Book of Abstracts

(Alphabetical Order)

8-12 July 2019

Equadiff 2019

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Invariant manifolds organising the propagation and control of dengue

Mon 08 Jul
17:50
CT6
KO-3

Pablo Aguirre (Universidad Técnica Federico Santa María)

Co-authors: Dana Contreras (Universidad Técnica Federico Santa María)

Arboviruses such as dengue, zyka and chikungunya are viruses transmitted to humans by mosquitoes. In particular, Aedes aegypti mosquito is the responsible for dengue transmission. In the absence of medical treatments and vaccines, one of the control methods is to introduce Aedes aegypti mosquitoes infected by the bacterium Wolbachia into a population of wild (uninfected) mosquitoes. The goal consists in achieving population replacement in finite time by driving the population of wild females towards extinction while keeping Wolbachia-infected mosquitoes alive. This strategy has several advantages for control of dengue: Wolbachia decreases the virulence of the dengue infection and it reduces the lifespan of the mosquito. Moreover, mating of a female uninfected by Wolbachia and an infected male leads to sterile eggs.We consider a competition model between wild Aedes aegypti female mosquitoes and those infected with bacteria Wolbachia in the form of a system of two reaction diffusion equations. Our aim here is to characterise traveling wave solutions with a novel approach from invariant manifold analysis. To this aim, we compute global stable and unstable manifolds of an associated 4D vector field. With this strategy we find uncountably many heteroclinic connections between stationary states (each associated to a wave front exhibiting the desired population replacement), as intersections of these global invariant manifolds in the 4D phase space.

Diffraction problem for parabolic equations describing experiments on the Soret effect

Tue 09 Jul
08:45
CT9
KO-3

Toyohiko Aiki (Japan Women's University)

Co-authors: Martijn Anthonissen (Technical University of Eindhoven), Miu Takahashi (Japan Women's University)

Recently, several reports for real experiments on application of the Soret effect to molecular separation were published. In this talk we focus on an article dealing with an experiment in which heat sources are periodically arranged in a two-dimensional domain. For the experiment we have proposed a system of two partial differential equations with cross diffusion terms. Precisely, the domain consists of two regions occupied by liquid containing two components and heat source metals. In the liquid region we consider heat and diffusion equations and in the metal region we impose only a heat equation with heat source effect. Also, on the boundary between the liquid and metal regions we suppose a diffraction type of boundary conditions for temperature fields on concentration of the liquids, since heat conductivities and diffusion constants on two regions are different. We will give a theorem concerned with existence of a weak solution to our model. Here, we note that we can not expect a strong solution to our problem on the whole domain because of the diffraction type of the boundary condition. Moreover, when solving numerical solutions, the model was approximated by introducing a dummy concentration variable into the metal region in order to overcome a difficulty arising from the diffraction boundary condition and complex structure of the domain. In this talk we also show the numerical results and our approximation method in detail.

Partitioned Average Vector Field Method for Nonlinear SchrÃűdinger Equation

Thu 11 Jul
08:45
CT18
KO-3

Canan Akkoyunlu (c.kaya@iku.edu.tr)

In this work, partitioned average vector field method (PAVF) is derived for nonlinear SchrÃűdinger equation (NLS) and strongly coupled SchrÃűdinger equation (SCNLS). The NLS and the SCNLS is discretized in space by finite difference and is solved in time by PAVF method. Numerical results compare with the AVF method. The results indicate that PAVF method are more effective to preserve global energy.

Transformation of the equations of dynamics

Alain Albouy (Observatoire de Paris)

Wed 10 Jul
08:45
MS27
KO-11

The theory of the "Transformation of the equations of dynamics" was mainly concluded by PainlevÃľ and Thomas. The subject is obviously important: to classify the transformations that send a "natural" mechanical system onto another one, the changes of time being allowed. But this theory was soon misunderstood: Whittaker presents it as an exercise, of which he gives the solution... which is obviously wrong. The theory was then universally forgotten. We claim that the reasons for this bad reception are:

i) A hesitation about the hypothesis: "natural" forces are they derived from a potential?

ii) A too complicated conclusion, unrelated with the classical examples, which are not even recalled.

iii) The lack of examples.

We will try to improve the situation of the three points, by also discussing a third hypothesis, by relating the conclusion with the examples, and by giving new examples.

See: [1] PainlevÃľ P., Sur les transformations des Ãľquations de la dynamique, Comptes Rendus, 1896, vol. 123, pp. 392-395.

[2] Thomas, T.Y., On the Transformation of the Equations of Dynamics, Journal of mathematics and physics, 1946, vol. 25, pp. 191-208.

[3] Whittaker, E.T. A Treatise on the Analytical Dynamics of Particles and Rigid Bodies. Cambridge: at the University Press, 1937, p. 261.

Point island dynamics under fixed rate deposition

Damien Allen (University of Strathclyde)

Co-authors: Michael Grinfeld (University of Strathclyde), Rafael Sasportes (Universidade Aberta)

Mon 08 Jul
15:00
CT3
KO-3

Submonolayer deposition (SD) is the term used to describe the initial stages of processes, such as molecular beam epitaxy, in which particles are deposited onto a surface, diffuse and form large-scale structures. A mathematical theory of SD that describes spatial distribution and the size statistics of the islands is an important goal of research. In this talk we will discuss a mean-field model of the dynamics of point islands during SD, in which the fragmentation of subcritical size islands is allowed. To understand the asymptotics of solutions, we use methods of centre manifold theory and for globalisation, we employ results from the theories of compartmental systems and of asymptotically autonomous systems of ordinary differential equations. We also compare our results with those obtained by making the quasi-steady state assumption.

On the stratification of the dynamics of three-dimensional real vector fields

Clementa Alonso (University of Alicante)

Co-authors: Fernando Sanz (University of Valladolid)

Tue 09 Jul
08:45
CT7
KO-1

A classical well known result states that given a planar real analytic vector field with an isolated singularity at the origin that is not of the center-focus type, we can decompose a sufficiently small open neighborhood of the singularity into finitely many hyperbolic, elliptic or parabolic sectors. This talk is devoted to the problem of extending this result from planar to three dimensional vector fields.

Spatial patterns in a diffusive modified Holling-Tanner predator-prey model

Claudio Arancibia-Ibarra (Queensland University of Technology (QUT) and Universidad de las Americas (UDLA))

Co-authors: Jose Flores (Department of Mathematics, The University of South Dakota), Michael Bode (Faculty of Science and Engineering, Queensland University of Technology), Graeme Pettet (Faculty of Science and Engineering, Queensland University of Technology), Peter van Heijster (Faculty of Science and Engineering, Queensland University of Technology)

Tue 09 Jul
19:00
Poster
KO

In this work, we consider the dynamics of a temporal and spatio-temporal modified Holling-Tanner predator-prey models with an alternative food for the predator. From our result of the temporal model, we present the analytical conditions for the bifurcation diagram. Additionally, we identify regions in parameter space in which Turing instability in the spatio-temporal model are expected. We use simulations to illustrate the behaviour of both the temporal and spatio-temporal model.

Computational properties of excitable network attractors

Peter Ashwin (University of Exeter)

Wed 10 Jul
10:15
MS26
KO-10

Neuronal systems perform computational tasks via their dynamic response to time-varying inputs. This talk will discuss recent work on excitable network attractors, where stable patterns of the network are nonetheless susceptible to small perturbations in certain directions. Such network attractors, which can be created at bifurcation from heteroclinic attractors, can provide a framework that explains how responses may be encoded and used and perform finite state computation, at least for artificial recurrent neural networks. This research is in collaboration with Claire Postlethwaite, Andrea Ceni and Lorenzo Livi.

On investigation of a dynamical thermoelastic piezoelectric model

Gia Avalishvili (I. Javakhishvili Tbilisi State University)
Co-authors: Mariam Avalishvili (University of Georgia, Tbilisi)

Tue 09 Jul
09:25
CT9
KO-3

The present paper is devoted to investigation of linear dynamical model of thermoelastic piezoelectric shell with variable thickness consisting of several inhomogeneous anisotropic thermoelastic piezoelectric layers with regard to magnetic field. In order to construct dynamical two-dimensional models variational formulation in curvilinear coordinates of the initial-boundary problem corresponding to the three-dimensional model of the shell is considered. Applying spectral approximation method a sequence of subspaces with special structure of the spaces corresponding to the three-dimensional problem is constructed and on these subspaces a hierarchy of dynamical two-dimensional models is obtained. The constructed two-dimensional initial-boundary value problems are investigated in suitable spaces of vector-valued distributions with respect to the time variable with values in the corresponding weighted Sobolev spaces. Moreover, it isproved that the sequence ofvector-functions of three space variables, constructed by means ofthe solutions of the two-dimensional problems, converges in the corresponding spaces to the exactsolution of the original three-dimensional problem and underadditional regularity conditions the rate of convergence isestimated. This work was supported by Shota Rustaveli National Science Foundation (SRNSF) [Grant Number 217596, Construction and investigation of hierarchical models for thermoelastic piezoelectric structures].

Variance continuity for Lorenz flows

Wael Bahsoun (Loughborough University)

Wed 10 Jul
09:45
MS15
KO-9

The classical Lorenz flow, and any flow which is close to it in the $C^{1+\alpha}$-topology, satisfies a Central Limit Theorem (CLT). We prove that the variance in the CLT varies continuously for this family of flows.

Large fronts in nonlocally coupled systems using Conley-Floer homology

Bente Hilde Bakker (Leiden University)
Co-authors: Jan Bouwe van den Berg (VU Amsterdam)

Wed 10 Jul
08:45
MS14
KO-5

This talk is on travelling front solutions for equations of the type

$$\partial_t u = N * S(u) + \nabla F(u), \qquad u(t,x) \in \mathbb{R}^d.$$

Here $N*$ denotes a convolution-type operator in the spatial variable x, either continuous or discrete. We develop a novel Morse-type theory, the Conley-Floer homology, which captures travelling front solutions in a topologically robust manner, by encoding fronts in the boundary operator of a chain complex. In various cases the resulting Conley-Floer homology can be interpreted as a homological Conley index for multivalued vector fields. Using the Conley-Floer homology existence and multiplicity results on travelling front solutions are derived.

High-dimensional Bayesian filtering with nonlinear local couplings

Thu 11 Jul
10:15
MS28
KO-12

Ricardo Baptista (MIT)
Co-authors: Alessio Spantini (MIT), Youssef Marzouk (MIT)

Ensemble Kalman Filters (EnKF) are a practical Bayesian filtering algorithm for systems with challenging nonlinear dynamics and high-dimensional states. While the EnKF yields robust ensemble approximations of the filtering distribution, it is limited by linear forecast to analysis transformations. To generalize the EnKF, we propose a methodology that transforms the non-Gaussian forecast ensemble at each assimilation step into samples from the current filtering distribution via a sequence of local nonlinear couplings. These couplings are based on transport maps that can be computed using fast convex optimization and can be enriched in complexity to reduce the intrinsic bias of the EnKF. In this presentation, we first analyze the low-dimensional structure inherited by the transport maps from the filtering problem, including decay of correlations, conditional independence, and local likelihoods. We then exploit this structure to regularize the estimation of the maps in high dimensions and with a limited ensemble size. The numerical performance of these algorithms will be presented in the context of chaotic dynamical systems (e.g., Lorenz 96).

Rigorous verification of wave stability

Mon 08 Jul
16:30
MS1
KO-4

Blake Barker (Brigham Young University)
Co-authors: Taylor Paskett (Brigham Young University), Kevin Zumbrun (Indiana University)

We discuss recent work regarding rigorous verification of stability properties of traveling waves. In particular, we describe our work developing computer assisted proof techniques to evaluate the Evans function in order to prove spectral stability of waves in the one-dimensional non-isentropic Navier-Stokes equations with an ideal, polytropic gas equation of state. For this system, spectral stability implies nonlinear stability. Proving spectral stability is the last piece of a program begun over 20 years ago for establishing the stability of traveling waves in this model. This is work with Taylor Paskett and Kevin Zumbrun.

