2021
CHAPTER

ICMC SUMMER MEETING
ON DIFFERENTIAL EQUATIONS

1-3 FEBRUARY 2021 | SÃO CARLOS-SP, BRAZIL

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ONLINE CONFERENCE

SESSIONS:

- Elliptic Equations
- Fluid Dynamics
- Harmonic Analysis and Related Topics
- Integral and Functional Differential Equations
- Linear Equations
- Multiscale Dynamics
- Nonlinear Dynamical Systems
- Stochastic Dynamics

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Welcome

It is a pleasure to welcome you to the online conference *ICMC Summer Meeting on Differential Equations - 2021 Chapter*, which is going to be held on 1-3 February 2021. We wish you enjoy the meeting.

Scientific Committee

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Anne Bronzi (UNICAMP/Brazil) & Gabriela Planas (UNICAMP/Brazil) - Fluid Dynamics

Tiago Picon (USP/Brazil) & Lucas Oliveira (UFGRS/Brazil) - Harmonic Analysis and Related Topics

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Contents

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

CHAPTER 2021

Plenary Talks

Global attractors of scalar parabolic equations: the Thom-Smale complex

Bernold Fiedler
Freie Universität Berlin, Germany

We consider the global attractors of scalar parabolic equations

$$u_t = u_{xx} + f(x, u, u_x)$$

under Neumann boundary conditions. The *Thom-Smale complex* decomposes a global attractor into the unstable manifolds of its (hyperbolic) equilibria $u_t = 0$. In general this is *not* a topological cell complex – not even in the presence of a gradient structure. For the above PDEs, however, the Thom-Smale complex turns out to be a signed regular topological cell complex: the boundaries of the unstable manifolds are topological spheres, each with a signed hemisphere decomposition.

On the other hand, the equilibria $u_t = 0$ are characterized by a meander curve, which arises from a shooting approach to the ODE boundary value problem $u_{xx} + f(x, u, u_x) = 0$. We explore a minimax characterization of boundary neighbors, along the meander. Specifically, we identify the precise geometric locations of these boundary neighbors in the signed Thom-Smale complex. This opens an approach to the construction of global attractors with prescribed Thom-Smale complex.

Many examples will illustrate this joint work with Carlos Rocha, dedicated to the memory of Geneviève Raugel. See arxiv:1811.04206 and doi: 10.1007/s10884-020-09836-5.

Non-local ODEs via conformal geometry

María del Mar González
Universidad Autónoma de Madrid, Spain

We will consider some results for non-local ODEs with good conformal properties, such as semi-linear equations for the fractional Laplacian with power non-linearity and linear equations with a Hardy-type critical potential. These equations appear in the construction of singular metrics of constant non-local cuvature. It turns out that conformal geometry provides powerful tools for existence, uniqueness, regularity and asymptotic behavior. We will survey some of those, together with some applications.

Singular elliptic problems and beyond

Vicentiu Radulescu
University of Craiova, Romania & Institute of Mathematics of the Romanian Academy, Bucharest

We are concerned with several types of singular phenomena arising in the theory of nonlinear elliptic equations. We describe sufficient conditions for the existence or the uniqueness of solutions and we establish asymptotic properties of solutions. We also establish that no monotonicity hypotheses are necessary in the statement of some classical theorems. Various types of comparison principles play a crucial role in the arguments developed in this talk. Several open problems are raised in the final part of this lecture.

A minimax property for global attractors of scalar parabolic equations

Carlos Rocha
CAMGSD, Instituto Superior Técnico, Universidade de Lisboa, Portugal

We overview recent results on the geometric and combinatorial characterization of global attractors of semiflows generated by scalar semilinear partial parabolic differential equations under Neumann boundary conditions. In special, we discuss a minimax property of the boundary neighbors of any specific unstable equilibrium. This property allows the identification of the equilibria on the cell boundary of any chosen equilibrium. This is a joint work with B. Fiedler.

Effects of chemotaxis sensitivity and logistic source on the dynamics of chemotaxis models

Wenxian Shen
Auburn University, United States

Chemotaxis models are used to describe the movements of mobile species or living organisms in response to certain chemicals in their environments. It is known that chemotaxis may induce finite-time blow-up in various minimal chemotaxis models. In a minimal chemotaxis model, there is no reaction term or source term in the governing equation for the living organisms. It has been attracting a lot of attention to study the dynamics of chemotaxis models with a nonlinear source. The current talk is concerned with the dynamics of chemotaxis models with a logistic source. In particular, I will discuss the finite-time blow-up prevention by a logistic source in parabolic-elliptic chemotaxis models on bounded domains and the effect of chemotaxis sensitivity on the front propagation dynamics in chemotaxis models with a logistic source on the whole space.

A mesoscopic ergodic theorem

Yingfei Yi
University of Alberta, Canada & Jilin University, China

The talk will discuss ergodic properties of mesoscopic systems described by stochastic ordinary differential equations. An ergodic theorem will be presented for systems with rough coefficients which do not necessarily generate flows or semiflows. Applications to thermodynamic systems will be discussed.

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

CHAPTER 2021

Special Sessions

Session on Elliptic Equations

Organizers: Giovany J. M. Figueiredo (UnB/Brazil) & Marcos T. O. Pimenta (UNESP/Brazil)

Recent results involving the 1-Laplacian in the whole $\mathbb{R}^N$

Claudianor O. Alves
Universidade Federal de Campina Grande, Brazil

In this talk we will show some recent results involving the 1-Laplacian operator in the whole $\mathbb{R}^N$. The main tools used are the variational methods for locally Lipschitz functionals and the approximation technique using p-Laplacian problems. Some of the results were written in collaboration with Marcos Pimenta and Giovany Figueiredo.

Optimal partitions for the Yamabe equation

Mónica Clapp
Universidad Nacional Autónoma de México. México

An optimal ℓ-partition for the Yamabe equation on a closed Riemannian manifold M is a cover of M by ℓ pairwise disjoint open subsets such that the Yamabe equation with Dirichlet boundary condition on each of these open sets has a least energy solution and the sum of the energies of these solutions is minimal.

We establish the existence of such a partition for every $\ell \geq 2$ under suitable assumptions on M.

This is joint work with Angela Pistoia and Hugo Tavares.

Prescribed norm solutions of Schrödinger equations with mixed power nonlinearities.

Louis Jeanjean
University of Bourgogne Franche-Comté, France

In this talk, I will present some recent results concerning the existence of prescribed norm solutions in problems where the associated nonlinearity is the sum of two powers, one which is mass-subcritical and one mass-supercritical. This leads to consider a constrained variational problem presenting a so-called convex-concave geometry. The issues of existence, multiplicity and orbital stability of solutions will be addressed with a special emphasize on the cases where the mass-supercritical power is Sobolev critical. If times permit, connections with problems involving a fourth order nonlinear Schrödinger equation will be made.

Existence of finite energy traveling waves for the Gross-Pitaevskii equation

David Ruiz
Universidad de Granada, Spain

The Gross-Pitaevskii equation is a Schrödinger equation under the effect of a Ginzburg-Landau potential, and has been proposed to study different phenomena like the Bose-Einstein condensation. In this talk we will focus on the existence of finite energy traveling waves for this equation.

Some previous existence results have been obtained via a constrained minimization procedure. This has the advantage of providing orbital stability of the solutions but, as a drawback, the speed of propagation appears as a Lagrange multiplier and is not controlled. In this talk we present a general existence result for almost all speeds in the subsonic regime.

This is joint work with Jacopo Bellazzini (U. Pisa).

Nonlinear elliptic equations with nonlocal diffusion coefficient

Antonio Suárez
Universidad de Sevilla, Spain

We present different theoretical results related to nonlinear elliptic equations with a nonlocal diffusion coefficient. We show the main differences. We will show the main differences with respect to the constant diffusion case and we will pay special attention to the degenerate coefficient case.

On the geometry of degenerate diffusion processes

Eduardo Teixeira
University of Central Florida, United States

I will report on the regularity theory for non-variational degenerate elliptic PDEs. The results include sharp fractional regularity estimates as well as differentiability for a class of degenerate fully nonlinear PDEs.

