the scale of the Arctic Ocean. We explore how the fractal dimension of these structures depends on the parameters characterizing their dynamical evolution. These investigations lead us into percolation theory, statistical physics, and topological data analysis. In related work, we consider a dynamical systems model of algae living in the brine inclusions, with model parameters treated as random variables. Uncertainty quantification methods are used to study bloom dynamics.

Holder vs Dini in Transfer Operators

Schedule: December 17 8:30-9:00 Capital Suite 4

Yunping Jiang
The City University of New York, Queens College and Graduate Center
USA

Abstract:
Ruelle transfer operators are central to thermodynamic formalism, providing critical insights into phenomena such as the existence and uniqueness of Gibbs measures, calculations of pressures and Hausdorff dimensions, and estimates of correlation decay rates. These operators exhibit distinct behaviors across different function spaces. This discussion will explore the contrast between transfer operators on Holder and Dini function spaces. I will discuss how the spectral gap can be used to analyze the exponential decay of correlations in expanding dynamical systems with Holder potentials. However, the spectral gap vanishes when the dynamical systems are not fully expanding or the potentials are not Holder. In collaboration with Yuan-Ling Ye, we established an optimal quasi-spectral gap condition for studying transfer operators in weakly expanding systems with Dini potentials. This condition enables us to derive precise estimates for the decay rate of correlations.

Some Results on Graph Induced Symbolic Systems

Schedule: December 17 13:30-14:00 Capital Suite 4

Puneet Sharma
Indian Institute of Technology Jodhpur
India

Co-Author(s): Prashant Kumar

Abstract:
In this talk, we will discuss the non-emptiness problem and some dynamical notions for graph induced symbolic shifts. We derive sufficient conditions under which non-emptiness problem and existence of periodic points for the shift space can be guaranteed. We also investigate properties such as transitivity, directional transitivity, weak mixing, directional weak mixing and mixing for the shift space under discussion. We provide necessary and sufficient criteria to establish horizontal (vertical) transitivity of the underlying shift space. We also provide examples to establish the necessity of the conditions imposed.

Ergodic theory on coded shift spaces

Schedule: December 17 13:00-13:30 Capital Suite 4

Christian Wolf
CUNY Graduate Center
USA

Co-Author(s): Tamara Kucherenko, Martin Schmoll

Abstract:
In this talk we present results about ergodic-theoretic properties of coded shift spaces. A coded shift space is defined as a closure of all bi-infinite concatenations of words from a fixed countable generating set. We derive sufficient conditions for the uniqueness of measures of maximal entropy and equilibrium states of H\{o}lder continuous potentials based on the partition of the coded shift into its concatenation set (sequences that are concatenations of generating words) and its residual set (sequences added under the closure). We also discuss flexibility results for the entropy on the sequential and residual set. Finally, we present a local structure theorem for intrinsically ergodic coded shift spaces which shows that our results apply to a larger class of coded shift spaces compared to previous works by Climenhaga, Climenhaga and Thompson, and Pavlov.

An Innovative Implicit-Explicit Fitted Mesh Higher-Order Scheme for 2D Singularly Perturbed Semilinear Parabolic PDEs with Non-Homogeneous Boundary Conditions

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Schedule: December 17 12:30-13:00 Capital Suite 4

Narendra Singh Yadav
Indian Institute of Information Technology, Sri City, Chittoor
India

Co-Author(s): Kaushik Mukherjee

Abstract:
This research presents an advanced numerical technique designed for solving two-dimensional singularly perturbed semilinear parabolic convection-diffusion equations, characterized by time-dependent non-homogeneous boundary conditions. The proposed method is a combination of an implicit-explicit fitted mesh method (FMM) and a Richardson extrapolation approach. The temporal discretization is handled through an Alternating Direction Implicit-Explicit (ADI) Euler scheme, which ensures accurate handling of time-dependent boundary values. For spatial discretization, we employ a hybrid finite difference scheme on a non-uniform rectangular mesh, while the time domain is discretized using a uniform grid. To begin, the paper explores the stability and asymptotic behavior of the analytical solution for the nonlinear problem. Following this, the stability properties of the implicit-explicit method are examined, and the convergence of the numerical solution is established, showing that the method achieves uniform convergence with respect to the perturbation parameter ε. The Richardson extrapolation technique is applied specifically to the time variable to enhance the accuracy and order of convergence in the temporal dimension. The proposed method is validated through a series of numerical experiments that confirm the theoretical predictions regarding stability and convergence rates. These numerical results demonstrate the effectiveness of the method in handling complex boundary conditions and solving the nonlinear parabolic PDEs with high accuracy.

Special Session 139 : New Developments in Computational Imaging, Learning, and Inverse Problems

Introduction: The field of computational inverse problems, broadly defined, is rapidly changing as new ideas and computational tools, such as those based on deep learning methods, reduced-order models, and optimal transport theory, are constantly introduced. This special session aims to bring together experts around the world to discuss recent developments in this exciting area of research.

Inverse radiative transfer via goal-oriented hp-adaptive mesh refinement

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Schedule: December 16 13:30-14:00 Capital Suite 11 A

Shukai Du
Syracuse University
USA

Co-Author(s): Shukai Du, Samuel N. Stechmann

Abstract:
The inverse problem in radiative transfer is critical for many applications, such as optical tomography and remote sensing. However, solving it numerically presents significant challenges, including high memory requirements and computational expense due to the problem`s high dimensionality and the iterative nature of the solution process. To address these challenges, we propose a goal-oriented hp-adaptive mesh refinement method for solving the inverse radiative transfer problem. A novel aspect of this approach is that it simultaneously combines two optimization processes -- one for inversion and one for mesh adaptivity. By leveraging the connection between duality-based mesh adaptivity and adjoint-based inversion techniques, we introduce a goal-oriented error estimator that is computationally inexpensive and can efficiently guide mesh refinement to solve the inverse problem numerically. For discretizing both the forward and adjoint problems, we employ discontinuous Galerkin spectral element methods. Using the goal-oriented error estimator, we then design an hp-adaptive algorithm to refine the meshes. Numerical experiments demonstrate that this method accelerates convergence and reduces memory usage, highlighting the efficiency of the goal-oriented mesh adaptive approach.

On computational passive imaging in the frequency domain

Schedule: December 16 12:30-13:00 Capital Suite 11 A

Thorsten Hohage
University of Goettingen
Germany

Co-Author(s): Bjoern Mueller

Abstract:
We consider passive imaging with randomly excited waves in order to reconstruct coefficients of a differential operator or the shape of a domain. Primary data are measurements of waves excited by independent realizations of the source. From this one can compute correlations as approximations of the covariance operator of the random solution to the differential equation restricted to the measurement domain, which serve is input data for the inverse problem. Challenges occur in the huge size of correlation data, often too large to be stored or computed, and very large pointwise noise levels. We present a computational technique which addresses both of these challenges by using only the primary data while exploiting the full information content of the correlation data and respecting the distribution of the correlation data by taking into account the forth order moments of the primary data. The efficiency of this technique is demonstrated on real and synthetic data from helioseismology.

Parameter Reconstruction in Kinetic Equations: an Inverse Problem for Chemotaxis

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Schedule: December 16 14:45-15:15 Capital Suite 11 A

Christian Klingenberg
Wuerzburg University
Germany

Co-Author(s): Kathrin Hellmuth, Qin Li, Min Tang

Abstract:
On the mesoscopic level, motion of individual particles can be modeled by a kinetic transport equation for the population density $f(t,x,v)$ as a function of time t, space x and velocity $v \in V$. A relaxation term on the right hand side accounts for scattering due to self-induced velocity changes and typically involves a parameter $K(x,v,v`)$ encoding the probability of changing from velocity $v`$ to v at location x: \begin{equation} \nonumber \partial_t f(t,x,v) + v \cdot \nabla f(t,x,v) = \int K(x,v,v`) f(t,x,v`) - K(x,v`,v)f(t,x,v) dv` . \end{equation} This hyperbolic model is widely used to model bacterial motion, called chemotaxis. We study the inverse parameter reconstruction problem whose aim is to recover the scattering parameter K and that has to be solved when fitting the model to a real situation. We restrict ourselves to macroscopic, i.e. velocity averaged data $\rho = \int f dv$ as a basis of our reconstruction. This introduces additional difficulties, which can be overcome by the use of short time interior domain data. In this way, we can establish theoretical existence and uniqueness of the reconstruction, study its macroscopic limiting behavior and numerically conduct the inversion under suitable data generating experimental designs. This work based on a collaboration with Kathrin Hellmuth (W\urzburg, Germany), Qin Li (Madison, Wisc., USA) and Min Tang (Shanghai, China).

LEARNING IN-BETWEEN IMAGERY DYNAMICS VIA PHYSICAL LATENT SPACES

Schedule: December 16 15:45-16:15 Capital Suite 11 A

Yoonsang Lee
Dartmouth College
USA

Co-Author(s): Jihun Han, Anne Gelb

Abstract:
We present a framework designed to learn the underlying dynamics between two images observed at consecutive time steps. The complex nature of image data and the lack of temporal information pose significant challenges in capturing the unique evolving patterns. Our proposed method focuses on estimating the intermediary stages of image evolution, allowing for interpretability through latent dynamics while preserving spatial correlations with the image. By incorporating a latent variable that follows a physical model expressed in partial differential equations, our approach ensures the interpretability of the learned model and provides insight into corresponding image dynamics. We demonstrate the robustness and effectiveness of our learning framework through a series of numerical tests using geoscientific imagery data.

Bi-level iterative regularization for inverse problems in nonlinear PDEs

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Schedule: December 16 15:15-15:45 Capital Suite 11 A

Tram Nguyen
Max Planck Institute for Solar System Research
Germany

Abstract:
We investigate the ill-posed inverse problem of recovering unknown spatially dependent parameters in nonlinear evolution PDEs. We propose a bi-level Landweber scheme, where the upper-level parameter reconstruction embeds a lower-level state approximation. This can be seen as combining the classical reduced setting and the newer all-at-once setting, allowing us to, respectively, utilize well-posedness of the parameter-to-state map, and to bypass having to solve nonlinear PDEs exactly. Using this, we derive stopping rules for lower- and upper-level iterations and convergence of the bi-level method. We discuss application to parameter identification for the Landau-Lifshitz-Gilbert equation in magnetic particle imaging, as well as to several reaction-diffusion applications, in which the nonlinear reaction law needs to be determined.

Sediment Measurement: an Inverse Problem Formulation

Schedule: December 16 13:00-13:30 Capital Suite 11 A

Lingyun Qiu
Tsinghua University
Peoples Rep of China

Co-Author(s): Jiwei Li, Zhongjing Wang, Hui Yu, Siqin Zheng

Abstract:
In this work, we present a novel approach for sediment concentration measurement in water flow, modeled as a multiscale inverse medium problem. To address the multiscale nature of the sediment distribution, we treat it as an inhomogeneous random field and use the homogenization theory in deriving the effective medium model. The inverse problem is formulated as the reconstruction of the effective medium model, specifically, the sediment concentration, from partial boundary measurements. Additionally, we develop numerical algorithms to improve the efficiency and accuracy of solving this inverse problem. Our numerical experiments demonstrate the effectiveness of the proposed model and methods in producing accurate sediment concentration estimates, offering new insights into sediment measurement in complex environments.

Numerical Analysis of Quantitative Photoacoustic Tomography in a Diffusive Regime

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Schedule: December 16 14:00-14:30 Capital Suite 11 A

Zhi Zhou
The Hong Kong Polytechnic University
Hong Kong

Co-Author(s): Giovanni S. Alberti, Siyu Cen

Abstract:
In this talk, we explore the numerical analysis of quantitative photoacoustic tomography, modeled as an inverse problem to reconstruct the diffusion and absorption coefficients in a second-order elliptic equation using multiple internal measurements. We establish conditional stability in the L^2 norm, under a provable nonzero condition, with randomly chosen boundary excitation data. Building on this stability, we propose and analyze a numerical reconstruction scheme based on an output least-squares formulation, using finite element discretization. We provide an \textit{a priori} error estimate for the numerical reconstruction, serving as a guideline for selecting algorithmic parameters. Several numerical examples will be presented to illustrate the theoretical results.

Special Session 140 : Symmetry and Overdetermined problems

Introduction: Symmetry and Overdetermined problems Many a times, it is useful to get qualitative information of a solution of a given PDE before even trying to find the exact solution. If we can show that a solution of PDE in $\R^n$ has radial symmetry, then the PDE reduces to an ODE. Such simplification helps in obtaining exact solutions, non existence of solutions, study of singular solutions, asymptotic behaviour of solutions and so on. Proving symmetry of solutions has successfully led to resolving Yamabe type problems on manifolds, sub-Riemannian manifolds, Chern-Simon theories, integral equation to mention a few. Overdetermined problems are PDEs defined on bounded domains (unbounded domains) where the boundary conditions (asymptotic behaviour) are such that they force symmetry of the solutions and/or the domain where the problems are considered. The results in this category can be broadly summarized as Serrin type problems on manifolds, Heisenberg group, sub-Riemannian manifolds, isoperimetric manifolds; Allen-Cahn type equations and its variants for more general operators and geometries. In this session I hope to bring together experts who have contributed to this field creating an opportunity for sharing recent progress, discussion on open problems and further collaborations.

The quasi-linear Liouville equation

Schedule: December 20 8:00-8:30   Capital Suite 10

Pierpaolo Esposito
Universit\\' degli Studi Roma Tre
Italy

Abstract:
In R^n we discuss classification and/or quantization results for a quasi-linear Liouville equation involving the n-Laplace operator and an exponential nonlinearity with the possible presence of some singular sources.

A rigidity result for the overdetermined problems with the mean curvature of the graph of solutions operator in the plane

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Schedule: December 20 15:00-15:30   Capital Suite 10

Yuanyuan Lian
Department of Mathematical Analysis, University of Granada
Spain

Co-Author(s): Yuanyuan Lian; Pieralberto Sicbaldi

Abstract:
Let $\Omega \subset \mathbb{R}^2$ be a $C^{1,\alpha}$ domain whose boundary is unbounded and connected. Suppose that $f : [0, +\infty) \to \mathbb{R}$ is C^1 and there exists a nonpositive prime F of f such that $F(0) = \sqrt{2}/2 - 1$. If there exists a positive bounded solution $u \in C^3$ with bounded ∇u to the overdetermined problem $\begin{cases} \mathrm{div}\left(\frac{\nabla u}{\sqrt{1+|\nabla u|^2}}\right) + f(u) = 0 \quad \text{in } \Omega, \; u = 0 \quad \text{on } \partial\Omega, \; \frac{\partial u}{\partial \nu} = 1 \quad \text{on } \partial\Omega, \end{cases}$ we prove that Ω is a half-plane. It means that a positive capillary graph whose mean curvature depends only on the height of the graph is a half-plane.