Reduced normal form of the periodic Hamiltonian system

Tue 09 Jul
09:05
CT7
KO-1

Alexander Batkhin (Keldysh Institute of Applied Mathematics of RAS)
Co-authors: Alexander Bruno (Keldysh Institute of Applied Mathematics of RAS)

First we consider the linear periodic Hamiltonian systems. For them we find normal forms of Hamiltonian functions in both complex and real cases. The real case has a specificy. Then we find normal forms of the Hamiltonian functions for nonlinear periodic systems also in complex and real cases. By means of additional canonical transformation of coordinates, such system always is reduced to an autonomous Hamiltonian system, which preserves all small parameters and symmetries of the initial system. Its local families of stationary points correspond to families of periodic solutions of the initial system. All that concludes the study of the problem mentioned in the title and partially given in Ch. II of the book [1]. We consider a nontrivial example with two degrees of freedom [2]. [1] A.D. Bruno, The Restricted 3-Body Problem: Plane Periodic Orbits. Walter de Gruyter, Berlin-New York, 1994. 362 p. [2] A.D. Bruno, Normal form of the periodic Hamiltonian system with n degrees of freedom // Keldysh Institute Preprints. 2018. No. 117. 19 p. (Russian) Doi:10.20948/prepr-2018-223 URL: http://library.keldysh.ru/preprint.asp?id=2018-223

Bifurcations of families of doubly symmetric periodic solutions

Wed 10 Jul
10:15
MS27
KO-11

Alexander Batkhin (Keldysh Institute of Applied Mathematics of RAS)

We consider an autonomous Hamiltonian system with two degrees of freedom, which system of canonic equations is t-invariant under finite group of linear transformations with two generators. We investigate bifurcations of natural families of doubly symmetric periodic solutions of such Hamiltonian system with the help of its monodromy matrix. Considering a doubly symmetric periodic solution as a solution of the first genre by Poincare with period T and stability index $s = \cos(2\pi p/q)$, where both p, q are integers, we state that in vicinity of such solution there exists: (i) one doubly symmetric periodic solution of second genre with period equals qT if both $p, q \neq 1$ are odd; (ii) four singly symmetric periodic solutions of second genre with period qT if one of p or q is even. New families of symmetric periodic solutions of the planar Hill's problem are investigated with the help of obtained results.

Hypocoercive diffusions

Fabrice Baudoin (University of Connecticut)

Mon 08 Jul
14:00
MS32
KO-10

We will review some of the methods developed in the last few years to prove convergence to equilibrium for degenerate diffusion processes.

Spectral Stability and the Maslov Index

Margaret Beck (Boston University)

Wed 10 Jul
11:30
Plenary
HK

Understanding the spectral stability of solutions to partial differential equations is an important step in predicting long-time dynamics. Recently, it has been shown that a topological invariant known as the Maslov Index can play an important role in determining spectral stability for systems that have a symplectic structure. In this talk, the notions of spectral stability and the Maslov Index will be introduced and an overview of recent results will be given.

Space-Time Finite Elements for Level-Set-Based Flow Simulation

Marek Behr (RWTH Aachen University)
Co-authors: Violeta Karyofylli (RWTH Aachen University)

Mon 08 Jul
18:00
MS3
KO-5

Moving-boundary flow simulations are an important design and analysis tool in many areas, including civil and biomedical engineering, as well as production engineering. Interface-capturing offers flexibility for complex free-surface motion, while interface-tracking is very attractive due to its mass conservation properties at low resolution. We focus on these alternatives in the context of flow simulations based on stabilized finite element discretizations of Navier-Stokes equations, including space-time formulations that allow extra flexibility concerning grid design at the interface.

Space-time approaches offer some not-yet-fully-exploited advantages; among them, the potential to allow some degree of unstructured space-time meshing. A method for generating simplex space-time meshes has been developed, allowing arbitrary temporal refinement in selected portions of space-time slabs. The method increases the flexibility of space-time discretizations, even in the absence of dedicated space-time mesh generation tools. The resulting tetrahedral and pentatope meshes are being used in the context of cavity filling flow simulations, such as those necessary to design injection molding processes.

The authors gratefully acknowledge the support of the German Research Foundation (DFG) under programs SFB 1120 and GSC 111. The computations were conducted on computing clusters provided by the RWTH Aachen University IT Center and by the JÃijlich Aachen Research Alliance (JARA).

Homogenization of coupled transport processes in heterogeneous porous media

Michal Benes (Czech Technical University in Prague)

Thu 11 Jul
09:05
CT17
KO-2

In this contribution, we establish a homogenization result for a doubly nonlinear parabolic system arising from the hygro-thermo-chemical processes in porous media taking into account memory phenomena. We present a meso-scale model of the composite (heterogeneous) material, where each component is considered as a porous system and the voids of the skeleton are partially saturated with liquid water. Heat and moisture flow through the porous system is associated with a system of strongly coupled nonlinear partial differential equations coupled with an integral condition and physically relevant boundary and initial conditions. We prove the global existence of weak solutions and show that the solution of the meso-scale problem is two-scale convergent to that of the upscaled problem as the spatial scale parameter goes to zero.

Modulation stability for dispersive periodic waves

Tue 09 Jul
15:30
MS21
KO-12

Sylvie Benzoni-Gavage (Université Claude Bernard Lyon 1)
Co-authors: Luis Miguel Rodrigues (Université Rennes 1)

Dispersive hydrodynamics - basically modeled by higher order perturbations of standard, inviscid fluid equations - involves a wide range of periodic travelling waves. Various types of stability can be considered for those waves. Roughly speaking, modulation stability of a periodic wave amounts to requiring that small perturbations of its parameters over large scales do not destroy its structure. This notion was introduced by Whitham fifty years ago and has led to numerous studies in particular in the physics literature. Mathematical results regarding modulation stability are still rare though. The talk will present a few recent ones.

Trace process and metastability

Fri 12 Jul
10:15
MS19
KO-8

Nils Berglund (IDP, University of Orléans)
Co-authors: Manon Baudel (CERMICS, Ecole des Ponts)

The trace process associated with a subset A of the space of a Markov chain is the process monitored only when visiting A. I will show on a number of simple examples how this process is useful to uncover the metastable dynamics of chains in discrete or continuous space; in particular, how it allows to determine spectral properties, without having to assume reversibility. Joint work with Manon Baudel (CERMICS, Ecole des Ponts).

Reducing the impact of geometrical errors in flow computations by assimilation of velocity data

Fri 12 Jul
08:45
MS33
KO-4

Cristóbal Bertoglio (University of Groningen)
Co-authors: David Nolte (University of Groningen)

Numerical blood flow simulations are typically set up from anatomical medical images and calibrated using velocity measurements. However, the accuracy of the computational geometry itself is limited by the resolution of the anatomical image. We first show that applying standard no-slip boundary conditions on inaccurately extracted boundaries can cause large errors in the results, in particular the pressure gradient. In this talk, we therefore propose to augment the flow model calibration by slip/transpiration boundary conditions, whose parameters are then estimated using velocity measurements by means of the solution of an inverse problem. Numerical experiments show that this methodology can considerably improve the accuracy of the estimated pressure gradients and 3D velocity fields when the vessel geometry is uncertain.

Tears of Wine and Shock Dynamics

Fri 12 Jul
14:45
Plenary
HK

Andrea Bertozzi (University of California, Los Angeles)

We review the classical tears of wine problem which can result from a Marangoni stress causing wine to climb up the side of a wine glass seemingly against the force of gravity. This problem can be modeled by a nonlinear partial differential equation that includes the effects of the surface stress, gravity, and bulk surface tension. The model has been studied in thermally driven films but never before for the tears of wine problem. We present a scenario along with experimental results that suggest the tears of wine result from nonclassical shocks in which the characteristics pass through the shock resulting in disturbances creating tears flowing back down the side of the glass. We review the mathematical theory of undercompressive shocks in scalar conservation laws and how they relate to this well-known phenomenon.

Modulation equation for SPDEs in unbounded domains with coloured noise

Mon 08 Jul
17:00
MS10
KO-8

Luigi Amedeo Bianchi (Università degli Studi di Trento)
Co-authors: Dirk Blömker (Universität Augsburg)

In this talk, we present the approximation via modulation equations of SPDEs on unbounded domains with additive noise that is white in time and coloured in space. As a guiding example, we consider the stochastic Swift-Hohenberg equation on the real line. The spatial correlation of the noise is physically significant in this example, modelling the corresponding correlation of thermal oscillation in the heat source. We work on weighted spaces, in order to compensate for the unboundedness of solutions at infinity, and show error estimates for the approximation, considering the difference between the mild solutions of the Swift-Hohenberg equation and the mild formulation of the slow modulation of the amplitude.

Asynchronous phase oscillator networks

Mon 08 Jul
15:30
MS4
KO-6

Christian Bick (University of Exeter)

We will discuss some recent results on the network dynamics of oscillator networks which can decouple for some time as the dynamics evolve. Such dynamics arise are relevant for example for networks of neuronal oscillators with refractory periods and adaptive couplings. They also relate to the recently introduced framework of "asynchronous networks."

On the existence of an inertial manifold for a deconvolution model of the 2D mean Boussinesq equations

Mon 08 Jul
14:00
CT2
KO-2

Luca Bisconti (Department of Mathematics and Computer Science ”Ulisse Dini” (DIMAI), University of Florence)
Co-authors: Davide Catania (University of Brescia and eCampus University)

We show the existence of an inertial manifold (i.e. a globally invariant, exponentially attracting, finite-dimensional manifold) for the approximate deconvolution model of the 2D mean Boussinesq equations. This model is obtained by means of the Van Cittern approximate deconvolution operators, which is applied to the 2D filtered Boussinesq equations.

Synchronization of stochastic and random evolution equations

Fri 12 Jul
08:45
MS19
KO-8

Schmalfuss Björn (Jena)

tba

Approximate slow manifolds for SPDEs

Thu 11 Jul
17:30
MS19
KO-8

Dirk Blömker (Universität Augsburg)

We approximate the infinite dimensional stochastic dynamics of a stochastic partial differential equation by the motion along a finite dimensional slow manifold, which is not necessarily invariant for the deterministic dynamics.

Our main results are the derivation of an effective equation (given by a stochastic ordinary differential equations) on the slow manifold, and furthermore the stochastic stability of the manifold.

Applications are the multiple kink motion for the stochastic one-dimensional Cahn-Hilliard equation, the motion of a droplet along the boundary of the domain in the two- or three dimensional mass-conservative Allen-Cahn equation, and the motion of droplets in the stochastic Cahn-Hilliard equation.

Lagrangian chaos for models in fluid mechanics

Wed 10 Jul
08:45
MS15
KO-9

Alex Blumenthal (University of Maryland)
Co-authors: Jacob Bedrossian (University of Maryland), Samuel Punshon-Smith (Brown University)

In models of fluid mechanics, given a possibly time-varying, divergenceless vector field $u(x,t), x \in M, t \geq 0$, on a manifold M, the Lagrangian flow $\phi^t : M \to M$ on M is the flow generated by integrating along the streamlines of $u(x,t)$. Typically one assumes that $u(x,t)$ itself evolves according to one of the standard models of fluid mechanics, e.g., the Navier-Stokes equations.

It is anticipated that in many regimes (e.g., high Reynolds number, in the presence of suitably nondegenerate noise) that the dynamics of the Lagrangian flow ϕ^t should be chaotic in the sense of sensitivity with respect to initial conditions. I will present a recent joint work with Jacob Bedrossian and Sam Punshon-Smith in which we rigorously verify this chaotic property (a.k.a. the presence of a positive Lypaunov exponent) when u evolves according to various models in fluid mechanics, including stochastic Navier-Stokes on the 2D torus and stochastic hyperviscous Navier-Stokes on the 3D torus.

A consequence of our work is a rigorous verification of YaglomâĂŹs law, a scaling law for passive scalar advection analogous to the famous Kolmogorov 4/5 law for turbulence in the Naiver-Stokes equations.

Open problems in FDIS (discussion session)

Fri 12 Jul
10:15
MS13
KO-6

Alexey Bolsinov (Loughborough University)

TBA

Existence results for Sobolev type fractional differential equations with delay

Thu 11 Jul
08:45
CT16
KO-1

Swaroop Nandan Bora (Indian Institute of Technology Guwahati)
Co-authors: Bandita Roy (I I T Guwahati)

This work is devoted to the study of existence of mild solutions for a class of fractional differential equations of Sobolev type with delay. Here the results are established by means of fractional calculus and fixed point techniques.