Ginzburg–Landau functionals for a general compact vacuum manifold on planar domains

Jean Van Schaftingen
Université Catholique de Louvain, Belgium

Ginzburg–Landau type functionals provide a relaxation scheme to construct harmonic maps in the presence of topological obstructions. They arise in superconductivity models, in liquid crystal models (Landau–de Gennes functional) and in the generation of cross-fields in meshing. For a general compact manifold target space we describe the asymptotic number, type and location of singularities that arise in minimizers. We cover in particular the case where the fundamental group of the vacuum manifold in nonabelian and hence the singularities cannot be characterized univocally as elements of the fundamental group. The results unify the existing theory and cover new situations and problems.

This is a joint work with Antonin Monteil (Bristol, UK) and Rémy Rodiac (Paris–Saclay, France).

Rigidity results for Allen-Cahn equations

Juncheng Wei
University of British Columbia, Canada

I will discuss some recent advances in Allen-Cahn equations, including half space theorems and stability of saddle solutions in $\mathbb{R}^{8,10,12}$.

Variations on the logarithmic Laplacian operator

Tobias Weth
Goethe-University Frankfurt, Germany

The Logarithmic Laplacian Operator arises as formal derivative of fractional Laplacians at order $s = 0$. In this talk I will discuss properties of this operator and its relevance in the derivation of asymptotics of Dirichlet eigenvalues and eigenfunctions of fractional Laplacians in bounded domains as the order tends to zero. A further applications arises in the study of the monotonicity of solutions to fractional Poisson problems with respect to the fractional order s. As a byproduct of this study, we derive explicit bounds for the corresponding Green operator on arbitrary bounded domains which seem to be new even for the case $s = 1$, i.e., for the classical local Dirichlet problem $-\Delta u = f$ in Ω, $u \equiv 0$ on $\partial\Omega$. This is joint work with Huyuan Chen, Sven Jarohs, Ari Laptev and Alberto Saldana.

Session on Fluid Dynamics

Organizers: Anne Bronzi (UNICAMP/Brazil) & Gabriela Planas (UNICAMP/Brazil)

Incompressible fluid flow equations on logarithmic lattices

Ciro S. Campolina
Instituto Nacional de Matemática Pura e Aplicada, Brazil

Several open problems in fluid dynamics are related to the spontaneous development of small-scale structures. A traditional investigation procedure consists in simplifying the equations of motion preserving just a part of the system believed to be important. Here we present a different approach, in which, instead of simplifying equations, one introduces a simplified configuration space: velocity fields are defined on logarithmic lattices in Fourier space with proper algebraic operations and calculus. In this framework, equations of motion retain their exact original form and maintain most scaling properties, symmetries, and invariants. Classification of such models reveals a fascinating relation with renowned mathematical constants such as the golden mean and the plastic number. Using both rigorous and numerical analysis, we describe various properties of solutions for incompressible fluid flow on logarithmic lattices, from the basic concepts of existence and uniqueness to the blowup development and turbulent dynamics. In particular, we observe strong robustness of the chaotic blowup scenario in the three-dimensional incompressible Euler equations, as well as the Fourier mode statistics of developed turbulence resembling the full three-dimensional Navier-Stokes system. This is a joint work with Alexei A. Mailybaev.

Fluid-rigid body interaction problems

Nikolai Vasilievich Chemetov
Universidade de São Paulo, Brazil

We shall study the motion of a rigid body in an incompressible viscous fluid filling a bounded domain. We consider Navier's condition on the boundary of the body and on the boundary of the domain. It is well known that Navier's boundary condition permits collisions of the body with the boundary of the domain. The collisions create three important mathematical questions, related with:

1) Embedding results in cusp domains;

2) Renormalization property for solutions of the transport equation with velocity in the BD-bounded deformation space;

3) Construction of a strongly convergent sequence of solutions of Stokes-type equations in the cusp domain.

In the talk we present recent results, which have been obtained in collaboration with Prof. A. Mazzucato (Penn State University).

On long-time solvability with borderline regularity for the Euler equations in the rotational framework

Lucas Catão de Freitas Ferreira
Universidade Estadual de Campinas, Brazil

We consider the Euler equations in the rotational framework (ER). We show long-time solvability in Besov spaces for high speed of rotation Ω and arbitrary initial data. For that, we obtain Ω-uniform estimates and a blow-up criterion of BKM type in our setting. Our initial data class is larger than previous ones considered for (ER) and covers borderline cases of the regularity. The uniqueness of solutions is also discussed.

On a non-isothermal incompressible Navier-Stokes-Allen-Cahn system

Juliana Honda Lopes
Universidade Estadual de Campinas, Brazil

This work is devoted to the study of a non-isothermal incompressible Navier-Stokes-Allen-Cahn system which can be considered as a model describing the motion of the mixture of two viscous incompressible fluids. This kind of models are physically relevant for the analysis of non-isothermal fluids. The governing system of nonlinear partial differential equations consists of the Navier-Stokes equations coupled with a phasefield equation, which is the convective Allen-Cahn equation type, and an energy transport equation for the temperature.

We investigated the well-posedness of the nonlinear system. More precisely, existence and uniqueness of local strong solutions in two and three dimensions for any initial data are proved. Moreover, existence of global weak solutions and existence and uniqueness of global strong solution in dimension two, when the initial temperature is suitably small, are established.

Vanishing viscosity limits for incompressible flows with symmetry

Milton da Costa Lopes Filho
Universidade Federal do Rio de Janeiro, Brazil

In this talk we study the limiting behavior of certain symmetric flows in domains with boundary when viscosity is small. We consider circularly symmetric 2D flow on a disk, plane-parallel flow and parallel flow in a straight, circular pipe. We show that, in each case, the limiting flow satisfies the Euler equations, and we describe the error terms.

Sharp decay estimates for a semilinear damped wave equation with absorption

Cesar J. Niche
Universidade Federal do Rio de Janeiro, Brazil

Properties concerning the decay of solutions to the linear damped wave equation are essential tools for studying decay and long time behaviour of solutions to their semilinear and nonlinear counterparts. In this joint work with Armando Cárdenas, we extend and improve classical estimates for the linear damped wave equation obtained by Matsumura. Our main tool is the decay character of initial data, which has been used to prove similar results for other dissipative equations. We then apply these estimates to recover and improve decay results for the damped wave equation with absorption for initial data in different function spaces.

Vanishing viscosity and conserved quantities for 2D incompressible flow

Helena Nussenzveig Lopes
Universidade Federal do Rio de Janeiro, Brazil

Weak solutions of the incompressible Euler equations which are weak limits of vanishing viscosity Navier-Stokes solutions inherit, in two dimensions, conservation properties which are not available for general weak solutions. Research has focused on the behavior of energy and the p-moments of vorticity, always in fluid domains with no boundary. In this talk I will report on recent work in this direction.

Optimal minimax bounds for the Navier-Stokes equations and other infinite dimensional dissipative systems

Ricardo Martins da Silva Rosa
Universidade Federal do Rio de Janeiro, Brazil

Obtaining sharp estimates for quantities involved in a given model is an integral part of a modeling process. For dynamical systems whose orbits display a complicated, perhaps chaotic, behaviour, the aim is usually to estimate time or ensemble averages of given quantities. This is the case, for instance, in turbulent flows. In this work, the aim is to present a minimax optimization formula that yields optimal bounds for time and ensemble averages of dissipative infinite-dimensional systems, including the two- and three-dimensional Navier-Stokes equations. The results presented here are extensions to the infinite-dimensional setting of a recent result on the finite-dimensional case given by Tobasco, Goluskin, and Doering in 2017. The optimal result occurs in the form of a minimax optimization problem and does not require knowledge of the solutions, only the law of the system. The minimax optimization problem appears in the form of a maximization over a portion of the phase space of the system and a minimization over a family of auxiliary functions made of cylindrical test functionals defined on the phase space. The function to be optimized is the desired quantity plus the duality product between the law of the system and the derivative of the auxiliary function. This is a joint work with Roger Temam (Indiana University).