Overdetermined problems for p-Laplace and generalized Monge-Ampere equations

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Schedule: December 20 14:30-15:00 Capital Suite 10

Yichen Liu
Xi'an Jiaotong-Liverpool University
Peoples Rep of China

Co-Author(s): Behrouz Emamizadeh, Giovanni Porru

Abstract:
We investigate overdetermined problems for p-Laplace and generalized Monge Ampere equations. By using the theory of domain derivative, we find duality results and characterization of the overdetermined boundary conditions via minimization of suitable functionals with respect to the domain.

Some overdetermined problem in space forms

Schedule: December 20 16:45-17:15 Capital Suite 10

Marcello Lucia
City University of New York
USA

Abstract:
We present some rigidity results obtained for rotationally invariant Poisson equations subjected to overdertermined boundary conditions in space forms. This is a joint work with A. Greco and P. Sicbaldi.

Break of symmetry for semilinear elliptic problems in cones

Schedule: December 20 14:00-14:30 Capital Suite 10

Filomena Pacella
University of Roma Sapienza
Italy

Co-Author(s): Giulio Ciraolo and Camilla Polvara

Abstract:
We consider semilinear elliptic problems with mixed boundary conditions in spherical sectors contained in an unbounded cone in $\mathbb{R}^{\mathbb{N}}$ and address the question of the radial symmetry of the positive solutions. We present some results which show that the symmetry, as well as the break of symmetry depends on the kind of cones considered. This implies that a Gidas-Ni-Nirenberg type result does not hold in any spherical sectors. Similar results hold for the critical exponent Neumann problem in the whole cone.

On a Bliss-Moser type inequality

Schedule: December 20 8:30-9:00 Capital Suite 10

Bernhard Ruf
Accademia di Scienze e Lettere - Istituto Lombardo
Italy

Abstract:
We derive a limiting inequality for the integral inequalities by Bliss. We then consider a critical version of this inequality which is of Moser type, and discuss related non-compactness properties. Furthermore, we show that this inequality is related to critical boundary growth for functions on a disk in two dimensions. Finally, we prove the existence of solutions for related critical boundary value problems.

Domain variations of the first eigenvalue via a strict Faber-Krahn type inequality.

Schedule: December 20 17:15-17:45 Capital Suite 10

Anoop T V
Indian Institute of Technology Madras
India

Abstract:
We discuss a strict Faber-Krahn-type inequality (under the polarisations) for the first the eigenvalue of the p-Laplace operator satisfying mixed boundary conditions on domains with holes. As an application, we prove the strict monotonicity of the first eigenvalue with respect to certain variations of an obstacle inside a doubly connected domain.

Overdetermined elliptic problems in nontrivial contractible domains of the sphere

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Schedule: December 20 16:15-16:45 Capital Suite 10

Jing Wu
Autonomous University of Madrid
Spain

Abstract:
In this talk we will present the existence of nontrivial simply contractible domains of the sphere such that the overdetermined elliptic problem admits a positive solution. The proof uses a local bifurcation argument.

Abstracts for Contributed Sessions

Contributed Session 1 : ODEs and Applications

Introduction:

Fundamental Results on Discrete Waveform Relaxation Algorithms for RLC Transmission Line Circuits

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Schedule: December 16 12:30-12:50 Capital Suite 11 B

Marwa Alrefai
KU
United Arab Emirates

Co-Author(s): Marwa E. Alrefai, Mohammad D. Al-Khaleel, Mohamed Riahi

Abstract:
Waveform Relaxation (WR) is a technique for solving large systems of ordinary differential equations (ODEs) by decomposing them into smaller, parallelizable subsystems. While Classical WR (CWR) can suffer from slow convergence, Optimized Waveform Relaxation (OWR) enhances performance by introducing a free parameter that improves information flow between subsystems. However, OWR research has primarily concentrated on continuous formulations and frequently neglects the role of temporal discretization, which is crucial for practical applications. This study shifts to the discrete level, investigating OWR effectiveness in time dependent problems utilizing transmission line circuits. We analyze how temporal discretization impacts OWR convergence, providing insights that could enhance its practical application in large-scale computational problems.

Controllability of ψ-Caputo fractional Langevin dynamical systems with impulsive effects

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Schedule: December 18 8:00-8:20 Capital Suite 11 B

Md Samshad Hussain Ansari
Indian Institute of Technology Mandi
India

Co-Author(s): Dr. Muslim Malik

Abstract:
In this study, we consider ψ-Caputo fractional Langevin dynamical system with impulses. We establish necessary and sufficient conditions to ensure the total controllability of the linear Langevin impulsive system. Additionally, we establish some criteria to ensure the controllability of the considered nonlinear system. We transform the problem of controllability into a task of finding a fixed point. We use fractional calculus, Mittag-Leffler functions, Gramian-type matrices, and Schauder`s fixed point technique to derive our main results. Finally, we provide a numerical example to check the validity and accuracy of our results.

Approximation of solutions to abstract neutral impulsive differential equations

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Schedule: December 19 15:15-15:35 Capital Suite 11 B

Shahin Ansari
Indian Institute of Technology Mandi
India

Co-Author(s): Dr. Muslim Malik

Abstract:
In this article, we study approximation of solutions to a class of first order nonlinear neutral differential equations with non-instantaneous impulses in an arbitrary separable Hilbert space. We use a projection scheme of increasing sequence of finite dimensional subspaces and projection operators to define approximations. Our main results are developed by utilizing analytic semigroup theory, fixed point theorem, and Gronwall`s inequality. Also, we study the Faedo-Galerkin approximate solutions and their convergence to the solution of our given problem. At last, an example involving a partial differential equation is presented to illustrate the discussed abstract results.

The Lower and Upper Solutions Method for Three Points p-Laplacian Boundary Value Problems in Time Scales

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Schedule: December 19 15:35-15:55 Capital Suite 11 B

Sasmita Das
University of Hyderabad
India

Co-Author(s): Prof. Saroj Panigrahi

Abstract:
We consider a three points p-Laplacian boundary value problems with integral bounday conditions on a half-line of the form\

$$(\phi_p(u^{\Delta}(t)))^{\Delta} + r(t)f(t, u(t), u^{\Delta}(t)) = 0, \quad t \in (0, +\infty)_{\mathbb{T}},$$

$$u(0) = \lambda \int_0^{\eta} u(s)\Delta s,$$

$$\lim_{t\to+\infty} u^{\Delta}(t) = u^{\Delta}(+\infty) = C,$$

where $r : (0, +\infty)_{\mathbb{T}} \to (0, +\infty)_{\mathbb{T}}$, $f : [0, +\infty)_{\mathbb{T}} \times \mathbb{R} \times \mathbb{R} \to \mathbb{R}$ are continuous functions, and $C \geq 0$. $\phi_p(s)$ is a p-Laplacian function and $\phi_q(s)$ is the inverse function of $\phi_p(s)$. Here, $\phi_p(s) = |s|^{p-2}s$, $\phi_p^{-1}(s) = \phi_q(s) = |s|^{q-2}s, p > 1$ and $\frac{1}{p} + \frac{1}{q} = 1$. Moreover, $\phi_p(s)$ and $\phi_q(s)$ are increasing functions with respect to $s \in (-\infty, +\infty)_{\mathbb{T}}$ and they are odd functions. We will use the upper and lower solution method along with the Schauder`s fixed point theorem to establish the existence of at least one solution which lies between pairs of upper and lower solutions. Further, by assuming two pairs of upper and lower solutions, the Nagumo condition on the nonlinear term involved in the first-order derivative, we will establish the existence of multiple solutions on an infinite interval by using the topological degree theory. Finally, examples are included to illustrate the validation of the results.

The discrete nonlinear Schr{\o}dinger equation with linear gain and nonlinear loss

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Schedule: December 16 12:50-13:10 Capital Suite 11 B

Georgios Fotopoulos
Abu Dhabi Polytechnic
United Arab Emirates

Co-Author(s): N.I.Karachalios, V. Koukouloyannis, P. Kyriazopoulos and K. Vetas

Abstract:
We consider the discrete nonlinear Schr{\o}dinger equation with linear gain and nonlinear loss. We show that for the infinite lattice with nonzero boundary conditions, which describe solutions decaying on a finite background, solutions to the corresponding initial-boundary value problem exist for any initial condition if and only if the background amplitude has a specific value A_*, determined by the gain-loss parameters. For the finite-dimensional dynamical system defined by the periodic lattice, the dynamics for all initial conditions are governed by a global attractor, represented by a plane wave with amplitude A_*. Consequently, any instability effects or localized phenomena observed in the finite system are only transient before convergence to this trivial attractor. Finally, we study the dynamics of localized initial conditions on the constant background and investigate the potential impact of the global asymptotic stability of the background with amplitude A_* on the system`s long-term evolution.

Resonant grazing bifurcations in simple impacting systems.

Schedule: December 18 8:20-8:40 Capital Suite 11 B

Indranil Ghosh
Massey University
New Zealand

Co-Author(s): David J.W. Simpson

Abstract:
Many practical engineering systems include impacts and vibrations. Researchers have tried to explain the effects of these impacts by studying oscillators with a single degree of freedom. The onset of impacts corresponds to a grazing bifurcation. Studies have found good agreements between the Poincare maps and the physical measurements of these simple impacting systems. Truncating the map to the Nordmark map with a square-root singularity will approximate the dynamics near the grazing bifurcation. However, this is only useful in an extremely small parameter range. The main goal of this talk is to realize whether the reason for this is the presence of small damping. When the damping is small, the frequency of the external periodic forcing will coincide with the natural frequency of the system, giving rise to resonance. I will also talk about finding and computing curves of period-doubling and saddle-node bifurcations that will help explain the dynamics of the system.

Infinite horizon linear quadratic optimal control problems for fractional systems

Schedule: December 19 15:55-16:15 Capital Suite 11 B

Jianping Huang
Hunan University of Science and Technology
Peoples Rep of China

Abstract:
In this paper, we consider fractional systems with quadratic cost functional over the infinite time horizon. By using the Mittag-Leffler matrix function and its properties, we show that if $\alpha \in (0, 1/2]$, the finiteness of the cost functional implies the initial value must be equal to zero which results in that there is no optimal control whence the initial value is not zero, while the cost functional must be finite if $\alpha \in (1/2, 1)$. Moreover, the existence and uniqueness of the optimal control for $\alpha \in (1/2, 1)$ is characterized by maximum principle type necessary conditions, and based on this characterization, an additional interesting finding that the optimal control for linear quadratic optimal control of the fractional system cannot be obtained by linear feedback with a constant gain satisfying an algebraic Riccatic equation is concluded.

Approximate Controllability of Nonconvex-valued Semilinear Differential Inclusions with Nonlocal Conditions

Schedule: December 16 13:10-13:30 Capital Suite 11 B

BHOLANATH KUMBHAKAR
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
India

Co-Author(s): Prof. Dwijendra Narain Pandey

Abstract:
In this paper, we consider the approximate controllability of semilinear differential inclusion featuring multivalued nonlinearities with non-convex values and the nonlocal conditions described by a multivalued map. Initially, we explore the existence result by assuming the underlying state space to be a reflexive Banach space. Then, we discuss the approximate controllability results in super-reflexive state spaces based on two different growth conditions on the multivalued nonlinearity. Incorporating multivalued maps with non-convex values adds complexity to the studied differential inclusions yet enhances their practical applicability, serving as the core motivation for this research endeavor. We conclude by presenting an illustrative example that satisfies the criteria outlined in this paper.

Billiards in generic convex bodies

Schedule: December 18 8:40-9:00 Capital Suite 11 B

Joao Lopes Dias
ISEG, University of Lisbon
Portugal

Co-Author(s): M Bessa, G del Magno, JP Gaivao, MJ Torres

Abstract:
We show that there exists a C2 open dense set of convex bodies with smooth boundary whose billiard map exhibits a non-trivial hyperbolic basic set. As a consequence billiards in generic convex bodies have positive topological entropy and exponential growth of the number of periodic orbits. This work is contained in Advances in Mathematics 441, 109592 (2024).

Inverse Problem for Neutral Degenerate Differential Equation

Schedule: December 19 16:15-16:35 Capital Suite 11 B

Santosh Ruhil
Indian Institute of Technology Mandi
India

Co-Author(s): Muslim Malik

Abstract:
Inverse problems are the most important mathematical problems in science and mathematics because they provide information about factors that are difficult to study directly. In particular, inverse problems for neutral degenerate differential equations are essential for the accurate modeling and simulation of complex systems with inherent delays and degeneracy, which have been found to have applications in various areas. The main focus of this talk is to discuss an inverse problem for a neutral degenerate differential equation in a Banach space using two approaches: one for regular data and another for irregular data. For regular data, we use the direct approach using the Volterra integral equation, and for irregular data, we use an optimal control approach. In the optimal control approach, under certain hypotheses, the characterization of the limit of the sequence of approximate solutions demonstrates that it is the solution of the original inverse problem.

Boundary value problems for a second-order differential equation with involution in the second derivative and their solvability

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Schedule: December 19 16:35-16:55 Capital Suite 11 B

Abdissalam Sarsenbi
Research Center of Theoretical and Applied Mathematics, Department of Mathematics, M. Auezov South Kazakhstan University
Kazakhstan

Co-Author(s): Sarsenbi Abdizhahan

Abstract:
We considerwo-point boundary value problems for a nonlinear one-dimensional second order differential equation with involution in the second derivative and in the lower terms. The questions of existence and uniqueness of the classical solution of two-point boundary value problems are studied. The definition of the Green`s function is generalized for the case of boundary value problems for the second order linear differential equation with involution, indicating the points of discontinuities and the magnitude of discontinuities the first derivative. Uniform estimates for the Green`s function of the linear part of boundary value problems are established. Using the contraction mapping principle and the Schaffer fixed point theorem, theorems on the existence and uniqueness of solutions to the boundary value problems are proved. The results obtained in this paper cover the boundary value problems for one-dimensional differential equations with and without involution in the lower terms.

Direct problem for the heat equation with fractional order and complex coefficient

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Schedule: December 18 9:00-9:20 Capital Suite 11 B

Bolat Seilbekov
Research Center of Theoretical and Applied Mathematics, Department of Mathematics, M. Auezov South Kazakhstan University
Kazakhstan

Co-Author(s): Elmira Mussirepova, Abdissalam Sarsenbi

Abstract:
In this paper, we study direct problems with a fractional Caputo differential operator using the Fourier variable separation method. The equation contains a linear transformation of the involution in the second derivative. As a consequence of the proved theorem on the equivalence of eigenfunction expansions, we prove the basicity in the space of $L2\,(-1,1)$ of the eigenfunctions of the spectral problem. The existence and uniqueness of the solution of the studied problems for a fractional differential operator with an involution and with a complex-valued coefficient is proved.