Wave interaction with a semi-porous cylindrical storage tank

Tue 09 Jul
19:00
Poster
KO

Swaroop Nandan Bora (Indian Institute of Technology Guwahati)
Co-authors: Abhijit Sarkar (I I T Guwahati)

The current study deals with diffraction of linear waves around a cylindrical storage tank in finite depth, whose inner part contains a cylindrical pile and outer part contains a porous wall. The main aim is to construct a storage tank surrounding the cylindrical pile of the aerogenerators for aquaculture. The current projects includes a plan to integrate aquaculture around wind farm. The velocity potentials satisfy appropriate free surface condition, bottom boundary condition, matching conditions and Sommerfeld radiation condition at infinity. We use the method of separation of variables to obtain the analytical expressions for corresponding potentials in each flow region. Here we discuss two cases: the first one a thick porous wall and the second one a the thin porous wall. For the thick porous wall, we use Darcy's condition and for thin wall, Sollitt and Cross approach. By using matching conditions along the boundaries of the regions, a system of linear equations for the unknown coefficients is derived and solved. A set of values of hydrodynamic force and wave run-up are obtained for different radii, different drafts and different porosity of the cylinder. It is observed that change in values in radii, draft and porosity have significant effect on the hydrodynamic loads and wave run-up. It is found that for thin wall case, hydrodynamic force and wave run-up become more pronounced and effective than those for the thick wall case.

Stability Properties of Solitary Waves for a Generalized Fractional BBM Equation

Thu 11 Jul
09:05
CT16
KO-1

Handan Borluk (Ozyegin University)

Co-authors: Goksu Oruc (Istanbul Technical University), Gülçin M. Muslu (Istanbul Technical University)

The generalized fractional Benjamin-Bona-Mahony (gfBBM) equation is derived by Erbay et al. (Phys Lett A, 2015) to model the propagation of small amplitude long unidirectional waves in a nonlocally and nonlinearly elastic medium. The gfBBM equation includes two fractional terms; $D^{\alpha}u_x$ like in fKdV equation and $D^{\alpha}u_t$ like in fBBM equation. In this study, we obtain nonlinear stability and spectral instability results for the solitary wave solutions of the gfBBM equation.

Heat and Schroedinger evolution in almost-Riemannian geometry

Mon 08 Jul
16:30
MS32
KO-10

Ugo Boscain (CNRS, LJLL)

In this talk I will discuss the heat and Schroedinger evolution in almost-Riemannian geometry. An almost Riemannian manifold is a generalized Riemannian manifold in which the vectors of an orthonormal frame could become collinear. The simplest example is the Grushin plane. For the Schroedinger equation, different phenomena occur depending on the chosen quantization scheme.

Rare event and large deviation theory for climate and the solar system dynamics

Tue 09 Jul
15:30
MS30
KO-7

Freddy Bouchet (CNRS and ENS de Lyon)

This talk will address several recent applications of averaging, large deviation theory, and rare event algorithms to the dynamics of complex deterministic systems like climate or the solar system dynamics. On the theoretical side, I will introduce a new mathematical framework for dynamical systems for which the phase space structure is slowly changing over time. This is an unexplored situation that does not belong to the classical approaches of the averaging paradigm. On the numerical side, I will discuss the use or rare event algorithms. We will apply these tools to extreme heat waves in climate, and the probability of planet collision in planetary system dynamics.

Bramson delays in non-local KPP problems

Thu 11 Jul
08:45
MS5
KO-4

Emeric Bouin (CEREMADE - Université Paris-Dauphine)

We consider the non-local Fisher- KPP equation modeling a population with individuals competing with each other for resources with a strength related to their distance, and obtain the asymptotics for the position of the invasion front starting from a localized population. Depending on the behavior of the competition kernel at infinity, the location of the front is either as in the local case, or polynomial. This is a joint work with Christopher Henderson (U. Chicago) and Lenya Ryzhik (Stanford).

3D unsteady Navier-Stokes problem with memory and subdifferential boundary condition

Wed 10 Jul
08:45
CT15
KO-3

Mahdi Boukrouche (Lyon University, UJM, UMR-5208, ICJ)

We consider a mathematical model which describes the motion of a 3D unsteady fluid flow governed by Navier-Stokes system, and subjected to mixed boundary conditions with a given velocity on one part of the boundary and nonlinear slip conditions with a memory term reminiscent of Coulomb's friction law on the other part. We establish first some regularity properties and estimates for a simplified model. Then we prove the existence of a solution to our problem by using a successive approximation technique and compactness arguments based on Helly's theorem for the velocity field.

Accuracy of some approximate Gaussian filters for dissipative PDEs with spatially sparse nodal observations

Wed 10 Jul
09:15
MS28
KO-12

Michal Branicki (University of Edinburgh)

Key challenges in data assimilation for PDE driven dynamics stem from model error in the approximate finite-dimensional forward dynamics, as well as spatio-temporarily sparse observations. Two stochastically parameterised filtering algorithms are compared with 3DVAR - a prototypical time-sequential algorithm known to be accurate for filtering dissipative systems with a suitably inflated âĂŸbackgroundâĂŹ covariance when enough low Fourier modes are observed independently. We derive criteria for accuracy of 3DVAR estimates from spatially sparse observations which inevitably mix up the dynamics of low and high Fourier modes. Moreover, we provide the first evidence that the stochastically parameterised algorithms, which do not rely on detailed knowledge of the underlying dynamics and do not require covariance inflation, can compete with an optimally tuned 3DVAR algorithm, and they can overcome competing sources of error in a range of dynamical scenarios.

A computer-assisted study of the equilibria of a cross-diffusion system in population dynamics

Mon 08 Jul
17:00
MS1
KO-4

Maxime Breden (Technical University of Munich)
Co-authors: Roberto Castelli (VU Amsterdam)

Cross-diffusion is a mechanism that can be used in population dynamics to model a repulsive effect between individuals. Mathematically, this corresponds to adding a nonlinear diffusion term to classical reaction-diffusion systems. Cross-diffusion effects generate a rich variety of solutions, whose qualitative behavior seems to better fit observations (spatial segregation phenomenom), but it also complicates the mathematical study of these solutions.

In this talk, I will explain how this problem can be tackled by combining numerical simulations with a posteriori estimates, to obtain computer-assisted proofs. First, I will briefly present the general strategy behind this kind of computer-assisted techniques, namely to apply a fixed point theorem in a neighborhood of a numerical solution, which then yields the existence of a true solution. Then, I will illustrate how these techniques can be applied to study inhomogeneous steady states of the SKT triangular system:

$$\begin{cases} \dfrac{\partial u}{\partial t} = \Delta((d_1 + d_{12}v)u) + (r_1 - a_1 u - b_1 v)u \\ \dfrac{\partial v}{\partial t} = \Delta(d_2 v) + (r_2 - b_2 u - a_2 v)v, \end{cases}$$

This is the result of a joint work with R. Castelli (VU Amsterdam).

Existence of stationary fronts in a coupled system of two inhomogeneous sine-Gordon equations

Tue 09 Jul
10:15
MS9
KO-8

Jacob Brooks (University of Surrey)
Co-authors: Gianne Derks (University of Surrey), David Lloyd (University of Surrey)

In this talk we investigate the existence of stationary fronts in a coupled system of two sine-Gordon equations with a smooth, "hat-like" spatial inhomogeneity. The spatial inhomogeneity corresponds to a spatially dependent scaling of the sine-Gordon potential term. Numerically, we find the uncoupled inhomogeneous sine-Gordon equation has stable stationary fronts. These front solutions persist in the coupled system. Carrying out further numerical investigation it is found that stable fronts bifurcate from these inhomogeneous sine-Gordon fronts provided the coupling between the two inhomogeneous sine-Gordon equations is strong enough. In order to analytically study the emerging fronts, we first approximate the smooth spatial inhomogeneity by a piecewise constant function. With this approximation, we prove analytically the existence of a pitchfork bifurcation of the inhomogeneous sine-Gordon fronts. To complete the argument, we use geometric singular perturbation theory to prove transverse fronts for a piecewise constant inhomogeneity persist for the smooth "hat-like" spatial inhomogeneity.

Computation of Killing vector fields on compact manifolds

Tue 09 Jul
19:00
Poster
KO

Gaëlle Brunet (University of Eastern Finland)

Killing vector fields are important in differential geometry because their flows generate isometries on Riemannian manifolds. Equations for Killing fields is an overdetermined system of PDEs which can be hard to solve explicitly. This problem can be reduced to a symmetric eigenvalue problem where Killing fields are generated by the eigenvectors corresponding to zero eigenvalue. The method itself is valid in any dimension, but numerical results are computed only in two dimensional case. To solve numerically this problem we used finite element method. On a manifold one has to use in general several coordinate systems to describe the problem, and the technical difficulty is then how to patch these coordinate systems together. We propose to solve this eigenvalue problem on the sphere and the projective plane with several local coordinate systems. This method of constructing operators on manifolds can also be used to study other PDE systems.

Expansion of ODE solutions into transseries

Thu 11 Jul
16:50
CT19
KO-1

Alexander Bruno (Keldysh Institute of Applied Mathematics)

We consider a polynomial ODE of the order n in a neighbourhood of zero or of infinity of the independent variable. A method of calculation of its solutions in the form of power series and an exponential addition, which contains one more power series, was described. The exponential addition has an arbitrary constant, exists in some set E_1 of sectors of the complex plane and can be found from a solution to an ODE of the order $n-1$. An hierarchic sequence of such exponential additions is possible, that each of these exponential additions is defined from an ODE of a lower order $n-i$ and exists in its own set E_i. Here we must check the non-emptiness of intersection of the sets $E_1 \cap \ldots \cap E_i$. Each exponential addition continues into its own exponential expansion, containing countable set of power series. As a result we obtain an expansion of a solution into a transseries, containing countable set of power series, all of which are summable. The transseries describes families of solutions to the initial ODE in some set of sectors of the complex plane [1, 2]. [1] A.D. Bruno, Expansion of ODE solutions into transseries // Keldysh Institute Preprints. 2018. No. 117. 19 p. (Russian) Doi:10.20948/prepr-2018-117. URL: http://library.keldysh.ru/preprint.asp?id=2018-117 [2] A.D. Bruno, Expansion of solutions to an ordinary differential equation into transseries // Doklady Mathematics, 2019, Vol. 99, No. 1, pp. 1âĂŞ4.

Newest methods of celestial mechanics

Thu 11 Jul
08:45
MS27
KO-11

Alexander Bruno (Keldysh Institute of Applied Mathematics)

The last volume of the book âĂIJLes mÃľthods nouvelles de la Mecanique sÃľlestaâĂİ by H.PoincarÃľ was published 120 years ago. Since then, the following methods have arisen. 1. Method of normal forms, allowing to study regular perturbations near a stationary solution, near a periodic solution and so on. 2. Method of truncated systems, found with a help of the Newton polyhedrons, allowing to study singular perturbations. 3. Method of generating families of periodic solutions (regular and singular). 4. Method of generalized problems, allowing bodies with negative masses. 5. Computation of a net of families of periodic solutions as a âĂIJskeletonâĂİ of a part of the phase space.

Chaos in homeostatically regulated neural systems

Thu 11 Jul
09:15
MS26
KO-10

Sue Ann Campbell (University of Waterloo)

Co-authors: Wilten Nicola (Imperial College London), Peter John Hellyer (Imperial College London), Claudia Clopath (Imperial College London)

We consider a model for large scale neural network with homestatic regulation. The model consists of a network of Wilson-Cowan nodes, with connectivity derived from functional magnetic resonance imaging data, and weights dynamically modified due to the homeostatic regulation. We show that this system has a rich dynamical repertoire, including mixed-mode oscillations, mixed-mode chaos, and chaotic synchronization. We study the origin of this behaviour through analytical and numerical bifurcation analysis. Our analysis shows that the homeostatic regulation is a key factor in producing the complex dynamics.

Exponential quadrature rules without order reduction for integrating linear initial boundary value problems

Thu 11 Jul
09:25
CT18
KO-3

Begoña Cano (Universidad de Valladolid)

Co-authors: María Jesús Moreta (Universidad Complutense de Madrid)

In this presentation, a technique will be suggested to integrate linear initial boundary valueproblems with exponential quadrature rules in such a way that the order in time is as high as possible. Bounds for the error will be given both for the classical approach of integrating the problem firstly inspace and then in time and for doing it in the reverse order in a suitable manner. Time-dependentboundary conditions will be considered with both approaches. Numericalexperiments will be shown which corroborate that, for example, with the suggested technique, order 2sis obtained when choosing the s nodes of the Gaussian quadrature rule.