On the Control for some PDEs from Fluid Mechanics

Diego Araujo de Souza
Universidad de Sevilla, Spain

The Navier-Stokes equations and their variants have been studied since many years and its understanding is very relevant from both mathematical and physical viewpoint. Many researchers have been concerned to solve several related major open problems. On the other hand, the control of PDEs has brought a lot of attention in the last few decades. This was motivated by its relevant role in applications. In this talk we present some recent results dealing with the control of systems of the Navier-Stokes kind.

Session on Harmonic Analysis and Related Topics

Organizer: Tiago Picon (USP/Brazil) & Lucas Oliveira (UFGRS/Brazil)

A tale of three integrals

Emanuel Carneiro
ICTP, Italy & IMPA, Brazil

This talk is about three integrals related to Montgomery's pair correlation conjecture for the zeros of the Riemann zeta-function. The conjectured asymptotic for any of these three integrals is actually equivalent to Montgomery's conjecture. I will discuss how we can substantially improve the known upper and lower bounds for these integrals by using Fourier analysis.

Weak endpoint estimates for Calderón-Zygmund operators in von Neumann algebras

José Manuel Conde Alonso
Universidad Autónoma de Madrid, Spain

The classical Calderón-Zygmund decomposition is a fundamental tool that helps one study endpoint estimates near L1. In this talk, we shall study an extension of the decomposition to a particular operator valued setting where noncommutativity makes its appearance, allowing to get rid of the (usually necessary) UMD property of the Banach space where functions take values. Based on joint work with L. Cadilhac and J. Parcet.

Wavelet representation and sharp weighted estimates for multiparameter singular integrals

Francesco Di Plinio
Washington University, United States

We describe a new representation technique for one and multiple parameter singular integrals in terms of continuous model operators. Unlike the well-established dyadic counterpart, our representation reflects the additional kernel smoothness of the operator being analyzed.

Our representation formulas lead naturally to a new family of $T(1)$ theorems on weighted Sobolev spaces whose smoothness index is naturally related to kernel smoothness. In the one parameter case, we obtain the Sobolev space analogue of the A_2 theorem; that is, sharp dependence of the Sobolev norm of T on the weight characteristic is obtained in the full range of exponents. In the bi-parametric setting, where local average sparse domination is not generally available, we obtain quantitative A_p estimates which are best known, and sharp in the range $\max\{p, p'\} \geq 3$.

Tauberian theorems

Dimitar K. Dimitrov
Universidade Estadual Paulista, Brazil

The classical Tauberian theorems furnish the first term in the asymptotic behaviour of the partial sums of a series in terms of either the corresponding power series, Dirichler series or the discrete

Laplace transform. On the other hand, Wiener's Tauberian theorems provide necessary and sufficient conditions in order that the translates of a function f from either $L^1(\mathbb{R})$ or $L^2(\mathbb{R})$ are dense in the same space in terms of the quantity of real zeros of the Fourier transform of f.

The history of the development of this fundamental topic in Analysis and its tight relation to various long-standing problems in Number Theory will be discussed. We shall report two relatively recent results concerning this interplay and formulate some relevant open problems.

The Bourgain-Brézis-Mironescu formula in arbitrary bounded domains

Irene Drelichman
Universidad Nacional de La Plata, Argentina

In this talk we discuss what is a suitable replacement for the Gagliardo seminorm so that the Bourgain-Brézis-Mironescu formula on its limit behaviour when $s \to 1$ holds in arbitrary bounded domains, and comment on some related results. This is joint work with Ricardo G. Durán.

Bounded mean oscillation on shapes

Ryan Gibara,
Laval University, Canada

The space of functions of bounded mean oscillation (BMO) is known to be important in the study of both harmonic analysis and PDEs. Specifically, these are functions having bounded mean oscillation on all cubes. When the collection of cubes is exchanged for a more general collection of sets, we obtain a different function space. In this talk, I will give an overview of some recent work regarding the theory of this generalised BMO space. Both progress and still-open problems will be presented. This is joint work with Almut Burchard, Galia Dafni, Andrew Lavigne, Hong Yue.

Discrete polynomial averages and decoupling inequalities

Jose Ramon Madrid Padilla
University of California Los Angeles, United States

In this talk we will discuss some improving inequalities for discrete averaging operators along polynomials, and their connections to decoupling inequalities on the moment curve. We will also discuss decoupling inequalities for fractal subsets of the parabola.

Elliptic measures and square function estimates on 1-sided chord arc domains

Andrea Olivo
International Centre for Theoretical Physics (ICTP), Italy

Given a bounded domain, it is interesting to understand what is the relation between the harmonic/elliptic measure and the usual surface measure defined over its boundary. For example, what are the minimal conditions over the domain to ensure that the harmonic/elliptic measure is absolutely continuous with respect to the surface measure or vice versa? Usually, there is a deep connection between the properties of the harmonic/elliptic measure of a domain and the regularity of the boundary expressed in terms of its rectifiability. Additionally, in nice environments, such as Lipschitz or chord-arc domains, it is well known that the solvability of the Dirichlet problem for an elliptic operator with data in some L^p, for a finite p, is equivalent to the fact that the associated elliptic measure belongs to the Muckenhoupt class A_∞ (a quantitative version of absolute continuity). In turn, any of these conditions occurs if and only if the gradient of every bounded null solution satisfies a Carleson measure estimate. This has been recently extended to much rougher settings such as those of 1-sided chord-arc domains. In this work, we are in the same environment and consider a qualitative analog of the latter equivalence showing that one can characterize the absolute continuity of the surface measure with respect to the elliptic measure in terms of the finiteness almost everywhere of the truncated conical square function for any bounded null solution.

This is a joint work with José María Martell and Mingming Cao (ICMAT).

Fractional Poincaré-Sobolev inequalities and Harmonic Analysis

Carlos Pérez Moreno
University of the Basque Country and BCAM, Spain

In this mostly expository lecture, we will discuss some recent results concerning fractional Poincaré and Poincaré-Sobolev inequalities with weights, the degeneracy. These results improve some well known estimates due to Fabes-Kenig-Serapioni from the 80's in connection with the local regularity of solutions of degenerate elliptic equations and also some more recent results by Bourgain-Brezis-Minorescu. Our approach is different from the usual ones and is based on methods that come from Harmonic Analysis. We will discuss also some new results in the context of multiparameter setting improving also some results from Shi-Torchinsky and Lu-Wheeden from the 90's.

Session on Integral and Functional Differential Equations

Organizer: Everaldo M. Bonotto (USP/Brazil) & Pierluigi Benevieri (USP/Brazil)

Resonant problems for systems of delay differential equations

Pablo Amster
Universidad de Buenos Aires & IMAS-CONICET, Argentina

In this talk, we shall present sufficient conditions for the existence of periodic solutions of some systems of functional-delay differential equations. Specifically, we shall give elementary proofs of some Landesman-Lazer type result for systems and explore its connection with the fundamental theorem of algebra.

Periodic solutions of measure functional differential equations

Everaldo M. Bonotto
Universidade de São Paulo, Brazil

Measure differential equations are classically known to deal well with discontinuities, we mention, for instance, problems in quantum mechanics involving jumps. In this talk, we will present some results concerning the existence of periodic solutions for a class of measure functional differential equations.

Path integration and applications

Márcia Federson
Universidade de São Paulo, Brazil

We address some issues on Henstock's and Feynman's path integrals as well as on its applications.

Positive solutions for an indefinite Minkowski-curvature equation: an overview of recent results

Guglielmo Feltrin
University of Udine, Italy

The talk focuses on the indefinite Minkowski-curvature equation

$$\left(\frac{u'}{\sqrt{1-(u')^2}}\right)' + \lambda a(t) g(u) = 0, \tag{1}$$

where $\lambda > 0$ is a parameter, $a(t)$ is a T-periodic sign-changing weight function and $g\colon [0,+\infty[\to [0,+\infty[$ is a continuous function having superlinear growth at zero. We present some recent contributions [1, 2, 3, 4], that we also compare with the ones for the semi-linear equation $u'' + \lambda a(t) g(u) = 0$.