Fractional logistic equation with variable kernel in the Caputo sense

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Schedule: December 16 13:30-13:50 Capital Suite 11 B

Madhukant Sharma
Dhirubhai Ambani Institute of Information and Communication Technology Gandhinagar, Gujarat
India

Co-Author(s): Madhukant Sharma, Sharad Dwivedi, Sanjeev Singh

Abstract:
We consider a Caputo-type fractional derivative of order $q \in (0,1]$ with a variable kernel ψ, which has been introduced in the literature for its efficacy in analyzing real-world models through appropriate selection of fractional derivatives. This inspired us to incorporate this generalized fractional operator in the logistic differential equation, pivotal in studying population dynamics. We identify the equilibrium points and evaluate their stability using the $\psi-$Laplace transform technique. The proof of the solution`s existence and uniqueness is achieved through employing the fixed-point theorem. Additionally, we derive the representation for the analytic solution as an infinite series by introducing the fractional $\psi-$series expansion, which has a positive radius of convergence. To conclude, by considering various kernels, we demonstrate the utility of the truncated series in closely approximating the analytical solution for different values of q.

Sampled-data control for Synchronization of N-Coupled Hindmarsh-Rose Neuronal Model

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Schedule: December 19 16:55-17:15 Capital Suite 11 B

Sasikala Subramaniyam
Vellore Institute of Technology, Vellore
India

Co-Author(s): Prakash Mani

Abstract:
This study focuses on the synchronization problem of N-coupled Hindmarsh-Rose (H-R) neuronal model with constant delays through a sampled-data control (SDC) approach. In literature, the stability of the H-R model is determined without solving the nonlinearities of the model. However, the present study investigates the stability of the model without changing the dynamical behavior of the original model by employing the T-S fuzzy approach. The T-S fuzzy-based H-R model, without any desired controlled input, serves as the master model, with controlled input serves as the slave model. In this regard, the present study designs the SDC scheme in the form of a discrete-time type with a zero-order holder (ZOH) technique for handling discrete-time control actions. The closed-loop error dynamics were obtained from the master and slave model, namely the error model. Synchronization analysis for the proposed error model is analyzed by employing the Lyapunov stability theory. In this regard, the Lyapunov-Krasovskii Functional (LKF) is constructed to derive the sufficient condition for the proposed error model. The sufficient conditions are derived from the derivative of the LKF in terms of linear matrix inequalities (LMIs). LMIs are solved with the help of the MATLAB YALMIP toolbox. The sufficient condition ensures the global asymptotic stability of the proposed error model. Finally, the numerical simulation shows the effectiveness of the theoretical framework.

ON OSCILLATORY NONLINEAR 2-D NEUTRAL DYNAMIC SYSTEMS ON TIME SCALES

Schedule: December 16 13:50-14:10 Capital Suite 11 B

ARUN KUMAR akt TRIPATHY
Sambalpur University
India

Co-Author(s): Shibanee Sahu

Abstract:
\noindent \noindent This work is concerned with the oscillation results of a class of 2-D neutral dynamic system of the form: \begin{align*} \begin{bmatrix} u(t)+p(t)u(t-\tau)\ v(t)+p(t)v(t-\tau) \ \end{bmatrix} ^{\Delta}= \begin{bmatrix} a_{1}(t) &\ a_{2}(t) \ a_{3}(t) &\ a_{4}(t) \ \end{bmatrix} \begin{bmatrix} \phi_{1}(u(t-\alpha))\ \phi_{2}(v(t-\beta))\ \end{bmatrix} \end{align*} on time scales $\mathbb{T}$, where $a1(t), a2(t), a3(t), a4(t), p(t)$ are real valued $rd-continuous$ functions defined on $\mathbb{T}$ such that $|p(t)|0\ and\ r\phi2(r) > 0\ for\ r \neq 0$, and for every right dense point r in $\mathbb{T}$. \noindent {\bf Keywords:} Oscillation, nonoscillation, time scales, Krasnoselskii`s fixed point theorem. \noindent {\bf Mathematics Subject classification (2020):} 34N05, 34K11, 34K40, 34A34.

Periodic Solution: Hopf Bifurcation or Hidden Attractor?

Schedule: December 18 9:20-9:40 Capital Suite 11 B

Muhammad Ismail Yunus
Khalifa University of Science and Technology
Indonesia

Co-Author(s): Muhammad Ismail Yunus

Abstract:
This writing inspired from paper by Jafari, Sprott, Golpayegani (2013) whereas they found 17 chaotic systems with chaotic flow without no-equilibrium. This paper indicate that all of the system happens to have cascade of period-doubling. In this paper, we found that this cascade of period-doubling can be obtained either from periodic solution of Hopf bifurcation or hidden attractor. Thus, we try to study these models to see if the periodic solution happens because of Hopf bifurcation or have hidden attractor since the beginning.

Contributed Session 2 : PDEs and Applications

Introduction:

Fractional-Order Operational Matrix Method for Eigenvalue Analysis of Nonsingular Second-Order Sturm-Liouville Problems

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Schedule: December 16 19:00-19:20 Capital Suite 11 B

Lana Abdelhaq
United Arab Emirates University
United Arab Emirates

Co-Author(s): Lana Abdelhaq, Sondos M. Syam, Muhammad I. Syam

Abstract:
This article focuses on the theoretical and numerical analysis of the eigenvalues associated with a non-singular fractional second-order Sturm-Liouville problem. We employ a fractional-order modified operational matrix method to approximate the eigenvalues, transforming the Sturm-Liouville problem into a sparse, non-singular linear system, which is then solved using the continuation method. Theoretical findings for the problem are presented and proven, with the fractional derivative defined in the Modified Atangana-Baleanu Fractional Derivative sense. The numerical results validate the accuracy of the proposed algorithm.

Exponential asymptotics for the stability of discrete Schr\{o}dinger solitons

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Schedule: December 16 15:25-15:45 Capital Suite 11 B

Theodore Adriano
Khalifa University
United Arab Emirates

Co-Author(s): Farrell Theodore Adriano, Abrari Noor Hasmi, Rudy Kusdiantara, Hadi Susanto

Abstract:
In this study, the existence and stability of dark solitons in the discrete nonlinear Schr\{o}dinger (DNLS) equation in the continuum limit (strong coupling between lattice sites) are analyzed. Our analysis shows that the DNLS admits only two types of solutions, namely the onsite and intersite solitons corresponding to the soliton`s centre being at a lattice site and between lattice sites, respectively. While numerical studies have been done to show the instability of both solitons, an analytical study of their instability has yet to be examined. We develop an exponential asymptotics/asymptotics beyond all orders method to analyze the instability of the intersite solitons. Our analytical prediction shows excellent agreement with the numerical results. We also extend our results to study the existence and stability of discrete bright solitons in the DNLS. Our application shows the versatility of this approach for analyzing multiscale problems in discrete nonlinear systems.

Second order divergence constraint preserving entropy stable finite difference schemes for two-fluid plasma flow equations

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Schedule: December 17 9:00-9:20 Capital Suite 11 B

Jaya Agnihotri
Indian Institute of technology, Delhi.
India

Co-Author(s): Deepak Bhoriya, Harish Kumar, Dinshaw Balsara and Praveen Chandrashekar

Abstract:
Two-fluid plasma flow equations describe the plasma flow of ions and electrons with different densities, velocities, and pressures. The system of equations has flux consisting of three independent components, one each for ions and electrons flows and a linear Maxwell`s equation flux for the electromagnetic fields. The coupling of these components is via source terms. This article introduces second-order finite difference schemes aimed at maintaining the consistent evolution of divergence constraints on both electric and magnetic fields. The core concept involves developing a numerical solver for Maxwell`s equations, utilizing a multidimensional Riemann solver at vertices to ensure discrete divergence constraints. To handle the fluid components, we employ an entropy-stable discretization approach. Our proposed schemes are collocated, boasting second-order accuracy, entropy stability, and ensuring the divergence-free evolution of the magnetic field. Time discretization is accomplished through explicit and Implicit-Explicit (IMEX) schemes. To demonstrate the accuracy, stability, and divergence constraint-preserving ability of the proposed schemes, we present several test cases in one and two dimensions. We also compare numerical results with schemes with no divergence cleaning and perfectly hyperbolic Maxwell (PHM) equations based divergence cleaning schemes for Maxwell`s equations.

On the regularity for aggregation-confinement-diffusion models with saturation

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Schedule: December 18 8:00-8:20 Capital Suite 11 B

Yousef Alamri
King Abdullah University of Science and Technology (KAUST)
Saudi Arabia

Abstract:
Aggregation-confinement-diffusion models with saturation are examples of degenerate parabolic equations that arise in models of chemotaxis and population dynamics. The presence of the degeneracy weakens the structure of the equation; and thus some of the properties of its solutions are lost. We explain an approach for proving the H\older regularity for the solution of these equations based on the method of intrinsic scaling.

Semi-analytical solutions of (2+1)-dimensional KdV-Burgers equation using Homotopy Analysis Method

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Schedule: December 16 15:45-16:05 Capital Suite 11 B

Rajan Arora
Indian Institute of Technology Roorkee
India

Co-Author(s): Rajan Arora, Prince Sharma

Abstract:
In this study, we apply the Homotopy Analysis Method (HAM) to derive analytical solutions to the Korteweg-de Vries-Burgers (KdV-Burgers) equation, well-known (2+1) dimensional nonlinear evolution equations. These solutions are essential for explaining intricate physical processes in various disciplines, such as nonlinear optics, fluid dynamics, and plasma physics. Convergence of the HAM-based solution is demonstrated via the squared residual error approach. It is shown that there is a strong match between the HAM-based technique and the exact solution to the problems.

Properties of a ϕ-Laplacian]{Asymptotic properties of a ϕ-Laplacian

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Schedule: December 19 Capital Suite 11 B

Waldo w arriagada
Wenzhou-Kean University
Peoples Rep of China

Co-Author(s): Waldo Arriagada

Abstract:
In this talk we consider the ϕ-Laplacian problem with Dirichlet boundary condition,

$$\left\{ -\mathrm{div}\left(\phi(|\nabla u|)\frac{\nabla u}{|\nabla u|}\right) = \lambda\, g(\cdot)\, \phi(u) \ \text{ in } \ \Omega,\ \lambda \in \backslash\mathrm{re}, \backslash\mathrm{vspace}{-.1in}\ u|\partial\Omega = 0. \right.$$

The term ϕ is a real odd and increasing homeomorphism, g is a nonnegative function in $L^{\infty}(\Omega)$ and $\Omega \subseteq \mathbb{R}^N$ is a bounded domain. We analyze the asymptotic behavior of sequences of eigenvalues of the differential equation under mild hypotheses. The treatment is based solely on convergence assumptions on the associated sequence of eigenfunctions. We assume that the latter is asymptotic to either zero or infinity (in a precise sense). The core result of these notes establishes that the liminf of the associated sequence of eigenvalues coincides with the first eigenvalue of the usual p-Laplace operator. Moreover, we demonstrate that any weak-$\star$ limit of the eigenfunctions is an associated ground state.

HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS WITH DISCRETE EFFECT MEMORY AND ITS APPLICATION

Schedule: December 19 9:00-9:20 Capital Suite 11 B

Anar Assanova
Institute of Mathematics and Mathematical Modeling
Kazakhstan

Abstract:
In the present communication we study a questions for existence and uniqueness of solution to the problem for the system of hyperbolic partial differential equations with discrete effect memory subject initial and integral conditions on the rectangular domain. Considered problem is transferred to family of problems for differential equations with discrete effect memory and integral condition by introducing a new functions. Further, introducing functional parameters as the values of the desired solution along the lines of the domain partition with respect to the time variable, we obtain an equivalent problem for the system of differential equations with initial conditions and functional relations with respect to the introduced parameters. We have developed a two-stage procedure to approximately solve the latter problem. We have obtained some conditions for the convergence of approximate solutions to the exact solution of the problem under study in terms of input data and proved that these conditions guarantee the existence of a unique solution of the equivalent problem. Finally, we have established coefficient conditions for the unique solvability of the problem for the system of hyperbolic partial differential equations with discrete effect memory subject initial and integral conditions.

A Novel Iterative Discretization Method for Solving Nonlinear Partial Differential Equations

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Schedule: December 19 17:30-17:50 Capital Suite 11 B

Mohamed Ben Romdhane
Abdullah Al Salem University, Kuwait
Kuwait

Co-Author(s): Mohamed Ben-Romdhane and Helmi Temimi

Abstract:
We introduce a highly efficient and accurate iterative method for solving nonlinear boundary value problems encountered in various engineering and physical applications. Our Iterative Finite Difference (IFD) technique is derived by applying quasilinearization in function space, combined with finite difference discretization, leading to an iterative scheme. Each iteration involves solving an ordinary differential equation using the approximate solution from the previous iteration. The method is applied to various nonlinear test problems such as Bratu`s problem in one, two, and three dimensions; Troesch`s problem; Falkner-Skan problem; and Lane-Emden problems. Numerical simulations demonstrate the method`s accuracy and efficiency, particularly for highly nonlinear problems where traditional numerical methods struggle. The proposed method exhibits a quadratic rate of convergence. Furthermore, we explore extending the method to solve another class of nonlinear partial differential equations (time-dependent problems), such as Sine-Gordon and Klein-Gordon problems.

ANALYSIS OF MAGNETOGASDYNAMIC SHOCK WAVE IN A SELF-GRAVITATING NON-IDEAL DUSTY GAS USING LIE GROUP THEORY

Schedule: December 17 9:20-9:40 Capital Suite 11 B

Akshita Bhardwaj
Indian Institute of Technology Roorkee
India

Co-Author(s): Akshita Bhardwaj, Deepika Singh and Rajan Arora

Abstract:
Our study delves into the behaviour of a one-dimensional, unsteady flow following a shock wave in a non-ideal dusty gas, including an axial magnetic field and gravitational field. We aim to understand the propagation of shock waves in magnetogasdynamic flows. We investigate both adiabatic and isothermal flows. In this work, both cylindrical and spherical shock waves have been considered. The graphs of the flow variables have been analyzed to study how they vary with respect to the physical parameters like adiabatic exponent, Mach number, etc. In both cases, we obtain the shock path as a power and exponential law. However, the self-similarity solution is not obtained in the case of the power law shock path, the detailed evaluation has been presented as cases.