Spike-adding canard explosion of bursting oscillations in a class of square-wave bursters

Tue 09 Jul
08:45
MS8
KO-7

Paul Carter (University of Arizona)

In a class of Morris–Lecar–Terman-type square-wave bursting models with two fast variables and one slow variable, we examine a spike-adding bifurcation phenomenon whereby small amplitude canard cycles transition into large amplitude bursting oscillations along a single continuous branch in parameter space. We construct this transition rigorously using geometric singular perturbation theory; the continuous transition from canard cycles to N-spike bursting oscillations up to $N \sim \mathcal{O}(1/\epsilon)$ spikes occurs upon varying a single bifurcation parameter on an exponentially thin interval. Critical to understanding this transition are the existence of canard orbits as well as slow passage through a saddle homoclinic bifurcation.

Averaging and large deviations for SPDEs

Thu 11 Jul
18:00
MS19
KO-8

Sandra Cerrai (University of Maryland)

I will present some results about averaging and large deviations for stochastic partial differential equations and their interplay.

Dynamics of the second-order Kuramoto model on networks

Wed 10 Jul
09:15
MS5
KO-4

Hayato Chiba (Tohoku University)

The dynamics of a system of coupled phase oscillators defined on graphs with inertia is considered. The mechanism of a bifurcation will be revealed based on the generalized spectral theory.

Classification of Radial Solutions for gravitational O(3) gauge field model

Thu 11 Jul
16:30
CT22
KO-5

Nari Choi (Ewha Womans University)

Co-authors: Jongmin Han (Kyung Hee University)

In this talk, we will present an elliptic equation arising from the self-dual equations for the Maxwell $O(3)$ sigma model coupled with gravitation. We classify all radial solution for one singular source according to values of aN. There appear two constants: a positive parameter a representing a scaled gravitational constant and a nonnegative integer N representing the multiplicity of the singular source.

Dispersive Shock Waves in Granular Chains

Tue 09 Jul
17:30
MS11
KO-6

Christopher Chong (Bowdoin College)

Dispersive shock waves (DSWs), which connect states of different amplitude via an expanding wave train, are known to form in nonlinear dispersive media subjected to sharp changes in state. In this talk, DSWs in granular chains are explored. Various long-wave length approximations are used to describe the formation and structure of the DSWs. The analytical results are complemented by systematic numerical simulations and experiments.

Uniqueness of self-similar solutions obeying the problems of arbitrary discontinuity disintegration for the generalized Hopf equation

Fri 12 Jul
09:05
CT24
KO-2

Anna Chugaynova (Steklov Mathematical Institute of Russian Academy of Sciences)

Solutions of a problem about an arbitrary discontinuity disintegration for the generalized Hopf equation are under investigation. The solution is constructed from a sequence of the non-overturning Riemann waves and discontinuities having the stable stationary and non-stationary structure.The influence of small-scale effects of dissipation and dispersion are analyzed. Small-scale processes determine a discontinuity structure and a set of discontinuities with stationary structures. Among discontinuities with stationary structures there are special ones on which (in addition to relations following from conservation laws) some additional relations should be satisfied which follow from the requirement for the discontinuity structure to exist.The existence of special discontinuities leads to non-unique way to construct self-similarsolutions to the problem of arbitrary discontinuity disintegration.

SPDEs on domains with corner singularities

Thu 11 Jul
17:00
MS18
KO-7

Petru Cioica-Licht (Universität Duisburg-Essen)

Co-authors: Kyeong-Hun Kim (Korea University), Kijung Lee (Ajou University), Felix Lindner (Universität Kassel)

Although there exists an almost fully-fledged L_p-theory for (semi-)linear second order stochastic partial differential equations (SPDEs, for short) on smooth domains, very little is known about the regularity of these equations on non-smooth domains with corner singularities. As it is already known from the deterministic theory, corner singularities may have a negative effect on the regularity of the solution. For stochastic equations, this effect comes on top of the already known incompatibility of noise and boundary condition. In this talk I will show how a system of mixed weights consisting of appropriate powers of the distance to the vertexes and of the distance to the boundary may be used in order to deal with both sources of singularity and their interplay.

Deterministic and stochastic multiscale modeling for cell dynamics in developmental biology

Wed 10 Jul
08:45
MS24
KO-6

Frédérique Clément (INRIA)

Co-authors: Frédérique Robin (INRIA), Romain Yvinec (INRA), Marie Postel (Sorbonne-Université)

We will present middle-out, cell dynamics based modeling approaches for some developmental processes. The general underlying methodological framework is that of structured population dynamics, considered either from a deterministic viewpoint (non conservative transport equations) or a stochastic viewpoint (measure-valued population processes). We will focus on two biological applications: (i) oogenesis, the process of production and maturation of egg cells, which is intrinsically coupled with the growth and development of egg-surrounding somatic structures called ovarian follicles (folliculogenesis), and (ii) corticogenesis, the building-up of the cerebral cortex associated with the generation of neurons from progenitors cells. In addition to their own interest to investigate the variability of events occurring on the cell level (e.g. proliferation, death) or cell population levels (e.g. final cell pool size), stochastic formalisms can be required due either to intrinsic biological factors (when there are very few cells involved) or extrinsic factors (e.g. sampling induced by experimental protocols). The theoretical and numerical analysis of such multiscale dynamics raises several methodological issues. In particular, dealing with cell-to-cell or between cell populations interactions involve nonlinear and nonlocal terms entering the formulation of the velocity functions and boundary conditions in the deterministic case, or the process intensities in the stochastic case.

Understanding sensory induced hallucinations: from neural fields to amplitude equations

Tue 09 Jul
19:00
Poster
KO

Stephen Coombes (University of Nottingham)

Co-authors: Abigail Cocks (School of Mathematical Sciences, University of Nottingham, UK.), Alan Johnston (School of Psychology, University of Nottingham, UK.), Daniele Avitabile (School of Mathematical Sciences, University of Nottingham, UK.)

Explorations of visual hallucinations show that annular rings with a background flicker can induce visual hallucinations in humans that take the form of radial fan shapes and vice versa. The well-known retino-cortical map tells us that the corresponding patterns of neural activity in the primary visual cortex for rings and arms in the retina are orthogonal stripe patterns. The implication is that cortical forcing by spatially periodic input can excite orthogonal modes of neural activity. To understand this phenomenon we consider a simple planar neural field model, that supports a Turing instability to a spatially periodic pattern, and then include a further component of spatial drive. By utilising a weakly nonlinear multiple-scales analysis we determine the relevant amplitude equations for understanding pattern formation. These are found to be reminiscent of the Newell-Whitehead-Segel equations, generalised to include the effect of spatial periodic forcing. In turn we use these to uncover the parameter regimes which favour the excitation of patterns orthogonal to sensory drive, and thus shed light on psycho-physical observations.

Fluid-squeezing singularities for the free boundary Euler equations.

Thu 11 Jul
09:15
MS23
KO-8

Diego Cordoba (ICMat-CSIC)

I will discuss some recent results on stationary solutions with a splash singularity for the two-fluid Euler equations and the formation of squeezing singularities for the free boundary Euler equations.

Large-time behavior of the solution of the time-fractional heat equation

Tue 09 Jul
08:45
CT8
KO-2

Carmen Cortazar (P. Universidad Catolica de Chile)

Co-authors: Carmen Cortazar (P. Universidad Catolica de Chile), Fernando Quiros (Universidad Autonoma de Madrid), Noemi Wolanski (Universidad de Buenos Aires)

We study the asymptotic behavior as t goes to infinity of the solutions of

$$\partial_t^\alpha u = \Delta u \quad \text{in } \mathbb{R}^N \times \mathbb{R}_+, \qquad u(\cdot, 0) = u_0 \quad \text{in } \mathbb{R}^N$$

where $\partial_t^\alpha u$ is the Caputo α derivative.

Random evolution on combinatorial and metric graphs

Tue 09 Jul
17:30
MS6
KO-4

Francesca Cottini (University of Trento and University of Hagen)

We study linear evolution equations where the leading operator varies randomly in time as a stochastic process, taking values in a given set of operators. In particular, we analyze the heat equation on graphs âĂŞ both in the combinatorial and in the metric case âĂŞ which change their connectivity in time. If we study the heat diffusion on a fixed and connected graph G, it is well-known that the evolution semigroup converges to the projection onto the space of constant functions defined on G. Hence, given an initial distribution f, the solution of the system tends to the mean value of f on the graph for long times. Here, we investigate if the same holds when the system is no longer autonomous and deterministic. We start giving a set of graphs $\{G_1 \ldots, G_N\}$ and we consider a Markov chain $\{J_n\}_{n\geq 0}$ taking values in the set of graphs. Denoting by $A(G_i)$ the Laplace operator associated with the graph G_i, we present some random evolution models where the leading operator is given by $A(J_n)$ for all $n \leq t < n+1$. Therefore, we study diffusion systems where the graph changes at every integer time according to the Markov chain. We provide a new set of conditions such that the solution of these models still converges almost surely to the mean value of the initial datum, even if the graphs are not connected.

Convergence in HÃűlder and Sobolev norms for approximations of Gaussian fields

Fri 12 Jul
10:15
MS18
KO-7

Sonja Cox (University of Amsterdam)

Co-authors: Kristin Kirchner (ETH Zürich)

In models involving a Gaussian random field one frequently assumes the covariance operator to be given by a negative fractional power of a second-order elliptic differential operator of the form $L := -\nabla\cdot(A\nabla)+\kappa^2$. Whittle-MatÃľrn fields form an well-known example of such a model. Such covariance operators allow for a reasonable amount of model flexibility (adjustable correlation length and the smoothness of the field) whilst being relatively easy to simulate.In our work we established optimal strong convergence rates in HÃűlder and Sobolev norms for Galerkin approximations of such Gaussian random fields. More specifically, we considered both spectral Galerkin methods and finite element methods. The latter, although significantly more tedious to analyse, are more suitable for non-stationary fields on non-standard domains.The talk concerns joint work with Kristin Kirchner (ETHZ).

Seizure onset patterns are encoded by domino-like transient dynamics

Fri 12 Jul
09:15
MS25
KO-11

Jennifer Creaser (University of Exeter)

Co-authors: Congping Lin, (Huazhong University of Science and Technology), Thomas Ridler, Jonathan Brown, (Institute of Biomedical and Clinical Sciences, University of Exeter), Wendyl D'Souza, Udaya Seneviratne, Mark Cook, (Department of Medicine, University of Melbourne), John Terry, Krasimira Tsaneva-Atanasova, (Living System Institute, University of Exeter)

Around 1% of the worldsâĂŹ population are diagnosed with Epilepsy, a serious neurological condition in which people experience recurrent brain seizures. Current clinical classification of seizure types fails to account for the rich diversity of clinically and experimentally observed spatiotemporal patterns of seizure onset. Observing complex patterns of seizure onset in the clinic may lead to misdiagnosis or unnecessary invasive investigations. Improving diagnosis of epilepsy requires an advancement in the scientific classification of seizure types. We propose seizure onset to be the sequential âĂIJdomino-likeâĂİ recruitment of nodes within a network to an active state. We use a phenomenological network model in which each node has two stable states, quiescent and active (oscillatory). The transition between the two is driven by an external random 'noisy' input. The relationship between intrinsic node dynamics and coupling between nodes in the presence of noise is unknown. In this talk, we apply this modelling framework to clinical recordings from people with Idiopathic Generalised Epilepsy and show how different initiation patterns of paroxysms are the result of interplay between the heterogeneous node dynamics and the connectivity structure. We then apply the model to experimental data in which inhibitory coupling gradients are chemically modulated. We find that heterogeneous node dynamics are a key ingredient in creating diverse seizure onset patterns.

Data-driven predictions of dynamical systems in healthcare

Tue 09 Jul
19:00
Poster
KO

Nelida Črnjarić-Žic (University of Rijeka, Faculty of Engineering)

Co-authors: Senka Maćešić (University of Rijeka), Igor Mezić (University of California Santa Barbara)

The problem of prediction of behavior of dynamical systems has undergone a change in the second half of the 20th century with the discovery of the possibility of chaotic dynamics in simple dynamical systems. However, that approach does not account for another type of unpredictability: the "black swan" event. In our framework, the black-swan-type dynamics occurs when an underlying dynamical system becomes coupled to, or decoupled from, another one. Here we explore the problem of prediction in systems that exhibit such behavior. The mathematical theory and algorithms we use are based on an operator-theoretic approach in which the dynamics of the system are embedded into an infinite-dimensional space. We show that the framework correctly identifies a black swan event. Moreover, we show that the algorithms we developed enabled a successful prediction of the flu season, and prediction in other complex dynamics datasets such as physiology models.