In more detail, when dealing with a superlinear function $g(u) = u^p$ with $p > 1$, we prove that equation (1) has no positive T-periodic solutions for λ close to zero and two positive T-periodic solutions for λ large enough; while when dealing with the "super-exponential" function $g(u) = e^{u^p} - 1$ with $p > 1$, the equation has a positive T-periodic solution for all $\lambda > 0$. The proofs are based on the topological degree theory for locally compact operators in product of Banach spaces. The Neumann boundary conditions are also analysed.

References:

[1] A. Boscaggin, G. Feltrin, Pairs of positive radial solutions for a Minkowski-curvature Neumann problem with indefinite weight, Nonlinear Anal. 196 (2020).

[2] A. Boscaggin, G. Feltrin, Positive periodic solutions to an indefinite Minkowski-curvature equation. J. Differential Equations 269 (2020).

[3] A. Boscaggin, G. Feltrin, F. Zanolin, Positive solutions for a Minkowski-curvature equation with indefinite weight and super-exponential nonlinearity. Preprint (2020).

[4] A. Boscaggin, G. Feltrin, F. Zanolin, Uniqueness of positive solutions for boundary value problems associated with indefinite Φ-Laplacian type equations. Open Math. (2021).

A free boundary tumor model with variable nutrient and time delay

Xiaoying Han
Auburn University, United States

In this talk we introduce a free boundary model for tumor growth with time dependent nutritional supply and infinite time delays. The governing system consists of a nonlinear reaction diffusion equation describing the distribution of vital nutrients in the tumor and a nonlinear integro-differential equation describing the evolution of the tumor size. First, the global existence and uniqueness of a transient solution is established according to Banach fixed point theorem under some general conditions. Then with additional regularity assumptions on the consumption and net proliferation rates, the existence and uniqueness of a steady-state solution is shown and the convergence of the transient solution onto the steady-state solution is proved.

On renormalized solutions to elliptic inclusions with nonstandard growth

Piotr Kalita
Jagiellonian University, Krakow, Poland

We study the elliptic inclusion given in the following divergence form

$$\begin{aligned} -\operatorname{div} A(x, \nabla u) &\ni f \quad \text{in} \quad \Omega, \\ u &= 0 \quad \text{on} \quad \partial\Omega. \end{aligned}$$

As we assume that $f \in L^1(\Omega)$, the solutions to the above problem are understood in the renormalized sense. We also assume nonstandard, possibly nonpolynomial, heterogeneous and anisotropic growth and coercivity conditions on the maximally monotone multifunction A which necessitates the use of the nonseparable and nonreflexive Musielak–Orlicz spaces. We prove the existence and uniqueness of the renormalized solution as well as, under additional assumptions on the problem data, its boundedness. The key difficulty, the lack of a Carathéodory selection of the maximally monotone multifunction is overcome with the use of the Minty transform. Talk will be based on the article [1].

References:

[1] A. Denkowska, P. Gwiazda, P. Kalita, On renormalized solutions to elliptic inclusions with non-standard growth, to appear in Calculus of Variations and Partial Differential Equations,
doi: https://doi.org/10.1007/s00526-020-01893-4, arxiv: https://arxiv.org/abs/1912.12729

Periodic functions on isolated time scales

Jaqueline Godoy Mesquita
Universidade de Brasília, Brazil

In this work, we formulate the definition of periodicity for isolated time scales. This provides the basis for future research regarding periodicity on time scales with a positive graininess. The introduced definition is consistent with the known formulations in the discrete and quantum calculus setting. Using the definition of periodicity, we discuss the existence and uniqueness of T-periodic solutions to a family of linear dynamic equations on isolated time scales. Examples in quantum calculus and mixed isolated time scales are presented throughout. This is a joint work with Martin Bohner and Sabrina Streipert.

Some interesting results on linearization and on Lyapunov stability and instability on finite and infinite dimensional dynamical systems

Hildebrando Munhoz Rodrigues
Universidade de São Paulo, Brazil

First I will present a result on Linearization of Infinite dimensional dynamical systems. Secondly I will discuss some new results on robustness of stability and of exponential dichotomy under integrally small linear perturbation with application to rapidly oscillatory periodic, with small period, linear perturbations. In this line of ideas it will be presented as a control problem of stabilization of an unstable periodic linear system with large period that is stabilized by an addition of a periodic perturbation that is nonzero only in a short interval of time. Finally I will present two new examples of non robustness of Lyapunov Unstability that solve two open problems. These results come from some joint papers with J. Solà-Morales, Tomás Caraballo and Guilherme Nakassima.

Periodic perturbations of a class of Functional Differential Equations with applications to a HIV model

Marco Spadini
Università di Firenze, Italy

We study the harmonic response to periodic perturbations of a particular class of functional differential equations that have some biological relevance. Some applications are presented to a well-known model for HIV replication.

Our investigation is based on a combination of degree-theoretic methods and a technique that allows to associate the bounded solutions of a functional equation belonging to the class under scrutiny to bounded solutions of a suitable ordinary differential equation.

Session on Linear Equations

Organizers: Alexandre Kirilov (UFPR/Brazil) & Luis Fernando Ragognette (UFSCAR/Brazil)

Global solvability vs. global hypoellipticity on compact manifolds

Gabriel Araújo
Universidade de São Paulo, Brazil

In this talk I'll discuss some relationships between certain notions of solvability and regularity of linear differential operators from a global viewpoint. I will also present recent results on the subject obtained in collaboration with Igor A. Ferra (UFABC) and Luis F. Ragognette (UFSCar) concerning certain second-order operators, as well as new directions regarding systems of first-order operators in an ongoing project of the three of us plus Max R. Jahnke (UFSCar / Rutgers U.).

On the Cauchy problem for p-evolution equations in Gelfand-Shilov type spaces

Alessia Ascanelli
University of Ferrara, Italy

We study the initial value problem for a class of p-evolution equations including Schrödinger equation and Korteweg de Vries equation. The lower order terms are complex valued and depend on (t, x) in $[0, T] \times \mathbb{R}^n$; the imaginary parts satisfy (small) decay conditions as $|x|$ goes to infinity, the real parts may present an algebraic growth at infinity. The initial data present a certain Gevrey regularity and an exponential behavior at infinity, that is they belong to certain Gelfand-Shilov type spaces. We prove the existence of a solution with the same Gevrey regularity of the data and we describe its behavior at infinity.

Ellipticity and Fredholmness of pseudo-differential operators on $\ell^2(\mathbb{Z}^n)$

Aparajita Dasgupta
Indian Institute of Technology, India

The aim of this talk is to investigate the ellipticity and Fredholmness of pseudodifferential operators on $\ell^2(\mathbb{Z}^n)$ in the context of minimal and maximal operators, the domains of elliptic pseudo-differential operators, and Fredholm operators. The minimal operator and the maximal operator of an elliptic pseudodifferential operator with symbols on $\mathbb{Z}^n \times \mathbb{T}^n$ are proved to coincide and the domain is given in terms of a Sobolev space. Ellipticity and Fredholmness are proved to be equivalent for pseudo-differential operators on $\mathbb{Z}^n$. The index of an elliptic pseudo-differential operator on $\mathbb{Z}^n$ is also computed. (This is a joint work with Vishvesh Kumar)

Gevrey semi-global solvability for a class of complex vector fields

Paulo Dattori
Universidade de São Paulo, Brazil

Let

$$\mathcal{L} = \partial/\partial t + (a(x,t) + ib(x,t))\partial/\partial x, \quad b \not\equiv 0, \tag{2}$$

be a complex vector field defined on $\Omega = \mathbb{R} \times S^1$, where S^1 is the unit circle, and a and b are real-valued real-analytic functions. The characteristic set of the structure associated with $\mathcal{L}$, denoted here by $\mathcal{C}(\mathcal{L})$, is the set of all points $(x,t) \in \Omega$ where $\mathcal{L}$ fails to be elliptic, that is:

$$\mathcal{C}(\mathcal{L}) = \{(x,t) \in \Omega; \mathcal{L}_{(x,t)} \text{ and } \overline{\mathcal{L}}_{(x,t)} \text{ are linearly dependent}\}.$$

Let $\Sigma = \{0\} \times S^1$. We will assume that $\mathcal{C}(\mathcal{L}) = \Sigma$ and that each point in Σ is of infinite type. Hence, $(a+ib)(0,t) \equiv 0$ and $b(x,t) \neq 0$ for $x \neq 0$ and for all $t \in S^1$. Under our assumptions $\mathcal{L}$ satisfies the well-known *condition* $(\mathcal{P})$ of Nirenberg-Treves.