Mesh-free mixed finite element approximation for nonlinear time-fractional biharmonic equation using weighted b-splines

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Schedule: December 20 16:35-16:55

Sudhakar Chaudhary
Institute of Infrastructure, Technology, Research And Management
India

Abstract:
In this article, we propose a fully-discrete scheme for the numerical solution of a nonlinear time-fractional biharmonic problem. This problem is first converted into an equivalent system by introducing a new variable. Then spatial and temporal discretizations are done by the weighted b-spline method and $L2\text{-}1_\sigma$ approximation, respectively. The weighted b-spline method uses weighted b-splines on a tensor product grid as basis functions for finite element space and by construction, it is a mesh-free method. This method combines the computational benefits of b-splines and standard mesh-based elements. We derive α-robust \emph{a priori} bounds and convergence estimate in the $L^2(\Omega)$ norm for the proposed scheme. Finally, we carry out few numerical experiments to support our theoretical findings.

On a new singular and degenerate extension of the p-Laplace operator

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Schedule: December 17 9:40-10:00 Capital Suite 11 B

Yuanji Cheng
Malmo University
Sweden

Co-Author(s): George Baravdish, Yuanji Cheng, Olof Svensson

Abstract:
We study a novel degenerate and singular elliptic operator $\Delta_{\mathcal{T},\xi}$, which is a weighted sum of one-Laplacian and infinite-Laplacian. We establish the well-posedness of the Neumann boundary value problem for the parabolic equation $u_t = \Delta_{\mathcal{T},\xi}(u)$ in the framework of viscosity solutions. We also prove the consistency and the convergence of the numerical scheme for the finite difference method of the parabolic equation above. Numerical simulations show that this novel operator $\Delta_{\mathcal{T},\xi}$ gives better results than both the Perona-Malik (Perona and Malik, 1990) and total variation (TV) methods (Chan and Shen, 2005) when applied to image enhancement.

Stabilization of steady-states in a three dimensional network of ferromagnetic nanowires

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Schedule: December 20 8:00-8:20 Capital Suite 11 B

Sarabindu Dolui
National Institute of Technology Andhra Pradesh
India

Co-Author(s): Sharad Dwivedi

Abstract:
In this work, we analytically investigate the stability of steady-states in a three-dimensional network of ferromagnetic nanowires. We construct a three-dimensional network nanostructure comprising an array of straight nanowires aligned parallel to each other at an equidistance. The analysis is performed within the framework of the Landau-Lifshitz equation. We consider two cases, viz., the network model consists of infinite-length and finite-length nanowires. By employing the classical approach for both cases, we establish sufficient conditions that show that the considered steady-states are exponentially stable. We remark that sufficient conditions depend on the damping and anisotropy coefficients and remain independent of the size of the network and the lengths of the nanowires.

Fractional derivatives with respect to another function in modeling anomalous diffusion processes.

Schedule: December 16 16:05-16:25 Capital Suite 11 B

Aldona Dutkiewicz
Adam Mickiewicz Univesity in Poznan, Faculty of Mathematics and Computer Science
Poland

Co-Author(s): Tadeusz Kosztolowicz

Abstract:
We will consider the g-subdiffusion equation with the fractional Caputo time derivative with respect to another function g (T. K., A. D., Phys. Rev. E 104, 014118 (2021)). Such equation offers possibilities for modeling diffusion as a process in which a type of diffusion evolves continuously over time (T. K., A. D., Phys. Rev. E 106, 044119 (2022)). The stochastic interpretation of g-subdiffusion will be discussed (T. K., A. D., Phys. Rev. E 104, L042101 (2021)). The method for solving g-subdiffusion equation, based on Laplace-type transform with respect to the function g, will be presented. We also show the application of the g-subdiffusion equation to describe the release of antibiotic from gel beads and its further subdiffusion in a gel system. The g function is then determined by the best fit of theoretical results to empirical data (T. K., A. D. et al., Phys. Rev. E 106, 044138 (2022)).

Field reconstruction with noise and vibration tolerance: application to nuclear engineering

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Schedule: December 18 8:20-8:40 Capital Suite 11 B

Helin Gong
Shanghai Jiao Tong University
Peoples Rep of China

Co-Author(s): Helin Gong, Han Li, Sibo Cheng, Chuanju Xu

Abstract:
As operational reactors age, they experience increased mechanical vibrations, particularly affecting the in-core sensors and complicating the reconstruction of neutronic fields. Traditional field reconstruction methods are inadequate for dealing with the spatial movement of sensors. To address this, a novel technique combining Voronoi tessellation with convolutional neural networks (V-CNN) has been proposed. This method projects observations from movable sensors onto a unified global field structure through Voronoi tessellation, which preserves sensor magnitude and location data. The V-CNN learns the mapping from these observations to the global field, capable of reconstructing multi-physics fields such as fast flux, thermal flux, and power rate from single-field observations like thermal flux. Numerical tests using the IAEA benchmark have shown its effectiveness, achieving average relative errors below 5\% and 10\% in $L2$ norm and L_∞ norms, respectively, within a 5 cm amplitude around nominal sensor locations. Furthermore, the challenge of balancing lightweight design with the ability to handle unstructured data and robustness against observation noise and sensor vibrations is tackled by the introduction of the EIM-NN algorithm. This algorithm employs neural networks to determine coefficients within the subspace identified by the EIM algorithm. An enhanced version, the EIM-TNN algorithm, incorporates Tikhonov regularization into the loss function to improve robustness. The neural network, consisting of only two fully connected layers, is adept at managing unstructured data while maintaining a compact structure. The experimental results highlight the algorithm`s robustness against noise and vibrations, without sacrificing the accuracy of the original data fit. Its lightweight nature ensures that the additional training time and memory requirements are minimal compared to EIM, making it suitable for various industrial applications.

Shearlet Scattering Transform and Its Applications

Schedule: December 20 16:55-17:15

Wei Guo
Hebei Normal University
Peoples Rep of China

Abstract:
Convolutional neural networks have achieved significant success in in signal processing and computer vision, but its underlying mechanisms are not well understood. Recently, the understanding of convolutional neural networks has received more and more attention. The wavelet scattering transform is the pioneering work presented by Mallat who is one the founders of wavelet analysis. It can be proved that it has the properties of translation invariance and deformation stability. In this talk, we will introduce our proposed shearlet scattering transform. It combines the advantages of scattering transform and shearlet. In addition, we construct a hybrid shearlet scattering network by fusing the shearlet scattering transform with an appropriate convolutional neural network, and apply it to COVID-19 detection and fake news detection tasks, both of which achieve good application performance.

Existence, Symmetry and Regularity of Ground States of a Non Linear Choquard Equation in the Hyperbolic Space

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Schedule: December 20 8:20-8:40 Capital Suite 11 B

Diksha Gupta
Indian Institute of Technology Delhi
India

Co-Author(s): Diksha Gupta, Konijeti Sreenadh

Abstract:
We explore the positive solutions of the following nonlinear Choquard equation involving the green kernel of the fractional operator $(-\Delta_{\mathbb{B}}N)^{-\alpha/2}$ in the hyperbolic space

$$-\Delta_{\mathbb{B}}N u - \lambda u = \left[(-\Delta_{\mathbb{B}}N)^{-\frac{\alpha}{2}} |u|^p\right] |u|^{p-2} u,$$

where $\Delta_{\mathbb{B}}N$ denotes the Laplace-Beltrami operator,
$\lambda \leq \frac{(N-1)^2}{4} 1 < p < 2^*_\alpha = \frac{N+\alpha}{N-2} 0 < \alpha < N, N \geq 3, 2^*_\alpha$ is the critical exponent in the context of the Hardy-Littlewood-Sobolev inequality (HLS). This study is analogous to the Choquard equation in $\mathbb{R}^N$, involving non-local Riesz potential operator. We consider the functional setting within the Sobolev space $H^1(\mathbb{B}^N)$, employing advanced harmonic analysis techniques, the Helgason Fourier transform, and semigroup approach to the fractional Laplacian. The HLS inequality on complete Riemannian manifolds, as developed by Varopoulos, is pivotal in our analysis. We prove an existence result for the problem, demonstrate that solutions exhibit radial symmetry, and establish the regularity properties.

Study of fractional differential equations with impulses in both state and control

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Schedule: December 19 17:50-18:10 Capital Suite 11 B

Garima Gupta
Indian Institute of Technology Roorkee
India

Co-Author(s): Jaydev Dabas

Abstract:
In this paper, we initiate the study of impulsive controls in the context of impulsive fractional order differential equations with Caputo derivative of order $\alpha \in (0, 1)$ and present several results highlighting their significance. We address the problem of determining the existence and uniqueness of the considered fractional systems and provided the necessary and sufficient conditions. We provide a solution representation in the form of α families, using semigroup and impulsive operators, based on the fundamental assumption that the operator A, which governs the state, is the infinitesimal generator of a strongly continuous semigroup. Finally, we include an example to illustrate and verify all the obtained results.

Generalized concentration compactness principle and its applications to fractional problems with critical growth in $\mathbb{R}^N$

Schedule: December 17 12:30-12:50 Capital Suite 11 B

Shilpa Gupta
Indian Institute of Technology Kanpur
India

Co-Author(s): Gaurav Dwivedi and Sweta Tiwari

Abstract:
In this work, we discuss the following generalized non-local problem: \begin{equation*} (-\Delta)^{s}_{A}u(x) =\lambda g(x,|u|)u+ f(x,u) \ \ \hbox{in} \ \mathbb{R}^{N}, \end{equation*} where $N \geq 1$, $s \in (0,1)$, $A(x,y,t) = \int_0^{|t|} a(x,y,r)r\,dr$ and $a : \mathbb{R}^N \times \mathbb{R}^N \times [0,\infty) \to [0,\infty)$ is a generalized N-function. The functions $g : \mathbb{R}^N \times \mathbb{R} \to [0,\infty)$, $f : \mathbb{R}^N \times \mathbb{R} \to \mathbb{R}$ are continuous and $\lambda > 0$ is sufficiently small parameter. We assume that the nonlinearity g exhibits critical growth, while f possesses critical growth at infinity. Our primary goal is to establish the existence of weak solutions to the above problem in the setting of the homogeneous fractional Musielak-Sobolev space. To achieve this, we first establish a generalized concentration-compactness principle (CCP) corresponding to our problem, along with a variant at infinity. Subsequently, utilizing these results, we apply a variational approach, specifically invoking the mountain pass theorem, to demonstrate the existence of weak solutions.

Introduction on quantum hydrodynamic equation for semiconductors and the relaxation-time limit

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Schedule: December 19 18:10-18:30 Capital Suite 11 B

Zheng Hao
Chinese academy of science
Peoples Rep of China

Co-Author(s): Paolo Antonelli, Pierangelo Marcati

Abstract:
Quantum hydrodynamic (QHD) models study hydrodynamic phenomena where quantum effects must be taken into account, such as superfluidity, Bose-Einstein condensation, quantum plasmas, or semiconductor devices. In this talk, I will give a briefly introduction on the physical background of several QHD models, as well as some related mathematical problems and their literatures. Last, I will introduce some recent results about the 1-dimensional collisional Quantum Hydrodynamics (QHD) system and its relaxation-time limit, which is a work in collaborating with Paolo Antonelli and Pierangelo Marcati.

An analytical treatment to spatially inhomogeneous population balance model

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Schedule: December 18 8:40-9:00 Capital Suite 11 B

Saddam Hussain
Birla Institute of Technology and Science Pilani, Pilani Campus, India
India

Co-Author(s): Shweta, Rajesh Kumar

Abstract:
In modern liquid-liquid contact components, there is an increasing use of droplet population balance models. These components include differential and completely mixed contractors. These models aim to explain the complex hydrodynamic processes occurring in the dispersion phase. The hydrodynamics of these interacting dispersions include droplet breaking, coalescence, axial dispersion, and both entry and exit events. The resulting equations for population balance are represented as integro-partial differential equations, which rarely have analytical solutions, especially when spatial dependency is apparent. Consequently, the pursuit predominantly lies in seeking numerical solutions to resolve these complex equations. In this study, we have devised analytical solutions for inhomogeneous breakage and coagulation by employing the population balance equation (PBEs) applicable to both batch and continuous flow systems. The innovative approaches for solving PBEs in these systems leverage the Adomian decomposition method (ADM) and the homotopy analysis method (HAM). These semi-analytical methodologies effectively tackle the significant challenges related to numerical discretization and stability, which have often plagued previous solutions of the homogeneous PBEs. Our findings across all test examples demonstrate that the approximated particle size distributions utilizing these two methods converge to the analytical solutions continuously.

Existence of one-peak stationary solutions for the Gierer-Meinhardt model with advection term on the Y-shaped metric graph

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Schedule: December 16 17:00-17:20 Capital Suite 11 B

Yuta Ishii
National Institute of Technology, Ibaraki College
Japan

Abstract:
In this talk, we deal with the Gierer-Meinhardt reaction-diffusion model with advection term on the Y-shaped metric graph. The Y-shaped metric graph is a domain consisting of three finite segments joined a single junction. Moreover, we consider the advection velocity changes from segment to segment. We present the result on the existence of one-peak stationary solutions for the Neumann boundary condition and the Robin boundary condition, respectively. In particular, the location of a spike is decided by the three effects, the network structure of the Y-shaped graph, the choice of the boundary conditions, and the sign of the advection velocity.

Dynamics of nonlinear anomalous reaction-diffusion models: global existence and blow-up of solutions

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Schedule: December 17 12:50-13:10 Capital Suite 11 B

Khumoyun Jabbarkhanov
Institute of Mathematics and Mathematical Modeling
Kazakhstan

Abstract:
In this paper, we investigate a large class of nonlinear reaction-diffusion models with fractional Laplacians. We employ a combination of the concavity method and the first-order differential inequality technique to establish the necessary conditions for both global existence and blow-up solutions. We also illustrate our main results through concrete examples.