Novel mesh free scheme for solving the inverse problem of heat conduction

Tue 09 Jul
19:00
Poster
KO

Jaydev Dabas (Indian Institute of Technology Roorkee)
Co-authors: Surbhi Arora (IIT Roorkee)

In this work, we introduce a novel mesh free technique based on the method of fundamental solutions (MFS) and the energy equation associated with the model, to optimize the location of source points. We implement the scheme for the inverse Cauchy problem of heat conduction and provide numerical results to establish the new scheme as a superior alternative to MFS.

Multifrequency coupling and partial synchronisation in encephalographic signals

Fri 12 Jul
08:45
MS25
KO-11

Andreas Daffertshofer (Vrije Universiteit Amsterdam)

Partial synchronisation is omnipresent in encephalographic data that arguably stem from the activity of oscillatory networks. This is particularly true if the data contain two or more distinct frequency ranges. To describe this, first bifurcations in a model of two or more coupled phase oscillator networks will be examined by sketching circumstances under which these coupled networks can be considered a single one with bi- or multimodal frequency distribution. When synchronisation does not fully develop, one may identify so-called chimera states, in which a population of oscillators splits into two parts, with one locked to identical phases while the other remains incoherent. The interaction between such parts or subpopulations can be quantified via their time-lagged mutual information. In general, mutual information resembles the capacity or the maximum rate at which information can be transferred to recover a senderâĂŹs information at the receiver with a vanishingly low error probability. Despite full symmetry in our model, the desynchronized subpopulation preceded the one in the synchronized subpopulation, seemingly driving it. As will be discussed, this intriguing finding may have major consequences for interpreting the change in encephalographic signals as typically observed in perceptual motor tasks.

The Kuramoto model with compact bimodal frequency distributions and first-order phase transitions

Mon 08 Jul
14:30
MS4
KO-6

Andreas Daffertshofer (Vrije Universiteit Amsterdam)
Co-authors: Bastian Pietras (TU Berlin), Nicolás Deschle (Vrije Universiteit Amsterdam)

Complex oscillatory networks can exhibit first-order phase transitions when the distribution of the natural frequencies over nodes has a finite flat region at its maximum. First-order phase transitions including hysteresis and bistability are also present if the frequency distribution of a single network is bimodal. The interplay between these two configurations will be discussed by analysing the Kuramoto model of phase oscillators with compact bimodal frequency distributions in the continuum limit. The full bifurcation diagram for the system's order parameter dynamics can be derived by combining Kuramoto's self-consistency approach, Crawford's symmetry considerations, and the Ott-Antonsen ansatz applied to a family of rational distribution functions that converge towards the compact distribution. As will be shown, the route to synchronization always passes through a standing wave regime when the bimodal distribution is compounded by two unimodal distributions with compact support. This is in contrast to a possible transition across a region of bistability when the two compounding unimodal distributions have infinite support.

On the continuation of degenerate periodic orbits in nearly integrable Hamiltonian systems: normal form approach and possible applications

Tue 09 Jul
19:00
Poster
KO

Veronica Danesi (University of Milan)

We reconsider the classical problem of the continuation of degenerate periodic orbits in nearly integrable Hamiltonian systems. In particular we focus on periodic orbits that arise from the breaking of a completely resonant maximal torus. We propose a suitable normal form construction that allows to identify and approximate the periodic orbits which survive to the breaking of the resonant torus. Our algorithm allows to treat the continuation of approximate orbits which are at leading order degenerate, hence not covered by the classical averaging methods. The extension to the case of low dimensional tori will be also commented, together with connections with the problem of spatially localized solutions in Hamiltonian lattices.

Quantitative rate of convergence for the surface tension of the grad phi model

Thu 11 Jul
17:00
MS20
KO-9

Paul Dario (ENS Paris and Universite Paris Dauphine)

We consider the standard grad phi model. It is known that the finite volume surface tension of this model converges to a limit called the surface tension. The argument uses subadditivity and is thus qualitative. The goal of this talk is to show how one can use the tools developed in the theory of stochastic homogenization to quantify this rate of convergence. The analysis relies on the study of dual subadditive quantities, a variational formulation for the surface tension and tools from the theory of optimal transport.

Computational topology and the study of changing patterns in coupled-patch population models

Tue 09 Jul
09:45
MS29
KO-6

Sarah Day (William & Mary)

Co-authors: Laura Storch (William & Mary)

The prediction of critical transitions, such as extinction events, is vitally important to preserving vulnerable populations in the face of a rapidly changing climate and continuously increasing human resource usage. Predicting such events in spatially distributed populations is challenging because of the high dimensionality of the system and the complexity of the system dynamics. Here, we use computational topology to measure spatial features of population patterns and use these measurements to study pattern shifts as the system undergoes critical changes, including extinction events. We demonstrate this approach using simulations of a coupled-patch model. Additional applications of this technique include analysis of spatial data (e.g., GIS) and model validation.

Sofic shifts via Conley index theory: computing lower bounds on recurrent dynamics for maps

Mon 08 Jul
15:00
MS1
KO-4

Sarah Day (William & Mary)

Co-authors: Rafael Frongillo (University of Colorado, Boulder)

Recent work has demonstrated the effectiveness of computational Conley index techniques in extracting dynamics from discrete-time systems governed by maps. I will discuss an automated approach that builds on earlier work and uses Conley index information to construct sofic shifts that are topologically semi-conjugate to the system under study. This allows for the uncovering and recording of increasingly complicated dynamics in chaotic systems. As illustration, we present results for the two-dimensional Henon map and the infinite-dimensional Kot-Schaffer map.

Progress in the study of canards through folded nodes

Tue 09 Jul
09:45
MS8
KO-7

Peter De Maesschalck (Hasselt University)

TBA

Dynamics in reaction-diffusion systems near the Eckhaus boundary

Tue 09 Jul
16:00
MS9
KO-8

Björn de Rijk (University of Stuttgart)

Co-authors: Guido Schneider (University of Stuttgart), Tobias Haas (University of Stuttgart)

In nonlinear reaction-diffusion systems the process of pattern formation is initiated when a trivial ground state loses its stability as a system parameter crosses through a critical value and a family of stable, spatially periodic patterns emerges from the ground state. Upon altering the system parameter further, the periodic patterns might destabilize leading to the formation of more complicated structures. Thus, periodic patterns serve as a bridge between trivial and more complex dynamics. Although the onset of pattern formation from the ground state is well-understood, there is less mathematical insight into the transition of periodic patterns into more complicated structures. In this talk I focus on the dynamics at the so-called Eckhaus boundary, which is the region in (parameter, wavenumber)-space at which periodic patterns lose their stability. Depending on the type of destabilization at the Eckhaus boundary different amplitude equations can be derived (and rigorously verified) describing the dynamics of the destabilized periodic pattern. Technically closely related is the issue of nonlinear stability of the periodic patterns at the Eckhaus boundary. For destabilizations of Hopf type a key observation is that different critical modes exhibit different group velocities. In order to exploit this difference in velocities we developed nonlinear iteration schemes that track spatio-temporal dynamics in different co-moving frames.

Pseudospectral approximation of the Hopf bifurcation for delay differential equations

Thu 11 Jul
18:10
CT21
KO-3

Babette de Wolff (Freie Universität Berlin)

Co-authors: Odo Diekmann (Utrecht University), Francesca Scarabel (York University), Sjoerd Verduyn Lunel (Utrecht University)

Pseudospectral approximation for delay differential equations was introduced in 2005 by Breda et al. as a tool to approximate eigenvalues of delay equations by eigenvalues of ordinary differential equations. The pseudospectral approximation technique has been proposed as a method for numerical bifurcation analysis, because of the specific structure of the approximating ODEs. In this talk, we will discuss how the pseudospectral approximation can be used as a numerical tool for the Hopf bifurcation: we analytically study convergence of the Lyaponov coefficient and look at some case studies.This is joint work with Odo Diekmann, Francesca Scarabel and Sjoerd Verduyn Lunel.

Gluing methods for Vortex dynamics in Euler flows

Mon 08 Jul
10:00
Plenary
HK

Manuel del Pino (University of Bath)

We consider the two-dimensional Euler flow for an incompressible fluid confined to a smooth domain. We construct smooth solutions with concentrated vorticities around points which evolve according to the Hamiltonian system for the Kirkhoff-Routh energy. The profile around each point resembles a scaled finite mass solution of Liouville's equation. We discuss extensions of this analysis to the case of vortex filaments in 3-dimensional space, along the lines of Da Rios 1904 vortex filament conjecture in connection with the binormal flow of curves.

Infinite time singularity formation for the Keller-Segel system

Tue 09 Jul
08:45
MS7
KO-5

Manuel del Pino (University of Bath)

The classical model for chemotaxis is the planar Keller-Segel system

$$u_t = \Delta u - \nabla \cdot (u \nabla v), \quad v(\cdot, t) = \frac{1}{2\pi} \log 1|\cdot| * u(\cdot, t).$$

in $\mathbb{R}^2 \times (0, \infty)$. Blow-up of finite mass solution is expected to take place by aggregation, which is a concentration of bubbling type, common to many geometric flows. We build with precise profiles solutions in the critical-mass case 8π, in which blow-up in infinite time takes place. We establish stability of the phenomenon detected under arbitrary mass-preserving small perturbations.

Gibbs-Non-Gibbs Transitions Under Stochastic Dynamics

Tue 09 Jul
15:30
MS34
KO-11

Frank den Hollander (Mathematical Institute, Leiden University)

Interacting particle systems may exhibit transitions from Gibbs to non-Gibbs under a stochastic dynamics. Consider, for instance, a system of Ising spins on an infinite lattice that are subjected to a stochastic spin-flip dynamics. The initial distribution of the spins is chosen according to a Gibbs measure, i.e., a probability measure described by a locally summable interaction Hamiltonian at a given temperature. It turns out that the time-evolved distribution may loose the Gibbs property, i.e, after a finite time it can no longer be described by any (!) locally summable Hamiltonian at any (!) temperature. Interestingly, in some situations the time-evolved distribution may recover the Gibbs property at later times. A satisfactory explanation of why the dynamics may move the interacting particle system in and out of the set of Gibbs measures is still missing. The crossover is related to a ‘nature versus nurtureâĂŹ transition: for small times large deviations of the system are dominated by the initial Gibbs measure, while for large times they are dominated by the dynamics. The crossover from Gibbs to non-Gibbs is related to a bifurcation of the dynamical rate function describing the large deviations of past trajectories conditional on the present state.In this talk we give a brief historical overview of the Gibbs-non-Gibbs phenomenon and point to some key open problems. The follow-up talk by Frank Redig will address recent developments.

Problems with the Semiclassical Approximation in Quantum Geometrodynamics

Fri 12 Jul
09:45
MS31
KO-12

Maaneli Derakhshani (Universiteit Utrecht)

Proponents of quantum geometrodynamics claim that the âĂIJsemiclassical approximationâĂİ to the Wheeler-DeWitt equation circumvents the Problem of Time and the Hilbert Space Problem, and makes possible an Everettian theory of canonical quantum gravity [1, 2, 3]. I will show that this claim is false, first by explaining the Problem of Time and the Hilbert Space Problem, and then showing that: (1) for a pure state corresponding to a superposition of semiclassical Wheeler-DeWitt wave functionals, such as the Hartle-Hawking wave functional, it is not possible to recover independent functional Schroedinger equations for the matter components of the superposition state, nor can the semiclassical Einstein equations be recovered (as they can from a single semiclassical wave functional); (2) the associated reduced density matrix for the 3-geometry is mathematically undefinable because of the Hilbert Space Problem; (3) even if said reduced density matrix was mathematically definable, no decoherence mechanism exists to approximately diagonalize the reduced density matrix in the 3-geometry basis; and (4) as a consequence of (1)-(3), the semiclassical approximation to the Wheeler-DeWitt equation doesnâĂŹt circumvent the Problem of Time or the Hilbert Space Problem, and doesnâĂŹt make possible an Everettian theory of canonical quantum gravity. [1] C. Kiefer : Quantum Gravity, third edition. (Oxford University Press,Oxford), 2012.