In this talk we will address to the solvability of the equation $\mathcal{L}u = f$ when f is a Gevrey function on Ω.

The local solvability is well-understood.

We will present results concerning the solvability in a full neighborhood of Σ, in the following sense: given $s' \geq s > 1$ we say that $\mathcal{L}$ is (s',s)-*solvable* at Σ if for any f belonging to a subspace of finite codimension of $G^s(\Omega)$ there exists a solution $u \in G^{s'}$ to the equation $\mathcal{L}u = f$ defined in a neighborhood of Σ.

*The author was partially supported by CNPq and FAPESP.

Global M-hypoellipticity, global M-solvability and perturbations by lower order ultradifferential pseudodifferential operators

Bruno de Lessa Victor
Universidade Federal do Paraná, Brazil

We introduce a new class of ultradifferentiable pseudodifferential operators on the torus whose calculus allows us to show that global hypoellipticity, in ultradifferentiable classes, with a finite loss of derivatives of a system of pseudodifferential operators, is stable under perturbations by lower order pseudodifferential operators whose order depends on the loss of derivatives.

Planar vector fields with homogeneous singular points

Hamid Meziani
Florida International University, United States

In this paper, we study the equation $Lu = f$, where L is a C-valued vector field in the plane with a homogeneous singularity. The properties of the solutions are linked to the number theoretic properties of a pair of complex numbers attached to the vector field. As an application, we obtain results about an associated Riemann–Hilbert problem for the vector field L.

Global pseudo-differential analysis

Michael Ruzhansky
Ghent University, Belgium

In this talk we give an overview of several global quantizations on spaces with or without symmetries.

On a Bernoulli-type overdetermined free boundary problem

Mariana Smit Vega Garcia
Western Washington University, United States

We study a Bernoulli-type free boundary problem in the context of certain PDEs. In particular, we show that if K is a bounded convex set satisfying the interior ball condition and $c > 0$ is a given constant, then there exists a unique convex domain U containing K and a function u which solves the PDE in $U \setminus K$, has continuous boundary values 1 on the boundary of K and 0 on the boundary of U, such that $|\nabla u| = c$ on the boundary of U. Moreover, we study the regularity of the boundary of U.

Modulation spaces, harmonic analysis and pseudo-differential operators

Joachim Toft
Linnaeus University, Sweden

In the present talk we present recent results on composition, continuity and Schatten-von Neumann (SvN) properties for operators and pseudo-differential operators (ΨDOs) when acting on modulation spaces. For example we present necessary and sufficient conditions in order for the Weyl product should be continuous on modulation spaces. Such question is strongly connected to questions wether compositions of ΨDOs with symbols in modulation spaces remain as ΨDOs with a symbol in a modulation space.

We also present necessary and sufficient conditions for ΨDOs with symbols in modulation spaces should be SvN operators of certain degree in the interval $(0, \infty]$. Note here that there are so far only few results in the literature on SvN operators with degrees less than one.

Parts of the talk are based on joint works with D. Bhimani, Y. Chen, E. Cordero, R. Manna and P. Wahlberg.

Session on Multiscale Dynamics

Organizers: Yao Li (UMass Amherst/USA) & Zhongwei Shen (UAlberta/Canada)

A general theory of coexistence for ecological communities

Alexandru Hening
Tufts University, United States

A fundamental question from population biology is finding conditions under which interacting species coexist or go extinct. I present results that lay the foundation for a general theory of stochastic coexistence. This theory extends and makes rigorous Modern Coexistence Theory and leads to resolving a number of conjectures due to Chesson, Ellner, and Palis. I explain how this theory can be used to complete the classification of three-species stochastic ecological systems and end with an important example that shows that random environmental fluctuations can rescue species from extinction.

Reaction-subdiffusion equations

Sean Lawley
University of Utah, United States

Deriving evolution equations accounting for both anomalous subdiffusion and reactions is notoriously difficult, even in the simplest cases. In contrast to normal diffusion, reaction kinetics cannot be incorporated into evolution equations modeling subdiffusion by merely adding reaction terms to the equations describing spatial movement. Various competing models of reaction-subdiffusion have been proposed, and the type of mesoscopic equation depends on subtle assumptions about the microscopic behavior of individual molecules. Furthermore, the correspondence between mesoscopic and microscopic models is not well understood.

In this talk, we will introduce some reaction-subdiffusion models and highlight recent results on their solution, stability, and stochastic representation. Mathematically, the analysis relies on solving fractional differential equations in terms of integer order differential equations in which time is randomly changed according to the trajectory of the first crossing time inverse of a Levy subordinator.

Transient Oscillations in Immune Response Dynamics and Implications for HIV Control

Michael Li
University of Alberta, Canada

Oscillatory and cyclic behaviours are commonly observed in the natural responses of the immune system, including antibody responses to antigen challenges and T-Cell responses to various viral infections. These large-amplitude oscillations in the immune response data have two important characteristics: they appear and terminate within a finite time interval (transient), and they can be repeatedly induced and observed in animal experiments (robust). The transient nature makes these oscillations distinct from the limit cycle behaviours in predator-prey and other population models, and their robustness suggest that they are not completely unstable oscillations. What would be a suitable mathematical representation for transient and robust periodic oscillations? Can this type of oscillations be produced in mathematical models of immune response? In this talk, I will show how normally hyperbolic periodic solutions occur through Hopf bifurcation in a simple in-host model of CTL response to viral infections, and why normally hyperbolic periodic oscillations describe transient and robust oscillatory behaviours. I will also show some data from HIV elite controllers that show transient oscillations in CD4+ and CD8 T cells. This may suggest that transient oscillations may be related to the immune control of HIV in vivo.

Fourier's law from multiscale deterministic dynamics

Yao Li
Univ. of Massachusetts Amherst, United States

Fourier's law, or the law of heat conduction, is well-known for nearly two centuries, which states that the energy flux is proportional to the temperature gradient. However, the rigorous derivation of Fourier's law from microscopic Hamiltonian dynamics remains a great challenge to theorists. In this talk, I will show the derivation of macroscopic thermodynamic laws, including Fourier's law, from multiscale deterministic dynamics. A stochastic energy exchange model is numerically derived from a dynamical billiards heat conduction model that is not mathematically tractable. Then we take the mesoscopic limit of this energy exchange model by constructing two martingale problems. We find that Fourier's law is satisfied by the steady state of the mesoscopic limit equation.

Multiscale Poisson-Nernst-Planck systems: from protein structure to ionic flow properties

Weishi Liu
University of Kansas, United States

Protein structure is the most important factor for ionic flow properties of ion channels. The basic model for ionic flow is the Poisson-Nernst-Planck (PNP) system. Due to the micro-scale and multi-regions of ion channels, the PNP system naturally exhibits multi-scale structure.

In this talk, we will report our studies toward an understanding of protein structure (i.e. permanent charge and channel shape) effects on ionic flow via a quasi-one-dimensional PNP model. While the feature of multi-scale with multiple parameters presents a challenge for analyzing the problem, the same feature is also the reason for a rich dynamic behavior of the problem, some phenomena are quite counter-intuitive.

Quasi-stationary distributions in population biology

Weiwei Qi
University of Alberta, Canada

Absorbed diffusion processes are often used in population biology to model the evolution of interacting species. Although the eventual extinction of all species is inevitable due to finite resources, mortality, etc., species can typically persist for a period of time that is long compared to human timescales. It is important to understand the behavior of the ecosystem before the eventual extinction. This talk will address this issue by studying the quasi-stationary distribution (QSD) of the multi-dimensional diffusion process, which can characterize the coexistence among species before extinction. Under elementary Lyapunov conditions, the (principle) spectrum theory of the Fokker-Planck operator for general irreversible diffusion process is established. New existence, uniqueness and sharp convergence of QSDs are obtained. Applications to cooperative, competitive, and predator-prey Lotka-Volterra systems will be discussed.