Fine Boundary Regularity For The Fractional (p,q)-Laplacia

Schedule: December 19 18:30-18:50 Capital Suite 11 B

Ritabrata Jana
IISER Thiruvananthapuram
India

Co-Author(s): R. Dhanya, Uttam Kumar, and Sweta Tiwari

Abstract:
In this talk, we deal with the fine boundary regularity, a weighted H\{o}lder regularity of weak solutions to the problem involving the fractional (p, q)-Laplacian denoted by $(-\Delta)_p^s u + (-\Delta)_q^s u = f(x)$ in Ω, and $u = 0$ in $\mathbb{R}^N \setminus \Omega$; where Ω is a $C^{1,1}$ bounded domain and \$2 \leq p \leq q

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Adsorption effect on viscous fingering in porous media

Schedule: December 19 16:35-16:55 Capital Suite 11 B

Ajay Jangid
Indian Institute of Technology Ropar
India

Co-Author(s): Manoranjan Mishra

Abstract:
CO_2 plumes dissolved in brine or localized fluids with viscosities different from the surrounding fluid, may not always exhibit a planar interface. In cases such as pollutant contamination in soils, can take on an arbitrary initial shape and are subsequently carried and deformed by groundwater flows. These non-planar interfaces significantly influence the dynamics of fluid movement and can complicate predictions of the plume`s behaviour and spread in subsurface environments. We have considered a blob in rectilinear porous media. Since the adsorption plays a vital role in pollutant contaminant in groundwater, we have considered a non-linear type adsorption known as Langmuir adsorption isotherm in a convection-diffusion equation along with Darcy law, continuity equation and Arrhenius relation of viscosity and concentration. The above mentioned coupled system of partial differential equations is solved using Fourier pseudo spectral method and the time derivative is solved using a predator corrector method. We have observed a non-monotonic behaviour in the blob shape as the adsorption parameter increases. Initially, the blob transitions from an unstable regime to a comet-shaped regime. However, beyond a certain value of the adsorption parameter, the system re-enters the unstable regime. Additionally, we identified a competition between the retention parameter and the adsorption parameter. While the retention parameter slows down the movement of the blob, the adsorption parameter has the opposite effect, accelerating the blob`s progression.

Existence of weak solutions to a Baer--Nunziato type system

Schedule: December 16 17:20-17:40 Capital Suite 11 B

Martin Kalousek
Institute of Mathematics, Czech Academy of Sciences
Czech Rep

Abstract:
In this talk, a dissipative version of a compressible one velocity Baer--Nunziato type system for a mixture of two compressible heat conducting gases is considered. The complete existence proof for weak solutions to this system was addressed as an open problem in [2, Section 5]. The purpose of the talk is the presentation of most essential elements of the proof of the global in time existence of weak solutions to the one velocity Baer--Nunziato type system for arbitrary large initial data. Namely, the attention will be focused on the following three steps: (i) Transformation of the given system into a new one which possesses the Navier-Stokes-Fourier structure; (ii) Showing the existence of weak solutions of the new system by an adaptation of the approach used in the existence theory for the compressible Navier--Stokes--Fourier equations which is presented in [1]; (iii) Showing the existence of a weak solution to the original one velocity Baer--Nunziato system using the almost uniqueness property of renormalized solutions to pure transport equations. [1] E. Feireisl, A. Novotn\`y: Singular limits in thermodynamics of viscous fluids. Advances in Mathematical Fluid Mechanics. Birkh\auser Verlag, Basel, (2009). [2] Y.-S. Kwon, A. Novotn\`y, C.H. Arthur Cheng: On weak solutions to a dissipative Baer--Nunziato--type system for a mixture of two compressible heat conducting gases, \newblock Math. Models Methods Appl. Sci. 30 (2020) no. 8, 1517--1553.

Assessment of Leray-Type Regularization of Burgers Equation Using Physics-Informed Neural Networks

Schedule: December 18 9:00-9:20 Capital Suite 11 B

BONG-SIK KIM
American University of Ras Al Khaimah
United Arab Emirates

Co-Author(s): Bong-Sik Kim, Yuncherl Choi, Doo Seok Lee

Abstract:
The Leray-Burgers equation, used in our study, is a simplified model that retains essential features of the Leray regularization applied to the Navier-Stokes equations. Our research addresses a critical challenge: selecting the appropriate parameter α value, which controls the characteristic wavelength below which smaller-scale physical phenomena are averaged out. While α-type regularizations are well-studied, there has been no systematic method for choosing α, and the existing rule of thumb ties its selection to numerical schemes and mesh refinements. Our work aims to decouple α from these numerical factors, allowing for more general and practical application. By employing PINNs, we avoid the constraints of specific meshes and numerical schemes. Our results demonstrate that the choice of α depends on the initial data, with a practical range of values between 0.01 and 0.05 for continuous initial profiles and between 0.01 and 0.03 for discontinuous profiles. This study also highlights the effectiveness and efficiency of the Leray-Burgers equation in real practical problems, specifically Traffic State Estimation.

Non-uniqueness of H\older continuous solutions to 3D stochastic Euler equations on torus

Schedule: December 17 13:10-13:30 Capital Suite 11 B

Kush Kinra
NOVA University of Lisbon
Portugal

Co-Author(s): Ujjwal Koley

Abstract:
In this talk, we wii discuss the construction of infinitely many H\older continuous global-in-time solutions to the stochastic Euler equations in the space $C(\R; C^{\vartheta})$ for $0 < \vartheta < \frac{5}{7}\beta$, with $0 < \beta < \frac{1}{24}$. A modified stochastic convex integration scheme, using Beltrami flows as building blocks and propagating inductive estimates both pathwise and in expectation, plays a pivotal role to improve the regularity of H\older continuous solutions for the underlying equations. As a main novelty with respect to the related literature, our result produces solutions with noteworthy H\older exponents.

Ground state for a system of nonlinear Schr\{o}dinger equations with three waves interaction and critical nonlinearities

Schedule: December 19 16:55-17:15 Capital Suite 11 B

Hidenori Kokufukata
Graduate School of Science, Kanagawa University
Japan

Co-Author(s): Hiroshi Matsuzawa

Abstract:
We consider a system of nonlinear Schr\{o}dinger equations with three wave interactions and critical exponents and concern the existence of a nontrivial ground state solution. This problem has been studied by several researchers, for example Pomponio(2010) and Osada (2021, 2022, 2024) in the case where all the exponents of the nonlinearlities are subcritical. In this talk, we will demonstrate that even when the exponents of the nonlinearity admit the Sobolev critical exponent, a nontrivial ground state solution can still be obtained if the coupling constant is sufficiently large. Additionally, we show that when the coupling constant is large enough, the ground state solution is a vector solution, namely, a solution $(u1, u2, u3)$ which satisfies $ui \neq 0$ for all $i = 1, 2, 3$. Our method is to consider a minimization problem on the Nehari manifold.

Superdiffusion described by g-subdiffusion equation with fractional Caputo time derivative with respect to another function

Schedule: December 19 18:50-19:10 Capital Suite 11 B

Tadeusz Kosztolowicz
Institute of Physics, Jan Kochanowski University, Kielce, Poland
Poland

Co-Author(s): Aldona Dutkiewicz

Abstract:
Superdiffusion is usually described by an equation with a Riesz-type fractional spatial derivative. The derivative is nonlocal in space, so it is difficult to impose boundary conditions for this equation at a partially permeable thin membrane. If we define the function g appropriately, then the g-subdiffusion equation with the Caputo time derivative with respect to another function g also describes superdiffusion. The Green`s functions for both equations mentioned above converge in the long-time limit. The advantages of using the g-subdiffusion equation to describe superdiffusion will be presented, in particular, the ability to define boundary conditions at the membrane. The presentation is based on the following publications: T. Kosztolowicz, Phys. Rev. E 107, 064103 (2023), 106, L022104 (2022), 99, 022127 (2019), and T. Kosztolowicz, A.Dutkiewicz, Phys. Rev. E 104, 014118 (2021), 104 L042101 (2021).

Ergodic HJB equation: existence via duality

Schedule: December 16 17:40-18:00 Capital Suite 11 B

Hicham Kouhkouh
University of Graz
Austria

Abstract:
I will present a new method to prove the solvability of a class of nonlinear elliptic PDEs, namely Hamilton-Jacobi-Bellman equations, in the whole space and with merely measurable and unbounded coefficients. Such equations arise mainly in stochastic optimal control, but also in asymptotic problems in PDEs (homogenisation, long-time behaviour, ...). The method relies on duality and optimisation in abstract Banach spaces, together with thorough analysis of diffusion operators. The main idea is to derive the solution of the PDE from the dual variable of a suitably chosen optimisation problem. I will also discuss how the method can be generalised to tackle other PDEs. References: [1] H. Kouhkouh, A viscous ergodic problem with unbounded and measurable ingredients. Part 1: HJB equation. (SIAM J. Contr. Opt., 2024) [2] H. Kouhkouh, A viscous ergodic problem with unbounded and measurable ingredients. Part 2: Mean-Field Games. (arXiv:2311.04616) [3] H. Kouhkouh, The viscous eikonal equation in the whole space with nonsmooth right-hand side and stable drift. (In preparation)

Boundary Regularity of Solutions to Variable-exponent Gradient Degenerate PDEs

Schedule: December 16 16:25-16:45 Capital Suite 11 B

Priyank Kumar
Nazarbayev University
Kazakhstan

Co-Author(s): Jagmohan Tyagi

Abstract:
In this talk, I will present the boundary regularity of solutions to a class of variable-exponent gradient degenerate mixed fully nonlinear local-nonlocal elliptic Dirichlet problems. A crucial feature of the operators under consideration is that they degenerate on the set of critical points, $\mathcal{C}:=\{x : Du(x)=0\}$. First, we establish the Lipschitz and H\older regularity of solutions using the Ishii-Lions viscosity method for the cases when the order of the fractional Laplacian, s is within $\left(1/2,1\right)$ and $(0,1/2\big]$, respectively, under general conditions. Due to the inapplicability of the comparison principle for the equations under consideration, in general, the classical Perron`s method for the existence of a solution can not employed. However, by utilizing the Lipschitz/H\older estimates established and \enquote{vanishing viscosity} method, we prove the existence of a solution. Additionally, we prove interior $C^{1,\delta}$ regularity of viscosity solutions using an improvement of the flatness technique when s is close enough to 1 or 0. Furthermore, under suitable assumptions, we establish the H\older regularity of solutions up to the boundary.

Higher Order Fractional Weighted Homogeneous Spaces: Characterization and Finer Embeddings

Schedule: December 20 16:15-16:35

Rohit Kumar
Indian Institute of Technology Jodhpur
India

Co-Author(s): Dr. Nirjan Biswas

Abstract:
In this article, for $N \geq 2, s \in (1,2), p \in (1, \frac{N}{s}), \sigma = s - 1$ and $a \in [0, \frac{N-sp}{2})$, we establish an isometric isomorphism between the higher order fractional weighted Beppo-Levi space \begin{align*} {\mathcal D}^{s,p}_a(\mathbb{R}^N) := \overline{C_c^\infty(\mathbb{R}^N)}^{[\cdot]_{s,p,a}} \text{ where } [u]_{s,p,a} := \left(\iint_{\mathbb{R}^N \times \mathbb{R}^N} \frac{\left| \nabla u(x) -\nabla u (y) \right|^p}{\left|x-y \right|^{N+\sigma p}}\, \mathrm{d}x\mathrm{d}y \right)^{\frac{1}{p}}, \end{align*} and higher order fractional weighted homogeneous space \begin{align*} \mathring{W}^{s,p}_a(\mathbb{R}^N):= \left\{u \in L_a^{p^*_s}(\mathbb{R}^N): \|\nabla u\|_{L_a^{p^*_{\sigma}}(\mathbb{R}^N)} + [u]_{s,p,a} < \infty \right\} \end{align*} with the weighted Lebesgue norm \begin{align*} \|u\|_{L_a^{p^*_{\alpha}}(\mathbb{R}^N)}:= \left(\int_{\mathbb{R}^N} \frac{ |u(x)|^{p^*_{\alpha}}}{|x|^{\frac{2ap^*_{\alpha}}{p}}} \, \mathrm{d}x \right)^{\frac{1}{p^*_{\alpha}}}, \text{ where } p^*_{\alpha}=\frac{Np}{N-\alpha p} \text{ for } \alpha= s,\sigma. \end{align*} To achieve this, we prove that $\mathcal{C}_c^\infty(\mathbb{R}^N)$ is dense in $\mathring{W}_a^{s,p}(\mathbb{R}^N)$ with respect to $[\cdot]_{s,p,a}$, and $[\cdot]_{s,p,a}$ is an equivalent norm on $\mathring{W}_a^{s,p}(\mathbb{R}^N)$. Further, we obtain a finer embedding of $\mathcal{D}_a^{s,p}(\mathbb{R}^N)$ into the Lorentz space $L^{\frac{Np}{N-sp-2a},p}(\mathbb{R}^N)$, where $L^{\frac{Np}{N-sp-2a},p}(\mathbb{R}^N) \subsetneq L_a^{p_s^*}(\mathbb{R}^N)$.

Can we create (pseudo)randomness with polygons?

Schedule: December 19 19:10-19:30 Capital Suite 11 B

Sandeep Kumar
CUNEF University
Spain

Abstract:
In this talk, we will explore the Schr\odinger map equation, a geometric PDE, by examining its evolution for polygonal curves in various geometric settings. This equation is a special case of the renowned Landau--Lifshitz equation for ferromagnetism, and in Euclidean space, it describes the evolution of a vortex filament in a real fluid, commonly known as the vortex filament equation. When solved numerically for polygonal initial data, the dynamics exhibit intriguing fluid-like behaviours such as axis switching and multifractality, phenomena often linked to turbulence. Moreover, the algebraic construction of these solutions not only supports the numerical evolution but also reveals a degree of randomness, frequently seen in natural processes. I will present recent findings, focusing particularly on helical vortices and curves in hyperbolic space, and demonstrate that this seemingly random behaviour arising from a differential equation appears to be a generic phenomenon. [1]: S. Kumar, Pseudorandomness of the Schr\odinger map equation. arXiv:2311.01611. [2]: S. Kumar, On the Schr\odinger map for regular helical polygons in the hyperbolic space. Nonlinearity 35(1) (2022), 84--109. [3]: F. de la Hoz, S. Kumar and L. Vega, Vortex Filament Equation for a regular l-polygon in the hyperbolic plane. J. Nonlinear Sci. 32(9) (2022).

Understanding the dynamics of reaction diffusion equation using Transformer-based Koopman Autoencoder

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Schedule: December 17 13:30-13:50 Capital Suite 11 B

Nitu Kumari
Indian Institute of Technology Mandi
India

Abstract:
A Transformer based Koopman autoencoder is proposed for linearizing reaction diffusion equation. The primary focus of this study is on using deep learning techniques to find complex spatiotemporal patterns in the reaction diffusion system. The emphasis is not just solving the equation but also transforming the system dynamics into a more comprehensible, linear form. Global coordinate transformations are achieved through the autoencoder, which learns to capture the underlying dynamics by training on a dataset with 60,000 initial conditions. Extensive testing on multiple datasets was used to assess the efficacy of the proposed model, demonstrating its ability to accurately predict the system evolution as well as to generalize. We provide a thorough comparison study, comparing our suggested design to a few other comparable methods using experiments on various PDEs. Results show improved accuracy, highlighting the capabilities of the Transformer based Koopman autoencoder. The proposed architecture is significantly ahead of other architectures, in terms of solving different types of PDEs using a single architecture. Our method relies entirely on the data, without requiring any knowledge of the underlying equations. This makes it applicable to even the datasets where the governing equations are not known.