Unimodular Bohmian Geometrodynamics

Fri 12 Jul
08:45
CT23
KO-1

Maaneli Derakhshani (Universiteit Utrecht)

Quantum geometrodynamics (QGD) suffers from three interrelated problems [1, 2]: 1) the Problem of Time, 2) the Hilbert Space Problem, and 3) the Problem of No Outside Observers. I will show that the "unimodular" formulation of geometrodynamics can be combined with the Bohmian approach to quantum theory to yield unimodular Bohmian geometrodynamics (UBGD), and I will argue that this formally solves problems 1)-3) without relying on the problematic "semiclassical approximation" (discussed in my other talk). In addition I will show that UBGD avoids the criticisms raised by Kuchar [3] against unimodular quantum gravity based on orthodox quantum theory (as proposed by Unruh and Wald [4]). Finally I will suggest future avenues of research for UBGD.[1] C. Kiefer (2012). Quantum Gravity: Third edition, OUP.[2] W. Struyve and N. Pinto-Neto (2018). Bohmian quantum gravity and cosmology. In âĂİApplied Bohmian Mechanics: From Nanoscale Systems to CosmologyâĂİ, edited by Xavier Oriols Pladevall and JordiMompart. https://arxiv.org/abs/1801.03353[3] K. V. Kuchar (1991). Does an unspecified cosmological constant solve the problem of time in quantum gravity? Phys. Rev. D 43, 10, 3332.[4] W. G. Unruh and R. M. Wald (1989). Time and the interpretation of canonical quantum gravity. Phys. Rev. D 40, 8, 2598.

One-dimensional periodic solutions in a three-component reaction-diffusion system

Mon 08 Jul
15:00
MS35
KO-12

Gianne Derks (University of Surrey)

Co-authors: Peter van Heijster (Queensland University of Technology), David Lloyd (University of Surrey)

Periodic patterns occur ubiquitously in nature, but the mechanism behind the formation of periodic patterns away from onset is not well understood. In this talk we consider the mechanism behind the generation of periodic stationary solutions in a singularly perturbed reaction-diffusion system. The system has one fast nonlinear component, interacting with two slow components. We investigate the existence and bifurcations of families of one-dimensional periodic solutions in this system. It will be shown how changes in the slow manifold and changes in the fast dynamics lead to an intriguing sequence of self-replicating patterns of large amplitude periodic waves. We will conclude this talk with a discussion about extensions to two-dimensional patterns and travelling waves.

Synchronization in feed-forward networks

Mon 08 Jul
15:00
MS4
KO-6

Ana Dias (University of Porto)

Co-authors: Manuela Aguiar (University of Porto), Flora Ferreira (Porto), Michael Field (Rice University, Houston)

Patterns of synchrony of weighed networks can be described in a similar way as in the coupled cell networks formalism of Golubitsky, Stewart and collaborators. In this talk, we characterize the synchrony patterns of feed-forward networks, and we show how the addition of feedback loops to a feed-forward network can enrich the synchrony structure. One of the results, for identical cell networks with additive input structure and feedback from the final to the initial layer of the network, shows that periodic synchrony patterns can occur.

Twin semigroups and pseudospectral approximation

Tue 09 Jul
08:45
MS17
KO-10

Odo Diekmann (Utrecht University)

A delay equation is a rule for extending a function of time towards the future on the basis of the (assumed to be) known past. By translation along the extended function one defines a dynamical system. In the standard theory, the fundamental solution does not 'live' in the state space. Twin semigroup theory (developed in joint work with Sjoerd Verduyn Lunel) serves to eliminate this anomaly. It employs the Pettis integral developed by Kunze in the context of a norming dual pair of spaces. Pseudospectral approximation involves ODE systems that mimick the 'rule for extension + translation' structure of delay equations. It allows to use ODE numerical bifurcation tools to investigate the dynamics of general delay equations (joint work with Rossana Vermiglio, Dimitri Breda, Francesca Scarabel and others).

High frequency instabilities in the unsteady Interactive Boundary Layer model

Tue 09 Jul
09:15
MS21
KO-12

Helge Dietert (IMJ-PRG Paris, CNRS)

Co-authors: Anne-Laure Dalibard (Université Pierre et Marie Curie), David Gérard-Varet (Univserité Paris Diderot), Frédéric Marbach (CNRS)

The interactive boundary layer model is a famous extension of the Prandtl model for the behaviour of boundary layers in fluids. The talk will explain the classification of the high-frequency instabilities around shear-flows: depending on the background profile, there can be instabilities induced by the inviscid behaviour. Using a Penrose criterion like argument, the existence of unstable modes can be explicitly characterised by the background profile.

Global existence and stability for dissipative processes coupled across volume and surface

Karoline Disser (TU Darmstadt and WIAS Berlin)

Thu 11 Jul
17:30
MS22
KO-10

The dynamics of processes coupled across volume and surface domains has recently been systematically modelled using gradient structures. The aim of this talk is to analyze a typical dissipative class of these models and show global well-posedness. The dynamics can be highly nonlinear but the structure of the coupling preserves L^∞-bounds. To show not only existence but also stability based on L^∞-bounds, we use a functional analytic framework based on the isomorphism property of second-order divergence-form operators in $W^{-1,q}$ for $q > d$ larger than the spatial dimension d of the volume domain.

Pulse solutions for an extended Klausmeier model with spatially varying coefficients

Arjen Doelman (Universiteit Leiden)

Co-authors: Robbin Bastiaansen (Universiteit Leiden), Martina Chirilus-Bruckner (Universiteit Leiden)

Mon 08 Jul
14:00
MS35
KO-12

Motivated by its application in ecology, we consider in this talk an extended Klausmeier model – a singularly perturbed reaction-advection-diffusion equation with spatially varying coefficients. We establish the existence of stationary pulse solutions by blending techniques from geometric singular perturbation theory with bounds derived from the theory of exponential dichotomies. Moreover, the spectral stability of these solutions is determined, using similar methods. It is found that, due to the break-down of translation invariance, the presence of spatially varying terms can stabilize or destabilize a pulse solution. In particular, we show that this leads to the discovery of a pitchfork bifurcation and the existence of stationary multi-pulse solutions.

Coupled Mode Equations and Solitary Waves for Periodic Structures in d Dimensions

Tomas Dohnal (Martin Luther University Halle-Wittenberg)

Co-authors: Lisa Wahlers (Technische Universität Dortmund)

Fri 12 Jul
08:45
MS2
KO-5

In nonlinear periodic media of arbitrary dimension d we consider the small amplitude asymptotics of wavepackets. The wavepackets have several (N) carrier Bloch waves of equal frequency. We use the cubic Gross-Pitaevskii equation as a prototype of the governing equation. The asymptotic scaling leads to first order coupled mode equations (CMEs) as amplitude equations. In the well understood one dimensional case the coupling of counter-propagating Bloch waves leads to CMEs which support a family of solitary waves parametrized by the velocity $v \in (-1, 1)$. Can this be generalized to d dimensions such that in the CMEs a solitary wave family parametrized by $\vec{v} \in (-1, 1)^d$ exists? Solitary waves are typically found in spectral gaps. For $d \geq 2$ and $N \geq 4$ we prove the existence of standing solitary waves of CMEs. In the classical moving frame ansatz the spectral gap closes for $d \geq 2$. Hence, we have not been able to find moving solitary waves. We also provide a proof of the validity of the $d-$dimensional CME-asymptotics over asymptotically large time intervals.

On periodic boundary value problem for certain planar systems of nonlinear ordinary differential equations

Tue 09 Jul
15:50
CT12
KO-3

Matej Dolník (Brno University of Technology)

On an interval $[0, \omega]$ consider the system

$$u_1' = p_1(t)|u_2|^{\lambda_1}\mathrm{sgn}u_2 + q_1(t), \quad u_2' = p_2(t)|u_1|^{\lambda_2}\mathrm{sgn}u_1 + q_2(t) \tag{1}$$

subject to boundary conditions

$$u_1(0) = u_1(\omega) + c_1, \quad u_2(0) = u_2(\omega) + c_2. \tag{2}$$

Here we suppose that $p_i, q_i \in L([0, \omega])$, $c_i \in \mathbb{R}$, $i = 1, 2$ and

$$\lambda_1 > 0, \qquad \lambda_1\lambda_2 = 1.$$

We will discuss the problem of existence and uniqueness of problem (1), (2). Obtained result will be concretized for special case of the system (1) - so called one-dimensional λ-Laplacian:

$$(\Phi_\lambda(u'))' = p(t)\Phi_\lambda(u) + q(t), \qquad (1)$$

where $p, q \in L([0, \omega])$, $\lambda > 0$ and $\Phi_\lambda(x) := |x|^\lambda\mathrm{sgn}x$ for $x \in \mathbb{R}$.

Ground state solutions to nonlinear equations with p-Laplacian

Mon 08 Jul
15:30
MS16
KO-9

Zuzana Došlá (Masaryk University)
Co-authors: Serena Matucci (University of Florence)

The existence of positive radial solutions is investigated for a nonlinear elliptic equation with p-Laplace operator and sign-changing weight, both in superlinear and sublinear case. We prove the existence of solutions which are globally defined and positive outside of a ball and tend to zero at infinity.

Finite amplitude stability of internal steady flows of the Giesekus viscoelastic rate-type fluid

Fri 12 Jul
09:05
CT25
KO-3

Mark Dostalík (Charles University)
Co-authors: Vít Průša (Charles University), Karel Tůma (Charles University)

We investigate the finite amplitude stability of internal steady flows of viscoelastic fluids described by the Giesekus model. The flow stability is investigated using a Lyapunov functional that is constructed on the basis of thermodynamical arguments. Using the functional, we derive bounds on the Reynolds and Weissenberg number that guarantee the unconditional asymptotic stability of the corresponding flow. Further, the functional allows one to explicitly analyse the role of elasticity in the onset of instability, which is a problem related to the elastic turbulence. The application of the theoretical results is documented in the finite amplitude stability analysis of TaylorâĂŞCouette flow of the Giesekus fluid.

Smooth linearization of nonautonomous systems with a nonuniform dichotomy

Thu 11 Jul
16:30
CT20
KO-2

Davor Dragicevic (Department of Mathematics, University of Rijeka)

I will present some recent results that give sufficient conditions for the smoothness of conjugacies in the nonautonomous versions of the Grobman-Hartman theorem.

Limit laws for random hyperbolic dynamical systems

Thu 11 Jul
09:15
MS15
KO-9

Davor Dragicevic (Department of Mathematics, University of Rijeka)

I plan to discuss some recent result concerned with the statistical properties of random dynamical systems with some degree of uniform hyperbolicity.

1-D flow of a p-th power viscous micropolar and heat-conducting fluid

Tue 09 Jul
19:00
Poster
KO

Ivan Dražić (University of Rijeka, Faculty of Engineering)

In this work we consider the nonstationary one-dimensional flow of of a p-th power viscous micropolar and heat-conducting fluid, ie the fluid with the pressure defined by

$$p = \rho^p \theta,$$

where ρ is mass density, θ is temperature and $p \geq 1$ is the pressure exponent. The mathematical model is derived in the Lagrangian description.

We form the corresponding initial-boundary problem with homogeneous boundary conditions for velocity, microrotation and heat flux, as well as with smooth enough initial conditions, whereby we assume that initial density and initial temperature are strictly positive functions. Using the Faedo-Galerkin method we introduce a system of approximate equations and construct its solutions.

Understanding Bacterial Cheating: Biological and Practical Implications

Fri 12 Jul
09:45
CT23
KO-1

Fatima Drubi (University of Oviedo)
Co-authors: Alfonso Ruiz-Herrera (University of Oviedo)

We study the population dynamics of two strains of bacteria that compete for a limited nutrient during the course of an antibiotic treatment. One strain is resistant to the antibiotic, but the other is sensitive and acts as a cheater. The antibiotic action on the bacteria population consists of periodic doses at discrete times where the duration of a dose is generally rather brief in comparison to the time between two consecutive doses. Thus, the antibiotic amount in the medium is modeled with an impulsive differential equation. We show [1] that the dynamical behavior of the bacteria community is essentially coded by the system without antibiotic intervention, providing new biological mechanisms for the creation of population oscillations and bi-stability scenarios. These results complement some recent experimental work [2, 3]. We also analyze the biological influence on the bacteria of the usual variables associated with any antibiotic treatment. Our results strengthen the idea that bacteria cheating is a source of new and paradoxical phenomena. References: [1] Drubi F, Ruiz-Herrera A. Understanding bacterial cheating: Biological and practical implications. Accepted SIADS (2019) [2] Yurtsev EA, Chao HX, Datta MS, Artemova T, Gore J. Bacterial cheating drives the population dynamics of cooperative antibiotic resistance plasmids. Molecular Systems Biology 9 (2013) [3] Yurtsev EA, Conwill A, Gore J. Oscillatory dynamics in a bacterial cross-protection mutualism. PNAS 116 (2016)

The Fisher-KPP equation over simple graphs: Varied persistence states in river systems

Tue 09 Jul
09:05
CT8
KO-2

Yihong Du (University of New England)

We study the spreading of a new species in a river metwork with two or three branches via the Fisher-KPP advection-diffusion equation over some simple graphs with every edge a half infinite line. A rather complete description of the long-time dynamical behavior for every case under consideration is obtained, which can loosely described by a trichotomy, including two different kinds of persistence states as parameters vary. The phenomenon of "persistence below carrying capacity" revealed here appears to be new.