Long transient dynamics in stochastic systems

Zhongwei Shen
University of Alberta, Canada

Transient dynamics, often observed in multi-scale systems, are roughly defined to be the interesting dynamical behaviours that display over finite time periods. For a class of randomly perturbed dynamical systems that arise in chemical reactions and population dynamics, and that exhibit persistence dynamics over finite time periods and extinction dynamics in the long run, we use quasi-stationary distributions (QSDs) to rigorously capture the transient states governing the long transient dynamics. We study the noise-vanishing concentration of the QSDs to gain information about the transient states and investigate the dynamics near transient states to understand the transient dynamical behaviours as well as the global multiscale dynamics.

A coupling approach in the computation of geometric ergodicity for stochastic dynamics

Shirou Wang
University of Alberta, Canada

For a stochastic dynamics arising from random perturbation of a deterministic one, the convergence speed of the law of the system to the invariant distribution, in particular the rate of geometric ergodicity, is an important quantity for its importance in both theoretical aspect, such as it is closely related to the spectral gap of an associated differential operator, and applied applications in sampling, uncertainty quantification and sensitivity analysis. However, the quantitative study of geometric rate is difficult in general. This talk introduces a probabilistic approach to numerically compute the geometric convergence rates in discrete or continuous stochastic systems. By choosing appropriate coupling mechanisms and combine them together, this approach works well in many settings especially the high-dimensions. Using this approach, it is particularly observed that the rate of geometric ergodicity of a randomly perturbed system can, to some extent, reveal the degree of chaoticity of the unperturbed system. Potential applications of the coupling method to the visualization of higher dimensional non-convex functions, e.g., the loss functions of neural networks, will also be discussed.

Nilpotent bifurcations and multiscale dynamics in a pest control model in tea plantations

Huaiping Zhu
York University, Canada

In this talk, I will present a pest control model in tea plantations where a generalist predator mite (Anystis baccarum) serves as a natural enemy to control green leafhopper Empoasca (E. onukii). I will then explain the nilpotent singularity (elliptic, focus) and its bifurcations. The complex dynamics include the bi and tri-stability and multiscale dynamics involving three limit cycles.

Session on Nonlinear Dynamical Systems

Organizers: Marcone C. Pereira (USP/Brazil) & Phillipo Lappicy Lemos Gomes (USP/Brazil)

Gradient-like dynamics near a manifold of quasi-equilibria

Peter Bates
Michigan State University, United States

In a general Banach space we consider gradient-like dynamical systems with the property that there is a manifold along which solutions move slowly compared to attraction in the transverse direction. Conditions are given on the energy (or Lyapunov functional) that ensure solutions starting near the manifold stay near for a long time or even for ever. The abstract results are then used to show the super slow motion of interfaces for the vector Allen-Cahn and Cahn-Morral systems.

Lyapunov exponents of weakly-driven, weakly-damped random dynamical systems with applications to the Lorenz 96 model and others

Alex Blumenthal
Georgia Institute of Technology, United States

The Lyapunov exponent measures the rate at which nearby initial conditions of a dynamical system converge or diverge: a positive exponent, indicating divergence, is a classical hallmark of chaotic behavior. Unfortunately, it can be profoundly difficult to estimate the Lyapunov exponents of dynamical systems of physical interest. On the other hand, for volume-preserving systems subjected to random noise, positivity of the Lyapunov exponent must hold unless some severe degenerate behavior is present (due to work of Furstenberg and many others). A significant drawback of this theory is that it provides no quantitative estimate of Lyapunov exponents, only positivity. In this talk, I will discuss recent work with J. Bedrossian and S. Punshon-Smith providing a new, more quantitative perspective on Furstenberg-type criteria for Lyapunov exponents for SDE using a Fisher information-type identity and a quantitative re-working of aspects of Hormander's hypoellipticity theory. As an application, we are able to establish positivity of the Lyapunov exponent for a class of systems subjected to weak dissipation effects (e.g., drag, viscosity), including the Lorenz 96 system with arbitrarily many oscillators.

Dynamics of non-local partial differential equations with delays and memory

Tomás Caraballo
Universidad de Sevilla, Spain

In this talk we analyze a non-autonomous nonlocal parabolic equations when the external force contains hereditary characteristics involving bounded and unbounded delays. First, well-posedness of the problem is analyzed by the Galerkin method and energy estimations in the phase space $\mathbf{C}_{\rho}(X)$. Moreover, some results related to strong solutions are proved under suitable assumptions. The existence of stationary solutions is then established by a corollary of the Brower fixed point theorem. By constructing appropriate Lyapunov functionals in terms of the characteristic delay terms, a deep analysis on stability and attractiveness of the stationary solutions is established. Furthermore, the

existence of pullback attractors in $L^2(\Omega)$, with bounded and unbounded delays, is shown. We emphasize that, to prove the existence of pullback attractors in the unbounded delay case, a new phase space, E_γ, has to be constructed.

The center of mass of an isolated relativistic system and its motion

Carla Cederbaum
University of Tübingen, Germany

In Classical Mechanics, isolated systems are most easily analyzed by first computing their center of mass and determining its motion, and then, as a second step, expressing the motion of the full system relative to the center of mass. Mathematically, this works because the underlying partial differential equation, the Poisson equation, is linear and hence allows for superposition of solutions. This is in stark contrast to General Relativity, which is a nonlinear theory. Yet, near infinity, isolated relativistic systems are almost non-gravitating so that one can hope to effectively work with a linearized version of the nonlinear geometric partial differential equations of General Relativity.

After a rather extensive introduction of the central concepts and ideas, I will describe a new approach to defining the center of mass of an isolated relativistic system at a given time and explain the law of motion it is subject to. I will explain why this definition can be considered satisfactory from both mathematical and physical viewpoints and illustrate how it fixes deficiencies of previous definitions. This is joint work with Anna Sakovich.

A sharp measure damping condition satisfying (GCC)

Ma To Fu
Universidade de Brasília, Brazil

This talk is concerned with locally damped semilinear wave equations defined on compact Riemannian manifolds with boundary. We present a construction of measure-controlled damping regions which are sharp in the sense that their summed interior and boundary measures are arbitrarily small. The construction of this class of open sets is purely geometric, and by means of an obstacle control condition, we show that our class of measure-controlled regions satisfies the well-known geometric control condition (GCC). Therefore, many of known results for the control and stabilization of wave equations hold true in the present context.

Unbounded attractors for dynamical systems

Juliana Fernandes
Universidade Federal do Rio de Janeiro, Brazil

It would be crucial to have the machinery to explore unbounded attractors from an unified point of view. This would, in particular, prevent specific technicality of each type of equation one proposes to investigate. Motivated by that, the aim is to construct unbounded global attractors for general autonomous and nonautonomous dynamical systems, not necessarily corresponding to evolution equations. This is a joint work with M. Bortolan.

Quasiperiodic solutions of elliptic equations on the entire space

Peter Polacik
University of Minnesota, United States

In a joint project with Dario Valdebenito, we study elliptic equations on the Euclidean space of N+1 dimensions. Considering positive solutions with some predetermined behavior (such as decay and symmetry or periodicity) in the first N variables, we examine their behavior in remaining variable. Using center manifold and KAM theorems, we show the existence of uncountably many solutions which are quasiperiodic in that variable.

Homogenization for nonlocal evolution problems with three different smooth kernels

Julio D. Rossi
Universidad de Buenos Aires, Argentina

We consider the evolution problem associated with a jump process that involves three different smooth kernels that govern the jumps to/from different parts of the domain.

We assume that the spacial domain is divided into a sequence of two subdomains $A_n \cup B_n$ and we have three different smooth kernels, one that controls the jumps from A_n to A_n, a second one that controls the jumps from B_n to B_n and the third one that governs the interactions between A_n and B_n.