Well-Posedness of the Reactive Flow in Heterogeneous Porous Medium

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Schedule: December 18 9:20-9:40 Capital Suite 11 B

Sahil kundu
IIT Ropar
India

Co-Author(s): Surya N. Maharana, Manoranjan Mishra

Abstract:
Reactive flow in porous media plays a crucial role in various fields, including the petrochemical industry, water decontamination, biofilm metabolism, and the medical industry. This study focuses on reactive displacement in heterogeneous porous media involving a chemical reaction, $A + B \to C$, which serves as a fundamental building block for more complex reactions. Understanding this reaction can provide insights into a broader range of chemical processes. To model this phenomenon, we couple convection-diffusion-reaction equations with the Brinkman equation to account for momentum conservation. Additionally, the heterogeneity of the porous media is captured by modeling its permeability as an exponential function of the product concentration. Due to the inherent nonlinearities, we adopt a variational approach to establish well-posedness for the problem. We obtain various priori estimates using functional analysis tools such as Young`s and Holder`s inequalities. Using these estimates along with the Galerkin method, we establish the existence of a solution. Furthermore, we demonstrate continuous dependence on the initial data, ensuring the uniqueness of the solution

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Dynamic wind fields and the method of manufactured solutions for surface flow

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Schedule: December 16 18:20-18:40 Capital Suite 11 B

Johannes Lawen
Hamburg University of Technology
Germany

Abstract:
Coastal ocean models do not readily provide for manufactured forces to validate with the method of manufactured solutions. Therefore, this new method exploits dynamic wind fields to obtain compact solitary solutions. The latter is provided for the incompressible Euler and Navier-Stokes PDE. The nonlinear response of momentum advection is moved into a term for dynamic wind forcing. Then, the linear continuity PDE is solved by means of arbitrarily selected closure functions. The validation of numerical schemes is demonstrated for the Euler and Navier-Stokes PDE. As the nonlinear response is isolated in only one spatial dimension, the method permits to validate arbitrary unstructured meshes and domain geometries.

Iterative corrector scheme for modified NS PDE with and without sweeping

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Schedule: December 17 8:00-8:20 Capital Suite 11 B

Johannes Lawen
Hamburg University of Technology
Germany

Abstract:
The NS PDEs have been modified to enhance numerical tractability, followed by corrective iterations to recover solutions for the NS PDEs. It is shown that the scheme can be transformed into the implicit upwind approximation, yielding an identical solution. The iterative scheme guarantees convergence, a predictable number of iterations, and provides initial rapid convergence. The number of iterations depends on the size of mesh. In triangular matrix regions, iterations can be accelerated using a sweeping approach similar to the fast-marching method. Outside triangular submatrices, the iterative process is retained. This method is proposed to facilitate cross-validation with a reference solution.

Unconditionally energy gradient stable numerical scheme for Cahn-Hilliard equation with arbitrary polynomial formula degenerate mobility

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Schedule: December 20 8:40-9:00 Capital Suite 11 B

Gyeonggyu Lee
National Institute
Korea

Co-Author(s): Seunggyu Lee

Abstract:
In this study, we consider the Cahn--Hilliard (CH) equation with the arbitrary polynomial formula degenerate mobility, which is a function valued mobility depending on the concentration. Because the CH equation with the degenerate mobility relates to a various scientific topics, such as logarithm potential and the curvature-dependent mobility, it is important to confirm the dynamics and construct a numerical scheme, which satisfies a unique solvability, unconditional energy stability, and mass preservation. Accordingly, we propose an unconditionally energy gradient stable scheme based upon the linear stabilized splitting scheme. the energy dissipation and mass preservation properties of the CH equation with an arbitrary polynomial formula degenerate mobility are proved at first. Subsequently, the discrete mass preservation property, unique solvability, energy gradient stability, and accuracy of the considered numerical scheme are numerically analyzed and convicted from the numerical experiments.

Maximum principle and energy stablity preserving explicit scheme for solving Allen-Cahn equation

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Schedule: December 20 9:00-9:20 Capital Suite 11 B

Seunggyu Lee
Korea University
Korea

Co-Author(s): Seunggyu Lee, Woonjae Hwang

Abstract:
We propose an explicit linear scheme to solve the Allen--Cahn equation that satisfies energy stability and maximum principle. Our approach is based on a finite-difference spatial discretization, and we prove the maximum principle without any time-step restriction. The proposed method can be easily extended to the 2nd order accuracy in time. Numerical experiments demonstrate its accuracy, energy stability, and maximum principle.

Determine the exact value of the square root of 2

Schedule: December 20 14:00-14:20

Qing Li
shijiazhuang traditional chinese hospital
Peoples Rep of China

Abstract:
The calculation of the exact value of the square root of 2 is requested. In order to obtain its infinite value, A new concept is proposed where the accumulations of the infinitely many of finity is indicated by the change in direction which means that there is a jump from finity to infinity .The meaningless for an infinite number with a decimal point is indicated by this jump because any decimal number only have meanings within a finite range values and there is only an infinite integer quantity that can not be operated by algorithms like operations of multiplication,division,addition, and subtraction . The final result of the change in direction is two quantity where the second quantity and the first quantity extend in parallel line and never intersect and the second quantity represent the size of the first quantity. The first quantity is the infinitely great that can`t be talked about anything outside of it and can compress any quantities outside of it to nothing and it is the exact value of the square root of 2 .

Advancements in Active Vibration Control of Shear Beams Using Piezoelectric Actuators

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Schedule: December 17 8:20-8:40 Capital Suite 11 B

Assane Lo
University of Wollongong in Dubai
United Arab Emirates

Co-Author(s): Assane Lo, Umar Asghar, Ciara ODriscoll

Abstract:

This paper investigates the controllability properties of a Shear beam model without rotary inertia, extending previous research on its stability characteristics. While recent studies [28] have shown that this system lacks natural exponential stability when damping is applied only to the angle rotation, we demonstrate that the introduction of piezoelectric actuators significantly enhances the system`s controllability. We consider the Shear beam model governed by coupled partial differential equations for transverse displacement and rotation angle, subject to hinged boundary conditions. Our main result establishes the exact L^2-controllability of this system for any positive time T, using piezoelectric actuators placed at specific locations (ξ_1, μ_1), (ξ_2, μ_2) along the beam. The proof utilizes the Hilbert Uniqueness Method (HUM) and a generalization of Ingham`s inequality. We derive explicit conditions on the actuator placements and system parameters that ensure controllability. Furthermore, we provide a quantitative lower bound for the control energy required to steer the system between arbitrary initial and final states in the L^2 space. This controllability result has significant implications for the system`s behavior, effectively overcoming the limitations of non-exponential stability reported in previous work [28]. Our findings open new avenues for designing optimal control strategies and feedback stabilization schemes for Shear beam models, with potential applications in vibration suppression and precise motion control in various engineering contexts. To validate the practical aspects of our theoretical findings, we perform comprehensive numerical simulations. These simulations demonstrate the effectiveness of the proposed control strategy under various initial conditions and actuator configurations, confirming the robustness and applicability of our results in realistic scenarios.

Existence and multiplicity of non-radial sign-changing solutions for a semilinear elliptic equation in hyperbolic space

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Schedule: December 17 13:50-14:10 Capital Suite 11 B

Atanu Manna
Indian Institute of Technology Hyderabad
India

Co-Author(s): Dr. Bhakti Bhusan Manna

Abstract:

We consider the following problem: \begin{align*} -\Delta_{\mathbb{B}^N} u \, - \, \lambda u &= |u|^{p-1}u, \quad u \in H^{1}$\mathbb{B}^N$, \end{align*} where $\mathbb{B}^N$ represents the Poincar\`e ball model of the hyperbolic space, $1 < p < 2^* - 1 = \frac{N+2}{N-2}, \lambda < \frac{(N-1)^2}{4}, N \geq 4$. Here, we extend the results by Mancini, Sandeep [2008] and Bhakta, Sandeep [2012], which establish the existence of radial positive and radial sign-changing solutions, respectively. We prove the existence and multiplicity of non-radial sign-changing solutions. To prove the existence of such solutions, we consider two isometric group actions on $\mathbb{B}^N$ and pose a variational problem on a suitable subspace of H^1\($\mathbb{B}^N$\). We solve the variational problem in two cases, depending on the fixed point set of the groups.

Duality solutions and the hard-congestion model

Schedule: December 16 18:00-18:20 Capital Suite 11 B

Muhammed Ali Mehmood
Imperial College London
England

Co-Author(s): Nilasis Chaudhuri, Charlotte Perrin, Ewelina Zatorska

Abstract:
We introduce the notion of duality solution for a two-phase compressible/incompressible fluid model, known as the hard-congestion model, on the real line, and additionally prove an existence result for this class of solutions. This system is derived from the analysis of a generalised Aw-Rascle system (a model for traffic flow and crowd dynamics). We prove that under suitable assumptions on the initial data, solutions to the Aw-Rascle system converge towards the so-called duality solutions, which have previously found applications in other systems which exhibit compressive dynamics. We also discuss uniqueness issues and prove that one can obtain weak solutions to the limiting system under stricter assumptions on the initial data.

Some Recent Results on Stochastic Camass-Holm Type Equations: Global Existence, Blow-Up and Stability

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Schedule: December 17 14:10-14:30 Capital Suite 11 B

Yingting Miao
Xi'an Jiaotong-Liverpool University
Peoples Rep of China

Abstract:
This presentation discusses results on stochastic Camass-Holm type equations. We examine the impact of noise on global existence, blow-up and stability. We identify a family of nonlinear noises that prevent blow-up with probability 1. In the case of linear noise, we demonstrate that singularities occur in finite time with positive probability and provide lower bounds for these probabilities. Finally, we introduce the concept of stability of the exiting time, showing that one cannot improve the stability of the exiting time and simultaneously improve the continuity of the dependence on initial data.

Dispersive Effective Model in the Time-Domain for Acoustic Waves Propagating in Bubbly Media

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Schedule: December 18 9:40-10:00 Capital Suite 11 B

Arpan Mukherjee
Shenzhen MSU-BIT University
Peoples Rep of China

Co-Author(s): Mourad Sini, RICAM, Austrian Academy of Sciences, Austria

Abstract:

We derive the effective medium theory for the linearized time-domain acoustic waves propagating in a bubbly media. The analysis is done in the time-domain avoiding the need to use Fourier transformation. This allows considering general incident waves avoiding band limited ones as usually used in the literature. Most importantly, the outcome is as follows: 1. As the bubbles are resonating, with the unique subwavelength Minnaert resonance, the derived effective wave model is dispersive. Precisely, the effective acoustic model is an integro-differential one with a time-convolution term highlighting the resonance effect. 2. The periodicity in distributing the cluster of bubbles is not needed, contrary to the case of using traditional two-scale homogenization procedures. Precisely, given any C1-smooth function K, we can distribute the bubbles so that locally the number of such bubbles is dictated by K. In addition to its dispersive character, the effective model is affected by the function K. Such freedom and generality is appreciable in different applied sciences including materials sciences and mathematical imaging

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Improved L^p-L^q Hardy Inequalities

Schedule: December 20 14:20-14:40

Almat Orazbayev
Nazarbayev University
Kazakhstan

Co-Author(s): Durvudkhan Suragan

Abstract:

In this talk, we obtain a new version of the Hardy inequality which covers the recent inequality of Frank, Laptev, and Weidl (JMI (2015), (2), 437-447) and improves the result of Persson and Samko (J. Math. Sci. (N.Y.) 268 (2022), no. 3). It gives new results in one dimension. We analyse radial and non-radial multidimensional versions of the considered inequality as consequences.

Optimal System, Symmetry Reduction and Conservation Laws of Complex Modified KdV equation

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Schedule: December 20 14:40-15:00

Debendra Prasad Panda
BITS Pilani K K Birla Goa Campus
India

Co-Author(s): Manoj Pandey

Abstract:
This work examines the symmetry of the complex modified KdV (cmKdV) equation. We use the Lie symmetry approach to the hydrodynamic-like system generated from the cmKdV equation via the Madelung transformation. A thorough set of local point symmetries is defined. Optimal systems up to four dimensions are constructed using the adjoint transformation and the admitted Lie algebra invariants. A one-dimensional optimal system is utilized to obtain similarity reductions and invariant solutions, which are then graphically presented. Furthermore, we compute the governing system`s conservation rules using the multiplier approach and the nonlinear self-adjointness.

Decay rate for 4D energy-critical nonlinear heat equation in critical Sobolev spaces

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Schedule: December 19 8:00-8:20 Capital Suite 11 B

Gabriela Planas
Universidade Estadual de Campinas
Brazil

Co-Author(s): Leonardo Kosloff and Cesar J. Niche

Abstract:
We address the decay of solutions to the four-dimensional energy-critical nonlinear heat equation in the critical space $\dot{H}^1$. Recently, it was proven that the $\dot{H}^1$ norm of solutions goes to zero when time goes to infinity, but no decay rates were established. By means of the Fourier Splitting Method and using properties arising from the scale invariance, we obtain an algebraic upper bound for the decay rate of solutions.

Sign Changing Solution for a (p,q)-Laplacian System in $\mathbb{R}^N$

Schedule: December 20 15:20-15:40

Anusree R
Indian Institute of Technology Hyderabad
India

Co-Author(s): Bhakti Bhusan Manna

Abstract:
In this talk, we study the existence of sign-changing solutions to the (p,q)-Laplacian System: \begin{equation*} \begin{cases} \begin{aligned} -\Delta_{p} u +|u|^{p-2}u &= \alpha|u|^{\alpha-2}|v|^{\beta}u\ -\Delta_{q} v +|v|^{q-2}v &= \beta|u|^{\alpha}|v|^{\beta-2}v \quad \text{in } \mathbb{R}^N, \end{aligned} \end{cases} \end{equation*} with the exponents satisfying some suitable subcritical conditions. Symmetry plays a crucial role in this result, and we prove the existence of solutions that are invariant under some specific group action. Using the Mountain-Pass theorem and the Principle of Symmetric Criticality, we first discuss a special case for dimensions $N \neq 5$. Then by studying a suitable Palais-Smale sequence, we will establish a more general result which applies for all $N \geq 4$.

Fractional Hardy inequality with boundary singularity for the critical case sp=1 and Hardy inequality on functions of bounded variation

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Schedule: December 20 15:00-15:20

Vivek Sahu
Indian Institute of Technology Kanpur, India
India

Co-Author(s): Adimurthi, Prosenjit Roy

Abstract:
We address the open problem posed by B. Dyda for the critical case sp=1 by deriving a fractional Hardy inequality with a boundary singularity for sp=1 using an optimal logarithmic weight function. Furthermore, we extend our findings to the case p=1 by establishing the corresponding fractional Hardy inequality with a boundary singularity on bounded Lipschitz domains, incorporating logarithmic corrections. Utilising the result by Brezis, Bourgain, and Mironescu on the limiting behavior of fractional Sobolev spaces as s approaches 1, we obtain a Hardy inequality with a boundary singularity for functions of bounded variation on bounded Lipschitz domains.