Bayesian approach to elliptic inverse problems

Thu 11 Jul
09:45
MS28
KO-12

Svetlana Dubinkina (CWI)

Predicting the amount of gas or oil extracted from a subsurface reservoir depends on the soil properties such as porosity and permeability. These properties, however, are highly uncertain due to the lack of measurements. Therefore decreasing these uncertainties is of a great importance. Mathematically speaking, permeability can be represented by a random process, which in turn leads to a random partial differential equation. The solution of such a partial differential equation, for example pressure, is only partially observed and, moreover, contaminated with measurement errors. Therefore, instead of a well-posed forward problem of finding pressure from certain permeability, we are faced with an ill-posed inverse problem of finding uncertain random process from a few pressure measurements. We develop a Bayesian method for inverse problems, that is both general and computationally affordable.

Long-time homogenization of wave equations

Fri 12 Jul
08:45
MS20
KO-9

Mitia Duerinckx (ENS de Lyon)

In this talk, we will discuss and revisit some new results on long-time homogenization of linear wave equations.

Validity of the Nonlinear SchrÃűdinger Approximation for the Two-Dimensional Water Wave Problem With and Without Surface Tension

Mon 08 Jul
14:30
MS10
KO-8

Wolf-Patrick Düll (Universität Stuttgart)

We consider the two-dimensional water wave problem in an infinitely long canal of finite depth both with and without surface tension. In order to describe the evolution of the envelopes of small oscillating wave packet-like solutions to this problem the Nonlinear SchrÃűdinger equation can be derived as a formal approximation equation. In recent years, the validity of this approximation has been proven by several authors only for the case without surface tension. In this talk, we present the rigorous justification of the Nonlinear SchrÃűdinger approximation for the cases with and without surface tension by error estimates over a physically relevant timespan in the arc length formulation of the two-dimensional water wave problem. The error estimates are uniform with respect to the strength of the surface tension, as the height of the wave packet and the surface tension go to zero.

Symplectic Invariants in Integrable Hamiltonian Systems

Fri 12 Jul
09:45
MS13
KO-6

Holger Dullin (University of Sydney)

I will describe symplectic invariants in semitoric and more general integrable Hamiltonian Systems and their calculation. Toric system are classified by Delzants polygon invariant alone, while semitoric system have additional invariants. When leaving the semitoric category at least semi-globally the invariants of hyperbolic-hyperbolic points are also known. The notoriously difficult computation of the so called Taylor-Series invariant leads to the study of singular Abelian integrals and their associated Picard-Fuchs equations, which I will discuss in some examples.

On the periodic solutions to a highly nonlinear shallow water equation

Mon 08 Jul
16:50
CT5
KO-2

Nilay Duruk Mutlubas (Sabancı University)
Co-authors: Anna Geyer (Delft University of Technology), Ronald Quirchmayr (KTH Royal Institute of Technology)

A shallow water wave model equation has been proposed recently for waves of large amplitude as follows (Quirchmayr R., Journal of Evolution Equations 16(3), 539-567, 2016):

$$\begin{aligned} &u_t + u_x + \frac{3\varepsilon}{2} u u_x - \frac{\delta^2}{18}(4u_{xxx} + 7u_{xxt}) \\ &= \frac{\varepsilon\delta^2}{6}\Big(2u_x u_{xx} + u u_{xxx}\Big) - \frac{\varepsilon^2\delta^2}{96}\Big(398 u u_x u_{xx} + 45u^2 u_{xxx} + 154u_x^3\Big) \end{aligned}$$

. Here, ε and δ are the dimensionless amplitude and shallowness parameters, respectively. We give the local well-posedness results for the solutions to the corresponding Cauchy problem on the circle followed by observations on the regularity of the solutions.

Bifurcations and Monodromy of the Axially Symmetric 1:1:-2 Resonance

Thu 11 Jul
17:30
MS13
KO-6

Konstantinos Efstathiou (University of Groningen)

We consider integrable Hamiltonian systems in three degrees of freedom near an elliptic equilibrium in 1:1:−2 resonance. The integrability originates from averaging along the periodic motion of the quadratic part and an imposed rotational symmetry about the vertical axis. Introducing a detuning parameter we find a rich bifurcation diagram, containing three families of Hamiltonian Hopf bifurcations that join at the origin. We describe the monodromy of the resulting ramified 3âĂŞtorus bundle as variation of the detuning parameter lets the system pass through the 1:1:−2 resonance. âĂŤ Based on joint work with Heinz HanÃ§mann and Antonella Marchesiello.

How does nonlocal dispersal affect dryland vegetation patterns?

Thu 11 Jul
10:15
MS5
KO-4

Lukas Eigentler (Heriot-Watt University & The University of Edinburgh)
Co-authors: Jonathan A. Sherratt (Heriot-Watt University)

Vegetation patterns are a ubiquitous feature of semi-arid regions. On hillsides these patterns occur as stripes running parallel to the contours. The Klausmeier model, a coupled reaction-advection-diffusion system, is a deliberately simple model describing the phenomenon. To account for the possibility of long-range dispersal of seeds, we replace the diffusion term describing plant dispersal by a more realistic nonlocal convolution of the plant density with a probability distribution.

Our analysis focuses on the rainfall level at which there is a transition between uniform vegetation and pattern formation. We obtain results, valid to leading order in the large parameter comparing the rate of water flow downhill to the rate of plant dispersal, for a negative exponential dispersal kernel. Results indicate that both a wider dispersal of seeds and an increase in dispersal rate inhibit the formation of patterns. Assuming an evolutionary trade-off between these two quantities, mathematically motivated by the limiting behaviour of the convolution term, allows us to make comparisons to existing results for the original reaction-advection-diffusion system. These comparisons show that the nonlocal model always predicts a larger parameter region supporting pattern formation. We obtain the same parametric trends on the rainfall threshold for other dispersal kernels by numerical simulations and show that pattern existence further depends on the kernelâĂŹs type of decay at infinity.

Polyharmonic mappings and linearly connected domains

Tue 09 Jul
17:10
CT12
KO-3

Layan El Hajj (american university in dubai)

A 2p-times continuously differentiable complex valued function $f = u + iv$ in a simply connected domain Ω is polyharmonic (or p-harmonic) if it satisfies the polyharmonic equation $\Delta_p F = 0$. Every polyharmonic mapping f can be written as $f(z) = \sum_{k=1}^{p} |z|^{2(p-1)} G_{p-k+1}(z)$, where each G_{p-k+1} is harmonic. In this paper we investigate the univalence of polyharmonic mappings on linearly connected domains and the relation between univalence of $f(z)$ and that of $G_p(z)$. The notion of stable univalence and logpolyharminc mappings are also considered.

Self-similar 2d Euler solutions with vorticity of mixed sign

Wed 10 Jul
09:05
CT15
KO-3

Volker Elling (Academia Sinica)

We construct a class of self-similar 2d incompressible Euler solutions that have initial vorticity of mixed sign. The regions of positive and negative vorticity form algebraic spirals. Algebraic vortex spirals were previously conjectured to exist based on heuristic arguments. Existence is relevant for non-uniqueness issues of the multi-dimensional Euler equations.

Oscillation numbers in spectral theory of linear Hamiltonian systems

Mon 08 Jul
18:00
MS16
KO-9

Julia Elyseeva (Moscow State University of Technology)

We consider linear Hamiltonian differential systems $y'(t) = JH(t,\lambda)y(t), H(t,\lambda) = H^T(t,\lambda),\ J = \begin{bmatrix} 0 & I \\ -I & 0 \end{bmatrix}$ which depend in generalnonlinearly on the spectral parameter λ and with Dirichlet boundary conditions.In our consideration we do not impose any controllability and strict normalityassumptions and omit the Legendre condition for the Hamiltonian. We adapt thetheory developed by A.A. Abramov for the Hamiltonian spectral problems based onpiecewise constant transformations of their conjoined bases using the notion of thecomparative index. We introduce the concept of oscillation numbers which generalizethe notion of proper focal points and prove oscillation theorems relating thenumber of finite eigenvalues in the given interval with the values of the oscillationnumbers at the end points of this interval.

Dynamical behavior of an SIS epidemic model with delays

Mon 08 Jul
14:00
CT1
KO-1

Yoichi Enatsu (Tokyo University of Science)

Co-authors: Emiko Ishiwata (Department of Applied Mathematics, Tokyo University of Science), Kei Fushimi (Department of Applied Mathematics, Tokyo University of Science)

We investigate the dynamical behavior of an SIS (Susceptible-Infected-Susceptible) models with delays. In Paulhus, Wang (2015), global stability of equilibria has also been investigated by constructing suitable Lyapunov functionals. However, in the proof of global stability of a disease-free equilibrium, an additional condition is required. We establish an another sufficient condition under which the disease-free equilibrium is globally asymptotically stable. With the results in Paulhus, Wang (2015), we offer the complete analysis on the global stability of both a disease-free equilibrium and an endemic equilibrium. This is a joint work with Kei Fushimi and Emiko Ishiwata. Moreover, we also present the corresponding ongoing studies.

Discretized fast-slow systems near singularities

Mon 08 Jul
14:00
MS8
KO-7

Maximilian Engel (TU Munich)

Co-authors: Christian Kuehn (TU Munich), Luca Arcidiacono (TU Munich), Matteo Petrera (TU Berlin), Yuri Suris (TU Berlin)

We show how to extend slow manifolds near various kinds of singularities in fast-slow systems given by time discretizations of the corresponding continuous-time normal form. The analysis applies the blow-up method, which has so far mainly been used for flows, to fast-slow dynamical systems induced by maps and uses direct trajectory-based estimates.

For transcritical and pitchfork singularities, we prove that the qualitative behaviour is preserved by any time-discretization, where the step size is fully quantified relative to the time scale separation.

For canard points at folds, we demonstrate that, due to a formal conserved quantity, the Kahan discretization and related symplectic methods preserve canard solutions for relatively large step sizes and long times as opposed to, for example, the Euler method.

An analytical discussion of polycrystalline structures in single-slip crystal plasticity

Tue 09 Jul
19:00
Poster
KO

Dominik Engl (Universiteit Utrecht)

Co-authors: Carolin Kreisbeck (Universiteit Utrecht)

Many solids, such as metals, are polycrystals, meaning that they consist of a cluster of differently rotated single crystals. Such grain structures are known to impose restrictions on still finer microstructures, and highly influence the effective material response. We consider a model in the context of finite crystal plasticity with one active slip system and linear hardening under the assumption of elastically rigid behavior. Mathematically, the possible deformations of the material can be described by an inhomogeneous nonlinear differential inclusion subject to suitable boundary conditions.In this poster, we discuss different questions related to the solvability of these inclusions and their relaxed versions. The answers depend highly on the interplay between the orientation of the slip systems and the grain geometry. We present a geometry-independent sufficient condition by characterising globally affine solutions. Applying a generalized Hadamard compatibility condition to the boundary grains leads to a necessary condition, which turns out to be also sufficient for certain geometries. By explicit construction, we provide examples of piecewise affine solutions to the relaxed differential inclusion, allowing us to obtain Lipschitz solutions to the unrelaxed problem via convex integration theory.This is joint work with Carolin Kreisbeck (Utrecht University).