Assuming that $\chi_{A_n}(x) \to X(x)$ weakly in L^∞ (and then $\chi_{B_n}(x) \to 1 - X(x)$ weakly in L^∞) as $n \to \infty$ and that the initial condition is given by a density u_0 in L^2 we show that there is an homogenized limit system in which the three kernels and the limit function X appear.

When the initial condition is a delta at one point, $\delta_{\bar{x}}$ (this corresponds to the process that starts at $\bar{x}$) we show that there is convergence along subsequences such that $\bar{x} \in A_{n_j}$ or $\bar{x} \in B_{n_j}$ for every n_j large enough.

We also provide a probabilistic interpretation of this evolution equation in terms of a stochastic process that describes the movement of a particle that jumps in Ω according to the three different kernels and show that the underlying process converges in distribution to a limit process associated with the limit equation.

We focus our analysis in Neumann type boundary conditions and briefly describe at the end how to deal with Dirichlet boundary conditions.

Joint work with Monia Capanna, Jean C. Nakasato and Marcone C. Pereira

On the dynamics of some nonlocal diffusion problems in metric measure spaces

Anibal Rodriguez-Bernal
Universidad Complutense de Madrid, Spain

We present some results on the asymptotic behavior of linear and nonlinear nonlocal evolution problems in rough media, assimilated to metric measure spaces. We analize weak and strong maximum principles for stationary and evolution linear problems. For nonlinear problemas with local reaction we discuss global existence, asymptotic bounds and the existence of extremal solutions.

Session on Stochastic Dynamics

In memory of María José Garrido Atienza

Organizer: Jose A. Langa (Univ. de Sevilla, Spain) & Tomás Caraballo (Univ. de Sevilla, Spain)

A Glance to Random Differential Equations with Applications

Juan Carlos Cortés
Universitat Politècncia de València, Spain

Differential equations are useful tools in mathematical modelling. The consideration of uncertainty into their formulation leads to two main clases of differential equations, namely, Stochastic Differential Equations (SDEs) and Random Differential Equations (RDEs). There is a growing trend in the Uncertainty Quantification community to treat these terms as synonimous when in fact they are distinctly different and they require completely different techniques for analysis and treatment. We will first delineate the main differences between SDEs and RDEs. Solving SDEs and RDEs means computing not only its solution, which is a stochastic process but also its main statistical functions such as the expectation and standard deviation. The determination of its first probability density function (1-PDF) provides a more complete probabilistic description of the solution at each time instant.

We will present some ideas that have demonstrated to be useful to determine, exact or approximately, the 1-PDF of some ubiquitous classes of RDEs. The talk will present a variety of examples aimed at touching intuition. These examples will include the application of the results to modelling real problems using sampled data.

The lottery model for ecological competition in stochastic environments

Xiaoying Han
Auburn University, United States

In this talk we will introduce multi-species lottery competition model with non-stationary reproduction and mortality rates of both species is studied. First a diffusion approximation for the fraction of sites occupied by each adult species is derived as the continuum limit of a classical discrete-time lottery model. Then a non-autonomous stochastic differential equation on sites occupied by the species, as well as a Fokker-Planck equation on its transitional probability are developed. Existence, uniqueness, and dynamics of solutions for the resulting stochastic differential equation and Fokker-Planck equation are investigated, from which sufficient conditions for coexistence are established. Numerical simulations are presented to illustrate the theoretical results.

The limit distribution of inhomogeneous Markov processes and Kolmogorov's problem

Zhenxin Liu
Dalian University of Technology, China

In this talk, we will talk about the limit distribution of inhomogeneous Markov processes generated by SDEs. Meantime, we will also discuss the recent progress in Kolmogorov's problem on the limit behavior of stationary distributions of diffusion processes as the diffusion tends to zero.

Modeling bounded random fluctuations in the classical chemostat with non-monotonic consumption function

Javier López-de-la-Cruz
Universidad Politécnica de Madrid, Spain

Chemostat is a laboratory device very used in practice due to its large number of applications, such as waste water treatment, antibiotic production and fermentation models, to name the most popular applications. It consists on three different tanks, the feed bottle, the culture vessel and the collection vessel. The substrate is stored in the first tank and removed, by means of pumps, to the second tank, where the interactions between the substrate and the microbial biomass take place. In addition, in order to keep the volume constant in the culture vessel, another flow is pumped from the culture vessel to the third tank.

Even though many papers in the literature deal with the classical deterministic chemostat model with monotonic consumption function, it is very well known that real world is subject to fluctuations that are typically random and bounded. In addition, practitioners explain that some species do not consume the substrate it it is at high concentration. Motivated by this, in this talk we propose a way to model bounded random fluctuations in the classical chemostat model with non-monotonic consumption function. We will present some theoretical results concerning the existence and uniqueness of global positive solution of the model and provide conditions under which both extinction and weak and strong persistence can be proved mathematically. In addition, we will depict several numerical simulations to support the theoretical part.

Probabilistic solution of a finite dimensional linear control system with uncertainty

Ana Navarro Quiles
Universitat de València, Spain

Control theory is a branch of mathematics that study the behaviour of a dynamical system with controllers, one or more, applied through actuators. Furthermore, its main objective is to develop control models for controlling such systems using a controller in an optimum manner, that is ensuring the stability. A control problem consists in finding controls, u(t), such that the solution of a model, x(t;u), coincides or gets close to a value x1 in a final time instant T, i.e., x(T;u)=x1. Generally, an optimal control problem is defined as a set of differential equations, ordinary or partial, describing the states which depend on the control variables that minimize a particular cost function.

On the other hand, the parameters that appear in this kind of formulations are generally fixed from experimental data. Therefore, as these values are obtained from certain measurements and samplings, they contain an intrinsic uncertainty. This situation allows us to consider the inputs as random variables or stochastic processes rather than constants or deterministic functions.

As it has been pointed previously, a control problem is defined through a set of ordinary or partial differential equations depending on the dimensionality of the system, finite or infinite dimensional, respectively. In this contribution, given its interest, we consider a finite dimensional linear control system. We analyse the randomized control problem, from a probabilistic point of view, where all the entries in the model are assumed absolutely continuous random variables. To show the capability of the theoretical results previously established, we present some numerical examples.

Random attractors for stochastic parabolic evolution equations via pathwise mild solutions

Stefanie Sonner
Radboud University, the Netherlands

We consider stochastic parabolic partial differential equations with additive noise where the differential operators depend on time and the underlying probability space. In particular, we prove the existence of global and exponential random attractors and derive estimates on their fractal dimension. To apply the framework of random dynamical systems we use the recent concept of pathwise mild solutions which yields pathwise representations for the solutions. Our approach is different from the classical one where stochastic evolution equations are transformed into partial differential equations with random coefficients via the stationary Ornstein-Uhlenbeck process. This is joint work with C. Kuehn and A. Neamtu.

Existence and continuity of hyperbolic equilibria for nonautonomous random differential equations

Alexandre do Nascimento Oliveira Sousa
Universidade de São Paulo, Brazil

In this work, we study permanence of hyperbolicity for autonomous differential equations under nonautonomous random/stochastic perturbations. For the linear case, we study robustness and existence of exponential dichotomies for nonautonomous random dynamical systems. Next, we establish a result on the persistence of hyperbolic equilibria for nonlinear differential equations. We show that for each nonautonomous random perturbation of an autonomous semilinear problem with a hyperbolic equilibrium there exists a bounded random hyperbolic solution for the associated nonlinear nonautonomous random dynamical systems. Moreover, we show that these random hyperbolic solutions converge to the autonomous equilibrium. As an application, we consider a semilinear differential equation with a small nonautonomous multiplicative noise.

On the fine structure of attractors in the positive cone for non-autonomous reaction-diffusion equations with discontinuities

José Valero
Universidad Miguel Hernández de Elche, Spain

We study the fine structure of the pullback attractor of a non-autonomous differential inclusion modeling a reaction-diffusion equation with a discontinuous nonlinearity and consider the possible extension of the results to stochastic equations. For this aim, we obtain first several properties concerning the uniqueness and regularity of non-negative solutions. Second, we obtain the existence of a unique non-degenerate bounded complete trajectory, which is a non-autonomous equilibrium. Third, we study the structure of the pullback attractor in the positive cone, showing that it consists of the zero solution, the unique positive non-autonomous equilibrium and the heteroclinic connections between them, which can be expressed in terms of the solutions of an associated linear problem. Finally, we analyze the relationship of the pullback attractor with the uniform, the cocycle and the skew product semiflow attractors.