Inverse problem for parabolic equation with p-Laplacian and damping term

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Schedule: December 20 17:15-17:35

Aidos Shakir
Al Farabi Kazakh National University
Kazakhstan

Abstract:
Let Ω be a bounded domain in $\mathbb{R}^d$ with smooth boundary $\partial\Omega$, and $QT = \{(x,t): \ x \in \Omega, \ 00$ either negative \$\gamma1} 1

Analysis of Wave Propagation and Conservation Laws for A Shallow Water Model with Two Velocities Via Lie Symmetry

Schedule: December 17 8:40-9:00 Capital Suite 11 B

Aniruddha Kumar Sharma
Indian Institute of Technology Roorkee
India

Co-Author(s): Aniruddha Kumar Sharma, Sumanta Shagolshem, Rajan Arora

Abstract:
This research investigates a one-dimensional system of quasi-linear hyperbolic partial differential equations, obtained by vertically averaging the Euler equations between artificial interfaces. This system represents a shallow water model with two velocities and is explored using Lie symmetry analysis to derive several closed-form solutions. Through symmetry analysis, a Lie group of transformations and their corresponding generators are identified via parameter analysis. From these, an optimal one-dimensional system of subalgebras is constructed and classified based on symmetry generators and invariant functions. The model is further simplified by reducing it to ordinary differential equations (ODEs) using similarity variables for each subalgebra, yielding invariant solutions. Additionally, various conservation laws are formulated utilizing the nonlinear self-adjoint property of the governing system. The study concludes by analyzing the behavior of characteristic shocks, C^1-waves, and their interactions, offering a detailed understanding of their dynamics.

On global solutions of a fractional wave equation with nonlinear memory

Schedule: December 19 15:15-15:35 Capital Suite 11 B

Ibrahim Suleman
Khalifa University
Nigeria

Co-Author(s): Mokhtar Kirane

Abstract:
This paper addresses global existence of solutions to a space fractional wave equation with a nonlinear memory term. Specifically, we apply Matsumura-type estimates to establish the existence of unique solutions for all $t > 0$ in appropriately defined function spaces.

Optimal trading with regime switching: Numerical and analytic techniques applied to valuing storage in an electricity balancing market

Schedule: December 19 8:20-8:40 Capital Suite 11 B

David Zoltan Szabo
Corvinus University of Budapest
Hungary

Co-Author(s): Paul Jonhson, Peter Duck

Abstract:
Accurately valuing storage in the electricity market recognizes its role in enhancing grid flexibility, integrating renewable energy, managing peak loads, providing ancillary services and improving market efficiency. In this paper we outline an optimal trading problem for an Energy Storage Device trading on the electricity balancing (or regulating) market. To capture the features of the balancing (or regulating) market price we combine stochastic differential equations with Markov regime switching to create a novel model, and outline how this can be calibrated to real market data available from NordPool. By modelling a battery that can be filled or emptied instantaneously, this simplifying assumption allows us to generate numerical and quasi analytic solutions. We implement a case study to investigate the behaviour of the optimal strategy, how it is affected by price and underlying model parameters. Using numerical (finite-difference) techniques to solve the dynamic programming problem, we can estimate the value of operating an Energy Storage Device in the market given fixed costs to charge or discharge. Finally we use properties of the numerical solution to propose a simple quasi-analytic approximation to the problem. We find that analytic techniques can be used to give a benchmark value for the storage price when price variations during the day are relatively small.

Iterative Finite Difference Method for Solving the Nonlinear Gordon-type Problems

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Schedule: December 16 15:05-15:25 Capital Suite 11 B

Helmi Temimi
Abdullah Al Salem University
Kuwait

Co-Author(s): Mohamed Ben Romdhane

Abstract:
We introduce a new Iterative Finite Difference (IFD) method designed to efficiently solve highly nonlinear time-dependent problems. We propose a generalization of the IFD method, originally designed for nonlinear Ordinary Differential Equations (ODEs), to effectively address time-dependent nonlinear Partial Differential Equations (PDEs). We perform a novel high-order approximation in space and time. We perform a finite difference discretization at every iteration, leading to a generalized IFD method for solving nonlinear problems such as the known Sine-Gordon equation, Klein-Gordon equation, and the generalized Sinh-Gordon equation. Numerical simulation shows that the method has very fast convergence. It yields highly accurate solutions to the problem with a low computation cost.

Ill-posedness of the Thirring model below the critical regularity

Schedule: December 20 15:40-16:00

Achenef Tesfahun
Nazarbayev University
Kazakhstan

Co-Author(s): Sigmund Selberg

Abstract:
We consider an L^2-critical cubic Dirac equation in one space dimension known as the Thirring model. Global well-posedness in L^2 for this equation was proved by Candy. Here we prove that the equation is ill-posed in L^p-for $1 \leq p < 2$, and in the massless case also in H^s with $s

Multi-marginal stochastic flow for brain diseases

Schedule: December 19 15:35-15:55 Capital Suite 11 B

Zhenhao Wang
Huazhong University of Science and Technology
Peoples Rep of China

Abstract:
The human brain undergoes complex transitions between different states, which can be modeled as stochastic processes on graphs. By analyzing scRNA-seq data from different stages of a brain disease, we can reconstruct the underlying trajectory of cell populations and estimate the velocity of their evolution. This information can provide valuable insights into the disease mechanisms, such as identifying critical transition points and understanding the roles of specific cell types.

Continuous Data Assimilation from Scattered Spatial Observations in Time-Dependent PDEs

Schedule: December 19 15:55-16:15 Capital Suite 11 B

Tong Wu
University of Texas at San Antonio
USA

Co-Author(s): Humberto Godinez, Vitaliy Gyrya, James M. Hyman

Abstract:
Accurate modeling and forecasting of physical processes necessitate more than knowing the appropriate model. Even with the exact evolution model, accurate prediction remains unfeasible without precise knowledge of the system`s state. For complex systems, it is often impossible to observe the entire system`s state. Instead, observations are limited to local measurements through a finite set of observers. This limitation motivates the art and science of data assimilation. In this context, we have developed a novel nonlinear data assimilation algorithm that employs a feedback control penalty for solving partial differential equations. Our advancement on the existing AOT algorithm involves introducing a dynamic control process that enhances local feedback and achieves faster/predictable convergence rates. We have tested our algorithm on various one-dimensional and two-dimensional problems, demonstrating its efficacy in improving data assimilation for complex systems.

Homogenization of non-divergence type equation with oscillating coefficients defined on a highly oscillating obstacles.

Schedule: December 19 8:40-9:00 Capital Suite 11 B

Minha Yoo
National institute for mathematical sciences
Korea

Co-Author(s): Sunghoon Kim, Ki-Ahm Lee, and Se-Chan Lee

Abstract:
In this talk, we discuss the homogenization of a highly oscillating obstacle problem using the viscosity method. The equation we deal with is a non-divergence type equation with oscillating coefficients. To analyze the behavior of solutions in the obstacle problem, we construct a corrector function, periodic function when the obstacle is given as 1. By utilizing this corrector, we identify the so-called strange term behavior when the size of the domain where the obstacle is defined reaches a critical value. We then modify the corrector for critical size and analyze the solution`s behavior when the size of the obstacle is either larger or smaller than the critical value.

Pseudo-Differential Operators Associated with the Coupled Fractional Fourier Transform

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Schedule: December 16 14:45-15:05 Capital Suite 11 B

Ahmed Zayed
Depaul University
USA

Co-Author(s): S. Das and K. Mahato

Abstract:
The fractional Fourier transform (FRFT), which is a generalization of the Fourier transform, has ubiquitous applications in optics and signal processing. The FRFT depends on an angle $, 0 \leq \alpha \leq 2\pi$, and reduces to the standard Fourier transform when $\alpha = \pi/2$. The coupled fractional Fourier transform is a two-dimensional version of the fractional Fourier transform that depends on two angles α and β and is not a tensor product of two one-dimensional fractional Fourier transforms. The two angles are coupled in such a way that the transform depends on the sum $\alpha + \beta$ and the difference $\alpha - \beta$ of the two angles. This transform has interesting applications, such as explaining the rotations of the Wigner distribution in four dimensions. In this talk we extend the coupled fractional Fourier transform to Schwartz-like spaces and to the space of tempered distributions. We then investigate properties of pseudo-differential operators associated with the coupled fractional Fourier transform on a Schwartz-like space. We conclude the talk by applying the results to obtain solution of a generalized heat equation.

On the attractor for the Navier-Stokes-like system with the dynamic slip boundary condition

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Schedule: December 19 16:15-16:35 Capital Suite 11 B

Michael Zelina
Charles University, Faculty of Mathematics and Physics
Czech Rep

Co-Author(s): Dalibor Pra\v{z}\`{a}k

Abstract:
We consider the usual Navier-Stokes-like system describing an incompressible fluid in a two or three-dimensional domain Ω. It is either a bounded Lipschitz set or an infinite channel $\mathbb{R}^{d-1} \times (0, L)$. The system is completed with the so-called dynamic slip boundary condition: \begin{align*} \beta \partial_t \boldsymbol u + \alpha \boldsymbol s (\boldsymbol u) + \big[\mathbb{S} (D \boldsymbol u) \boldsymbol n \big]_{\tau} &= \beta \boldsymbol h , \ \boldsymbol u \cdot \boldsymbol n &= 0 . \end{align*} As the existence theory for such a system is already developed, we focus on the long-time behaviour of its solutions. In particular, in a 3D setting, we establish the existence of the global attractor and find an upper bound of its fractal dimension. Then, we take a closer look at a 2D situation, where we can find a more explicit upper bound of the dimension using the method of Lyapunov exponents. More specifically, we are interested in its dependence on parameters α and β -- since our boundary condition degenerates into Navier slip for $\beta = 0$, and into zero Dirichlet condition for $\alpha \to +\infty$. We will also outline some possible future research directions.

Contributed Session 3 : Modeling, Math Biology and Math Finance

Introduction:

Optimal Control Approaches for Managing Infectious Diseases with Behavioral Dynamics

Schedule: December 16 12:30-12:50 Conference Hall B (C)

Mo`tassem Al-arydah
Khalifa University
United Arab Emirates

Co-Author(s): Omar Forrest and Mo`tassem Al-arydah

Abstract:
COVID-19 transmission, incorporating the nonlinear effects of population caution on infection rates. The model`s validity is confirmed by demonstrating the existence of positive bounded solutions. The basic reproduction number is calculated, and the local stability of both the disease-free equilibrium (DFE) and endemic equilibrium (EE) is assessed, revealing that the EE only exists when the basic reproduction number exceeds a critical threshold. Global stability for both equilibria is established using Lyapunov functions. Additionally, an optimal control strategy for vaccination is proposed, proving its existence and uniqueness, with simulations showing that the strategy effectively minimizes infection rates and associated costs. The impact of integrating public education into the model is also explored, emphasizing its critical role in enhancing vaccination coverage and reducing overall transmission.

IMPACT OF SEASONALITY AND VERTICAL TRANSMISSION IN MOSQUITOES POPULATION IN THE DYNAMICS OF DENGUE DISEASE

Schedule: December 19 13:20-13:40 Conference Hall B (C)

Ahuod Alsheri
University of Bisha
Saudi Arabia

Abstract:
Many epidemic diseases are season-related. Dengue is one of them. Since it is associated with a mosquito`s life cycle that is genuinely affected by weather changes. In this paper, we model the dynamics of Dengue disease transmission in the human population by two systems of delay differential equations. First, we carry out the modelling with the vertical transmission in the mosquito population and demonstrate its basic properties. Then we implement the seasonality effect in a second model by choosing some of the parameters affected by weather changes to be periodically time-dependent and re-derive these parameters. We illustrate the conditions when the disease-free periodic solution is locally asymptotically stable and when it is unstable. Simulations of this case were compatible with the theoretical results.

QUANTITATIVE PREVENTIVE APPROACHES TO DIABETES: MATHEMATICAL MODELING AND ANALYSIS

Schedule: December 19 13:00-13:20 Conference Hall B (C)

Rushi P Bhatt
Montclair State University
USA

Abstract:
The rising prevalence of diabetes presents a pressing global health concern, necessitating effective control strategies. This study aims to construct a mathematical model to analyze the influence of diverse factors on blood sugar levels, with a focus on identifying optimal methods for maintaining healthy glucose levels. Employing ordinary differential equations (ODE), the model investigates variables including leptin resistance, fat mass, glucose, insulin resistance, beta cell mass, daily physical activity, and dietary intake. Utilizing parameter estimates from existing literature, the model`s framework is established, and simulation results elucidate the intricate interplay between lifestyle choices and blood glucose dynamics. Furthermore, the model evaluates the effectiveness of preventive interventions in blood sugar regulation and diabetes prevention. This research emphasizes the importance of adopting a holistic approach to diabetes prevention, encompassing regular exercise, balanced nutrition, and proactive management of risk factors.

Lotka-Volterra Competitive Systems with Certain Type Nonuniform Diffusion

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Schedule: December 16 12:50-13:10 Conference Hall B (C)

YOUNGSEOK CHANG
Gyeongsang National University
Korea

Co-Author(s): Inkyung Ahn, Wonhyung Choi

Abstract:
In this work, we explore a Lotka-Volterra competitive system in which the species` movement depends on certain criteria about the environment. The environmental criteria include the species` judgement about the distribution of resources, the density of individuals, and their relative species. Therefore, this reflects a more realistic species movement, as it is assumed that species movements can vary based on the ability to judge the population density ratio and the available resources within a habitat. From this assumption, we model the species` movement as nonlinearly dispersed, referred to as starvation-driven-type diffusion (SDTD), and understand the effects of nonlinear diffusion on the dynamics of the system. First, we investigate the species` fitness to its environment through nonlinear diffusion by analyzing the stability of the semitrivial solutions. We also explore several properties of the positive steady-state solutions from the impact of SDTD on species fitness. This work contains joint work with Wonhyung Choi and Inkyung Ahn.

Learning Parametric Koopman Decompositions for Prediction and Control

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Schedule: December 18 8:20-8:40 Conference Hall B (C)

Yue Guo
National University of Singapore
Singapore

Co-Author(s): Milan Korda, Ioannis G Kevrekidis, Qianxiao Li

Abstract:
We develop a data-driven method to learn Koopman-type decompositions for non-autonomous dynamical systems, including equations with static or time-varying parameters. Previous works on constructing Koopman operator dynamics were either limited to autonomous ones, or those whose dynamics are linear/bilinear in the state and parameters. In contrast, our method, which combines machine learning and Koopman operator theory, can handle general non-linear parametric dynamics, allowing greater flexibility in its application. We show theoretically the feasibility of our approach and demonstrate its performance on a variety of applications, including forward prediction problems and optimal control problems.