Harnack inequality and exponential integrability for Functional SDEs

Chenggui Yuan
Swansea University, United Kingdom

The dimension free Harnack inequality has become a useful tool in the study of diffusion semigroups, in particular, for the uniform integrability, contractivity properties, and estimates on heat kernels. In this talk, I will introduce the dimension-free Harnack inequality for functional stochastic differential equations (SDEs) with multiplicative noise. As an application of the Harnack inequality, we will investigate the exponential integrability for Functional SDEs.

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

CHAPTER 2021

Programme

	MONDAY 1	TUESDAY 2	WEDNESDAY 3
08:50-09:00 (UTC -3)	Opening		

Plenary Lectures

	MONDAY 1	TUESDAY 2	WEDNESDAY 3
Chair	Aníbal Rodriguez-Bernal	Ma To Fu	Carlos Rocha
09:00-09:50 (UTC -3)	**Carlos Rocha** Instituto Superior Técnico	**Vicentiu Radulescu** University of Craiova	**Yingfei Yi** Univ. of Alberta and Jilin Univ.
10:00-10:50 (UTC -3)	**Bernold Fiedler** Freie Universität Berlin	**María del Mar González** Universidad Autónoma de Madrid	**Wenxian Shen** Auburn University

Special Session on Nonlinear Dynamical Systems

	MONDAY 1	TUESDAY 2	WEDNESDAY 3
Chair	Phillipo Lappicy Lemos Gomes	Antônio Luiz Pereira	Marcone C. Pereira
14:00-14:50 (UTC -3)	**Peter Polacik** University of Minnesota	**Julio D. Rossi** Universidad de Buenos Aires	**Aníbal Rodriguez-Bernal** Univ. Complutense de Madrid
15:00-15:40 (UTC -3)	**Tomás Caraballo** Universidad de Sevilla	**Juliana Fernandes** Univ. Federal do Rio de Janeiro	**Carla Cederbaum** University of Tübingen
15:50-16:30 (UTC -3)	**Peter Bates** Michigan State University	**Alex Blumenthal** Georgia Institute of Technology	**Ma To Fu** Universidade de Brasília

Special Session on Elliptic Equations

	MONDAY 1	TUESDAY 2	WEDNESDAY 3
Chair	Giovany Figueiredo	Marcos Pimenta	Claudianor Alves
14:00-14:50 (UTC -3)	**Jun-Cheng Wei** University of British Columbia	**Louis Jeanjean** Univ. Bourgogne Franche-Comté	**Tobias Weth** Goethe Universität Frankfurt
15:00-15:40 (UTC -3)	**Antonio Suárez** Universidad de Sevilla	**Jean Van Schaftingen** Université Catholique de Louvain	**David Ruiz** Universidad de Granada
15:50-16:30 (UTC -3)	**Claudianor Alves** Univ. Federal de Campina Grande	**Eduardo Teixeira** University of Central Florida	**Mónica Clapp** Univ. Nac. Autónoma de México

Special Session on Fluid Dynamics

	MONDAY 1	TUESDAY 2	WEDNESDAY 3
Chair	Gabriela Planas	Anne Bronzi	Gabriela Planas
14:00-14:50 (UTC -3)	**Helena Nussenzveig Lopes** Univ. Federal do Rio de Janeiro	**Lucas Catão de Freitas Ferreira** Univ. Estadual de Campinas	**Milton Lopes Filho** Univ. Federal do Rio de Janeiro
Chair	Anne Bronzi	Gabriela Planas	Anne Bronzi
15:00-15:40 (UTC -3)	**Diego Araujo de Souza** Universidad de Sevilla	**Ricardo Rosa** Univ. Federal do Rio de Janeiro	**Ciro S. Campolina Martins** Instituto de Mat. Pura e Aplicada
15:50-16:30 (UTC -3)	**Cesar J. Niche** Univ. Federal do Rio de Janeiro	**Nikolai Vasilievich Chemetov** Universidade de São Paulo	**Juliana Honda Lopes** Univ. Estadual de Campinas

Special Session on Harmonic Analysis and Related Topics

	MONDAY 1	TUESDAY 2	WEDNESDAY 3
Chair	Tiago Picon	Dimitar Dimitrov	Lucas Oliveira
14:00-14:50 (UTC -3)	**Carlos Pérez Moreno** Basque Center for Applied Math.	**Emanuel Carneiro** ICTP and IMPA	**Dimitar Dimitrov** Univ. Estadual Paulista
15:00-15:40 (UTC -3)	**José Ramón Madrid Padilla** University of California	**Irene Drelichman** Universidad Nacional de La Plata	**Francesco Di Plinio** Washington University
15:50-16:30 (UTC -3)	**Andrea Olivo** ICTP	**José M. Conde-Alonso** Univ. Autónoma de Madrid	**Ryan Gibara** Laval University

Special Session on Integral and Functional Differential Equations

	MONDAY 1	TUESDAY 2	WEDNESDAY 3
Chair	Pierluigi Benevieri	Everaldo M. Bonotto	Jaqueline Godoy Mesquita
14:00-14:50 (UTC -3)	**Jaqueline Godoy Mesquita** Universidade de Brasília	**Pablo Amster** Universidad de Buenos Aires	**Márcia Federson** Universidade de São Paulo
15:00-15:40 (UTC -3)	**Xiaoying Han** Auburn University	**Marco Spadini** Università di Firenze	**Hildebrando M. Rodrigues** Universidade de São Paulo

15:50-16:30 (UTC -3)	**Everaldo M. Bonotto** Universidade de São Paulo	**Piotr Kalita** Jagiellonian University	**Guglielmo Feltrin** Università degli Studi di Udine

	Special Session on Linear Equations		
Chair	Gabriel Araujo	Paulo Dattori	Mariana Smit Vega Garcia
14:00-14:50 (UTC -3)	**Hamid Meziani** Florida International University	**Joachim Toft** Linnaeus University	**Michael Ruzhansky** Ghent University
15:00-15:40 (UTC -3)	**Paulo Dattori** Universidade de São Paulo	**Alessia Ascanelli** Università degli Studi di Ferrara	**Aparajita Dasgupta** Indian Institute of Technology
15:50-16:30 (UTC -3)	**Bruno de Lessa** Universidade Federal do Paraná	**Mariana Smit Vega Garcia** Western Washington University	**Gabriel Araujo** Universidade de São Paulo

	Special Session on Multiscale Dynamics		
Chair	Zhongwei Shen	Shirou Wang	Yao Li
14:00-14:50 (UTC -3)	**Michael Li** University of Alberta	**Weishi Liu** University of Kansas	**Huaiping Zhu** York University
15:00-15:40 (UTC -3)	**Alexandru Hening** Tufts University	**Sean Lawley** University of Utah	**Shirou Wang** University of Alberta
15:50-16:30 (UTC -3)	**Weiwei Qi** University of Alberta	**Yao Li** Univ. of Massachusetts Amherst	**Zhongwei Shen** University of Alberta

	Special Session on Stochastic Dynamics *In memory of María José Garrido Atienza*		
Chair	José A. Langa	Tomás Caraballo	Tomás Caraballo
14:00-14:50 (UTC -3)	**José Valero** Universidad Miguel Hernández	**Zhenxin Liu** Dalian University of Technology	**Juan Carlos Cortés** Univ. Politècnica de València
15:00-15:40 (UTC -3)	**Stefanie Sonner** Radboud University Nijmegen	**Xiaoying Han** Auburn University	**Ana Navarro Quiles** Universitat de València
15:50-16:30 (UTC -3)	**Alexandre Nascimento Sousa** Universidade de São Paulo	**Chenggui Yuan** Swansea University	**Javier López de la Cruz** Univ. Politécnica de Madrid

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

CHAPTER 2021

List of Speakers

List of speakers (ordered by last name)

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CHAPTER 2021

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