Beyond the Event Horizon: Mathematical Insights into Black Hole Shadows

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Schedule: December 18 8:00-8:20 Conference Hall B (C)

Sehrish Iftikhar
Lahore College for Women University, Lahore, Pakistan.
Pakistan

Co-Author(s): Dr. Sehrish Iftikhar

Abstract:
In this research work we study the shadow cast by a black hole which turns out to be a dark region covered by a deformed circle. We then derive the relevant photon orbits and discuss the effects of black hole parameters on the silhouette of the shadow. We observe the change in the size as well as the shape such as deviation from the perfect circle, of the shadow with variation in the black hole parameters. In view of the optical properties of the black hole, the shadow region is supposed to be equal to the high energy absorption cross section. According to this perspective, we also explore the rate of energy emission. Moreover, we introduce plasma background and discuss its influence on the nature of the shadow, such as shape, size and the rate of energy emission. We also compare our results with current observational data from M87 and Sgr A*.

Probability of early infection extinction depends linearly on the virus clearance rate

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Schedule: December 19 13:40-14:00 Conference Hall B (C)

Nora Juhasz
University of Szeged
Hungary

Co-Author(s): Gergely Rost, Ferenc A. Bartha, Sadegh Marzban, Renji Han

Abstract:
We provide an in silico study of stochastic infection extinction from a pharmacokinetical viewpoint. Our work considers a non-specific antiviral drug that increases the virus clearance rate, and we investigate the effect of this drug on early virus extinction. Infection extinction data is generated by a hybrid multiscale framework that applies both partial differential equations and discrete mathematical approaches. The central result of our work is the observation, analysis and explanation of a linear relationship between the virus clearance rate and the probability of early infection extinction. The derivation behind this simple relationship is given by merging different mathematical toolboxes.

Dynamics of autonomous Leslie-Gower model for the impacts of fear and its carry-over effects including predator harvesting

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Schedule: December 16 14:10-14:30 Conference Hall B (C)

Mahendra Mahendra
Indian Institute of Technology Roorkee
India

Co-Author(s): Dwijendra N. Pandey

Abstract:
In this work, we proposed an autonomous Leslie-Gower model incorporating some biological factors such as fear and its carry-over effects, prey refuge, and nonlinear predator harvesting. In the proposed model, first, we examined the wellposedness, positivity solutions, and their boundedness. Also, it is shown that new equilibrium points emerge and disappear with the change in the intrinsic growth rate of a predator. Further, we computed and analyzed the local and global stability at the interior equilibrium points. Furthermore, Hopf-bifurcation and direction and stability of the limit cycle at interior equilibrium points are established. Moreover, the sensitivity analysis of the biological parameters is carried out numerically with two statistical methods via Latin hypercube sampling and partial rank correlation coefficients. It was found that at the small values of the fear factor, carry-over effect, and refuge behavior of prey parameters, the autonomous system exhibits oscillatory behavior, whereas, for small values of prey birth rate and harvesting effort, the system remains stable. However, when the intrinsic growth rate of a predator increases from a low value to a higher value, the system shows the transition from stability to instability and back to stability.

Modelling of Massive Stellar Structure in High Curvature Framework

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Schedule: December 18 9:40-10:00 Conference Hall B (C)

Rubab Manzoor
University of Management and Technology Lahore Pakistan
Pakistan

Co-Author(s): Rubab Manzoor

Abstract:
This manuscript represents a spherically symmetric model of a star cluster as a self-gravitating fluid in high curvature gravitational theory. The high curvature terms are used as a mathematical candidate for dark matter in the Star cluster. Different evolutionary phases of star clusters are discussed by using structure scalar techniques along with evolution equations of dynamical terms like isotropic pressure, density homogeneity, homologous, and geodesic behavior. It is concluded that the presence of dark matter directly affects the features of clusters like anisotropic pressure, dissipation, expansion, shear as well as density homogeneity.

Correlating the Cellular Microenvironment with Cell Fate Decisions: The Efficiency differences of In Vitro and In Vivo for Directed Differentiation

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Schedule: December 16 13:10-13:30 Conference Hall B (C)

Yu-Chen Miao
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Lin Du,Shu-Tong Liu,Zi-Chen Deng,Celso Grebogi

Abstract:
Microenvironment fluctuations are a natural phenomenon occurring during cellular transcription expression, providing a weak background for biochemical molecular noise. The effectiveness of trans-differentiation induced by reprogramming factors heavily depends on microenvironmental conditions. To elucidate this mechanism, we developed a theoretical framework that combines single promoter switching models with cell fate decision promoter coupling circuits, utilizing the large deviation method to quantify the influence of microenvironment on cell phenotype transitions. Our results demonstrate that asymmetric differentiation trends in internal gene circuits can be determined by symmetric microenvironmental conditions. Consistent with Monte Carlo simulations, our theory provides a pathway for controlling stochastic systems through stochastic signal inputs

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Data-Driven Models for Wheat Yield Optimization

Schedule: December 19 14:40-15:00 Conference Hall B (C)

Gulden Y. Murzabekova
Seifullin University
Kazakhstan

Co-Author(s): Tazhibay Lyazzat

Abstract:
Identifying key climatic factors for forecasting wheat yield is crucial for developing effective strategies to adapt agricultural practices. This helps mitigate the adverse effects of climate change on wheat production, particularly in areas near Astana, the second coldest capital in the world. The goal of this research is to build machine learning models, such as linear regression, decision trees, and boosting algorithms, to determine the weather variables that most influence wheat yield. The study relies on wheat yield and meteorological data from the Akkol district in the Akmola region. The data include air temperature, humidity, precipitation, wind speed and direction, soil surface temperature, and air humidity deficit. In this research, six linear machine learning models were implemented to build predictive frameworks, four decision tree-based models and two boosting algorithms were tested. The results revealed that several features significantly impact wheat yield. Decision tree models outperformed others in prediction accuracy. These findings were interpreted and can provide valuable insights for making informed decisions in agricultural management.

Neural network modeling in the inverse problem on a graph-tree

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Schedule: December 18 8:40-9:00 Conference Hall B (C)

Karlygash B. Nurtazina
L.N. Gumilyov Eurasian National University
Kazakhstan

Co-Author(s): Karlygash Nurtazina

Abstract:
This talk proposes a result for solving the inverse for the heat conduction equation on a graph-tree. The constructed stable efficient algorithm for source identification is reduced to solving linear integral Volterra equations of the second kind. A feature of the new approach is the combination of deep learning and graph theory in solving the identification problem, which can serve as a good tool for solving inverse problems in complex systems. In the problem on the graph-tree graph neural networks are used. Such a model allows taking into account the connections between nodes for information processing and transmitting information along the graph structure.

Inter-temporal Defined Contribution Pension Management

Schedule: December 19 14:00-14:20 Conference Hall B (C)

Ho Man Tai
Dublin City University
Ireland

Co-Author(s): Paolo Guasoni, Bohan Li, Ho Man Tai, Tak Kwong Wong, Sheung Chi Phillip Yam

Abstract:
The objective of this article is to resolve the pension management problem with constant contribution from fund holders in the perspective of the manager who aims to maximize the expectation of generic running and terminal utilities of the management fees collected. Research on the existing literature largely neglects the impacts of inter-temporal reward for the manager. With the aim of the Dynamic Programming Principle, the problem is associated with a singular, fully non-linear HJB equation. We develop a direct mathematical primal analysis to establish the unique existence of its classical solution by transforming the problem into a non-canonical variational inequality problem and then solving it in a trailer Sobolev space. In addition, an efficient numerical scheme has been introduced to compute the optimal trading strategy and the value function numerically.

THE EVOLUTIONARY STABILITY OF PARTIAL MIGRATION WITH ALLEE EFFECTS

Schedule: December 18 9:00-9:20 Conference Hall B (C)

Yogesh Trivedi
Birla Institute of Technology and Science, Pilani Goa Campus
India

Co-Author(s): Yogesh Trivedi, Ram Singh, Anushaya Mohapatra

Abstract:
An Allee effect is a density-dependent phenomenon in which population growth or individual components of fitness increase as population density increases. Understanding the density-dependent effects is vital to elucidate how populations evolve and to investigate evolutionary stability. Partial migration, where a proportion of a population migrates while other individuals remain resident, is widespread across most migratory lineages. However, the mechanism still needs to be better understood in most taxa, especially those experiencing positive density-dependent effects. Here we will discuss the evolutionary stability of a partial migration population with only the migrant population experiencing Allee effects. Using the Evolutionary Game Theoretic (EGT) approach, we will show the existence and uniqueness of an evolutionary stable strategy (ESS). EGT provides a mathematical framework for understanding and modeling Darwinian evolution by natural selection. We also show that the ESS is the only Ideal Free Distribution (IFD) that arises in the context of a partially migrating population in a two-habitat environment. Keywords: Partial Migration, Allee Effects, Basic Reproduction Number, Ideal Free Distribution, Evolutionary Game Theory, Evolutionary Stable Strategy.

On the Impact of Smoking on Microbiome-Metabolism-Brain Interaction

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Schedule: December 16 13:30-13:50 Conference Hall B (C)

Siti Maghfirotul Ulyah
Khalifa University
United Arab Emirates

Co-Author(s): Symeon Savvopoulos, Herbert F. Jelinek, Mohammad Tahseen Al Bataineh, Haralampos Hatzikirou

Abstract:
Systemic interactions between human body organs, such as the gut-brain axis, and the corresponding mediators are largely unknown. This study aims to shed light on a specific aspect of these interactions by focusing on the oral microbiome, metabolism, and brain/behavior with respect to smoking. We analyze three comprehensive datasets covering oral microbiota composition, psychological traits, and metabolic pathways from smokers and non-smokers (based in UAE). Comparative analysis reveals no significant differences in the datasets between smokers and non-smokers. However, our findings show a tight correlation between metabolic pathway data and oral microbiome composition across all subjects. Using canonical correlation analysis (CCA) and non-linear regression, we identify steady-state interactions for the microbiome-metabolism-brain system. Our approach allows us to make accurate predictions of a patients system state. Moreover, we discover that smoking weakens the directed impact of metabolic pathways to psychological traits. The latter suggests that perturbations in these interactions could destabilize the steady-state observed in non-smokers, potentially leading to pathological conditions. This weakening of interaction pathways implies that smoking may inhibit the potential effectiveness of pharmacological treatments for psychological diseases by disrupting the metabolic-behavioral linkage. These insights underscore the complex role of smoking in modulating the delicate balance of microbiome-metabolism-behavior interactions.

A reduced inversion ZNN method for solving discrete periodic Riccati matrix equations

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Schedule: December 19 14:20-14:40 Conference Hall B (C)

Yurui Wang
Harbin Institute of Technology, Shenzhen
Peoples Rep of China

Co-Author(s): Ying Zhang

Abstract:
This study is concerned with the issue of solving the discrete periodic Riccati matrix equations (DPAREs) in discrete-time periodic linear systems. Currently, many existing results for solving the DPARE involve much matrix inversion operations. In order to diminish the matrix inversion operations, a novel reduced inversion zeroing neural network (RIZNN) model is established by constructing a special group of matrix-value error equations. Besides, a nonlinear activation function (NAF) that combines a hyperbolic sine function with an exponential function is designed to accelerate the convergence rate of the RIZNN model. Specially, with the help of a time-varying function, a prescribed-time convergent RIZNN (PT-RIZNN) model is constructed based on the RIZNN model. The distinctive feature of the PT-RIZNN model is that the setting time can be prescribed a prior. Moreover, the convergence property of the PT-RIZNN model and the superiority of the NAF are theoretically proven, respectively. Simulation results are supplied to demonstrate the effectiveness of the PT-RIZNN model and the superiority of the NAF.

Non-intrusive model combination in learning dynamics

Schedule: December 18 9:20-9:40 Conference Hall B (C)

Shiqi Wu
National University of Singapore
Peoples Rep of China

Co-Author(s): Ludovic Chamoin, Qianxiao Li

Abstract:
In data-driven modeling of complex dynamic processes, it is often desirable to combine different classes of models to enhance performance. Examples include coupled models of different fidelities, or hybrid models based on physical knowledge and data-driven strategies. A key limitation of the broad adoption of model combination in applications is intrusiveness: training combined models typically requires significant modifications to the learning algorithm implementations, which may often be already well-developed and optimized for individual model spaces. In this work, we propose an iterative, non-intrusive methodology to combine two model spaces to learn dynamics from data. We show that this can be understood, at least in the linear setting, as finding the optimal solution in the direct sum of the two hypothesis spaces, while leveraging only the projection operators in each individual space. Hence, the proposed algorithm can be viewed as iterative projections, for which we can obtain estimates of its convergence properties. To highlight the extensive applicability of our framework, we conduct numerical experiments in various problem settings, with particular emphasis on various hybrid models based on the Koopman operator approach.

A Density-Based Manifold Learning to Reconstruct High-Dimensional Dynamical Systems with Outliers

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Schedule: December 16 13:50-14:10 Conference Hall B (C)

Qing Xue
Northwestern Polytechnical University
Peoples Rep of China

Co-Author(s): Qing Xue, Lin Du, Feng Jiang \and, Cheng-Long Zhang, Zi-Chen Deng, Celso Grebogi

Abstract:
Dynamic Modelling from data is of great significance for understanding the evolution of complex systems. In this work, inspired by manifold learning framework of Charts and Atlases for Nonlinear Data-Driven Dynamics on Manifolds (CANDyMan), we propose the Density-based Decomposition on Manifold with Autoencoder Reduction (DDMAR) method, for discovering the intrinsic coordinates and for reconstructing complex dynamical behaviours with multiple outliers. Firstly, the density-based spatial clustering is employed to decompose the manifold structure into atlases, subsequently setting overlapping regions for adjacent atlases to achieve dynamic evolution. Then, an automated selection method of clustering parameters, which is different from prior settings, is developed for structural decomposition. On this basis, the reconstruction is accomplished by an autoencoder to reduce dimensionality, combined with feedforward neural network to achieve learning of low-dimensional dynamic behaviours. The results demonstrate that, DDMAR method is capable of automatically setting parameters based on the core point principle, making the manifold learning of dynamics more reliable and stable. Moreover, it exhibits good robustness to outliers, thereby enabling the extraction of intrinsic coordinates and the reduction of reconstruction errors. Additionally, it produces smoother dynamics in the reconstructed transition region. This work promotes the development of dimensionality reduction and reconstruction methods for complex manifolds with outliers in high-dimensional dynamical systems.