Zero dispersion limit of the convolution-type wave equation

Thu 11 Jul
16:50
CT20
KO-2

Albert Erkip (Sabanci University)

Co-authors: Husnu A. Erbay (Ozyegin University), Saadet Erbay (Ozyegin University)

We consider the convolution-type equation $u_{tt} = \beta * (u + u^{p+1})_{xx}$ which models the propagation of one-dimensional nonlinear waves in a nonlocal elastic material. In the regime characterized by long wavelength and small amplitude, we prove the following two assertions: (i) solutions exist over long times, and (ii) as the wave number tends to zero in which the kernel function β reduces to the Dirac delta function, solutions of the nonlocal equation converge uniformly to solutions of the classical elasticity equation $u_{tt} = (u + u^{p+1})_{xx}$. The present work extends two recent studies [1] and [2]. The main improvement here is a new energy estimate without loss of derivatives. This enables us to prove existence and comparison results for initial data with lower regularities than those in [1] and [2].

[1] H.A. Erbay, S. Erbay, A. Erkip, Long-time existence of solutions to nonlocal nonlinear bidirectional wave equations, Discrete Contin. Dyn. Syst., 39 (2019), 2877-2891.

[2] H.A. Erbay, S. Erbay, A. Erkip, Comparison of nonlocal nonlinear wave equations in the long-wave limit, Applicable Analysis (to appear).

BLOW-UP OF SOLUTIONS WITH HIGH ENERGIES OF A COUPLED SYSTEM OF HYPERBOLIC EQUATIONS

Thu 11 Jul
16:50
CT22
KO-5

Jorge Esquivel-Avila (Universidad Autónoma Metropolitana)

We consider an abstract coupled evolution system of second order in time. For any positive value of the initial energy, in particular for high energies, we give sufficient conditions on the initial data to conclude nonexistence of global solutions. We compare our results with those in the literature and show how we improve them.

Active fluid models for cell biology

Fri 12 Jul
09:45
MS22
KO-10

Christèle Etchegaray (Inria Bordeaux Sud-Ouest)
Co-authors: Nicolas Meunier (LaMME, Évry), Raphaël Voituriez (LJP, Sorbonne Université)

In this talk, I will present some fluid-based models for cell migration on a flat substrate. Cell displacement results from the activity of the so-called cytoskeleton inside the cell, which is a very dynamic structure made of out-of-equilibrium filaments. In the biophysics community, the active fluid theory proposes to model the cytoskeleton as a fluid that carries active terms to describe its underlying components. Cell migration then results from the fluid's activity interacting with the substrate and the cell membrane. I will present the active fluid modelling approach and give some examples of related models in cell biology. Then, I will focus on a model for cell migration and discuss interesting biological and modelling issues that arise.

On the solvability of the Yakubovich minimization problem

Mon 08 Jul
16:30
MS16
KO-9

Roberta Fabbri (Università di Firenze)
Co-authors: Carmen Nunez (Universidad de Valladolid)

A general non autonomous version of the Yakubovich Frequency Theorem, proved in the periodic case, was given by Fabbri, Johnson and Nunez in the bounded and uniformly continuous case in 2003. In particular, the problem of mimimizing the infinite horizon quadratic functional is formulated in terms of a corresponding linear Hamiltonian system, under a priori stabilization condition. In this work, without imposing the stabilization hypothesis, we establish condition for the linear Hamiltonian system (related to the presence of an exponential dichotomy) to characterize the set of initial data for which the functional can take finite values. Moreover we check that the mimimum is finite , we determine its value and we find a pair on which such a minimum is reached.

Nanopteron traveling waves in mass-in-mass lattices under the small mass limit

Mon 08 Jul
16:50
CT6
KO-3

Timothy Faver (Leiden University)

The mass-in-mass (MiM), or mass-with-mass, lattice consists of an infinite chain of identical particles that are both nonlinearly coupled to their nearest neighbors and linearly coupled to a distinct resonator particle. The MiM lattice is a prototypical model in the field of granular metamaterials, a large class of artificially constructed materials that possess certain highly tunable properties useful in experimental settings. This talk will present ongoing investigations into the existence and properties of traveling waves in the MiM lattice in the limit as the mass of the resonator goes to zero, at which point the MiM lattice reduces to a classical monatomic Fermi-Pasta-Ulam-Tsingou (FPUT) lattice. We are therefore interested in traveling waves in the MiM lattice whose profiles remain close to the well-known solitary wave that exists in the monatomic FPUT lattice. Following the methods of Hoffman and Wright for diatomic FPUT lattices with small mass ratio, we first discuss the existence of periodic traveling waves in this small mass limit and then construct from them nanopteron traveling waves, which are the superposition of one of these periodic waves, the FPUT solitary wave, and an exponentially decaying remainder.

Singular perturbations and nanopteron traveling waves in nonlinear lattices

Tue 09 Jul
19:00
Poster
KO

Timothy Faver (Leiden University)

Infinite lattices of nonlinearly coupled oscillators are prototypical models of wave propagation in granular media. By tuning the material parameters of a lattice to certain limits, we can produce different kinds of wave behavior in the lattice. In particular, we can excite exact periodic traveling wave solutions to the lattice equations of motion and may possibly construct homoclinic connections between these periodic "tails" and a particular exponentially localized solution that exists when the material parameter reaches its critical limit. Such waves formed by the superposition of a periodic oscillation and an exponentially localized profile are called nanopterons. We give an overview of recent and ongoing investigations in the existence and properties of nanopterons in the long wave and equal mass limits for diatomic Fermi-Pasta-Ulam-Tsingou lattices and the small mass limit for mass-in-mass lattices. This is joint work with Doug Wright and Hermen Jan Hupkes.

Reaction-diffusion systems: an influence of unilateral terms on Turing's patterns

Fri 12 Jul
09:25
CT25
KO-3

Martin Fencl (University of West Bohemia)

We consider a reaction-diffusion system exhibiting Turing's diffusion driven instability. The equation for an activator is supplemented by unilateral terms of the type $s_-(\mathbf{x})u^-$, $s_+(\mathbf{x})u^+$ describing sources and sinks active only if the concentration decreases below and increases above, respectively, the value of the basic spatially constant solution which is shifted to zero. We show that the domain of diffusion parameters in which spatially non-homogeneous stationary solutions can bifurcate from that constant solution is smaller than in the classical case without unilateral terms. Further we discuss the difference of resulting patterns in the case with unilateral terms and in the case with smooth approximations of these terms.

A Hamilton-Jacobi theory on fluctuation structures for a stochastic Carleman model

Tue 09 Jul
09:15
MS34
KO-11

Jin Feng (University of Kansas)
Co-authors: Toshio Mikami (Tsuda University), Johannes Zimmers (University of Bath)

The Carleman equation is an one dimensional toy model in gas kinetics. We study a special type of Hamilton-Jacobi PDE in the space of probability measures. Such abstract equation is associated with a stochastic version of the Carleman model through the theory of large deviation.

Through this example, we illustrate that, a large class of stochastic hydrodynamics can be approached as multi-scale convergence of Hamilton-Jacobi in the space of probability measures. In particular, we will make use of connection with the theory of weak KAM (Kolmogorov-Arnold-Moser) for infinite particles to explicitly derive limiting effective Hamiltonians in the continuum.

Symmetric periodic orbits of charges moving under the Coulomb force

Thu 11 Jul
10:15
MS27
KO-11

Marco Fenucci (University of Pisa)
Co-authors: Angel Jorba (Universitat de Barcelona)

We take into account a system composed by $N+1$ charged particles, with $N = 12, 24, 60$, of which one has positive charge $Q > 0$, and the remaining N have all the same negative charge $q < 0$. These particles move under the Coulomb force, and the positive charge is assumed to be at rest at the center of mass. Imposing a symmetry constraint, we were able to compute periodic orbits, using shooting method and continuation with respect to the value Q of the positive charge. Dynamical properties are also studied. In the setting of the classical N-body problem, the existence of such orbits is proved by minimizing the action functional. Here this approach does not seem to work, and numerical computations show that the orbits we compute are indeed saddle points. A rigorous theoretical proof of their existence is still missing. This is a joint work with Angel Jorba.

Nonlocal diffusion equation with impulsive action and remark about estimates of growth

Thu 11 Jul
17:10
CT20
KO-2

Jaqueline Ferreira (UFES)
Co-authors: Marcone Pereira (USP)

This talk is concerned with formulate the nonlocal problem with impulsive action and to present the remark about growth estimates of their solutions. The theory of impulsive partial differential equations provide natural framework for mathematical model of processes which are subject to brief perturbations during their evolution. Many general work about impulsive parabolic equations are found in [?] and [?]. Parallel, the nonlocal evolution equations of the form

$$u_t(x,t) = \int_{\mathbb{R}^n} J(x-y)u(y,t)dy - u(x,t)$$

and variations of it have been used to model diffusion processes [?, ?, ?]. However, in the literature, is not established this nonlocal problem with impulsive action. We explored the properties of the operator $K_J(u)(x,t) := \displaystyle\int_\Omega J(x-y)u(y,t)dy$ in order to discuss about the growth estimates of impulsive solutions.

Stable solutions to semilinear elliptic equations

Fri 12 Jul
11:30
Plenary
HK

Alessio Figalli (ETH Zurich)

Stable solutions to semilinear elliptic PDEs appear in several problems. It is known since the 1970âĂŹs that, in dimension $n > 9$, there exist singular stable solutions. In this talk I will describe a recent work with Cabré, Ros-Oton, and Serra, where we prove that stable solutions in dimension $n \leq 9$ are smooth. This answers also a famous open problem posed by Brezis, concerning the regularity of extremal solutions to the Gelfand problem.

Doubly nonlocal Fisher-KPP equation: Features and peculiarities

Thu 11 Jul
09:15
MS5
KO-4

Dmitri Finkelshtein (Swansea University)

We overview properties of solutions to a reaction-diffusion equation, arising, in particular, in population ecology, where both reaction and diffusion parts are nonlocal. We describe a criterion for the comparison principle to hold. We consider sufficient and necessary conditions for the linear speed of propagation, and discuss two possible asymptotics of traveling waves with minimal speeds. We discuss also mechanisms and present rates for the accelerated propagation.

The choice of representative volumes for random materials: Structure theorems for fluctuations in stochastic homogenization and their consequences

Thu 11 Jul
16:30
MS20
KO-9

Julian Fischer (IST Austria)

The most widely employed method for determining the effective large-scale properties of random materials is the representative volume element (RVE) method: It basically proceeds by choosing a sample of the random material - the representative volume element - and computing its effective properties. To obtain an accurate approximation for the effective material properties, the RVE should reflect the statistical properties of the material well. Hence, it is desirable to choose a large sample of the random medium as an RVE. However, an increased size of the RVE comes with an increased computation cost. For this reason, there have been attempts in material science and mechanics towards capturing the statistical properties of the material in a better way in an RVE of a fixed size. We provide an analysis of an approach by Le Bris, Legoll, and Minvielle, which has been demonstrated to be quite effective in numerical examples. Our analysis is based on a quantitative description of fluctuations in stochastic homogenization. In contrast to previous works, we are able to establish such quantitative fluctuation theorems in the setting of finite range of dependence.

Subsolutions for convex optimal control problems

Mon 08 Jul
14:30
MS34
KO-11

Markus Fischer (University of Padua)
Co-authors: Gianmarco Bet (University of Florence)

We illustrate an iterative procedure for constructing subsolutions for some deterministic or stochastic optimal control problems in discrete time with continuous state space. The procedure generates a non-decreasing sequence of subsolutions, giving true lower bounds on the minimal costs (value function). In each step, state trajectories starting from some fixed initial points are computed which serve to update the current subsolution. The functions thus constructed are shown to converge from below to the value function at the fixed initial points; moreover, they provide a posteriori bounds on the minimal costs at any point of the state space. If the Bellman operators of the control problem preserve convexity, then the subsolutions can be updated by adding supporting hyperplanes, in analogy with the cutting plane algorithm from convex optimization. No discretization of the state space is needed. Besides convergence results, we present numerical experiments for discrete-time problems derived from convexity-preserving controlled ItÃť diffusions. Possible extensions of the method might also be discussed.

Hardy inequalities in the Heisenberg group

Mon 08 Jul
15:30
MS32
KO-10

Valentina Franceschi (FMJH & IMO, Université Paris Sud)
Co-authors: Dario Prandi (CNRS & L2S, CentraleSupélec)

We present recent results about Hardy inequalities in the n-th Heisenberg group. In particular, we show that, contrary to the Euclidean case, a radial Hardy inequality, i.e., a Hardy inequality taking into account only the directional derivative w.r.t. the sub-Riemannian distance, does not hold in this context for any dimension. Motivated by this fact, we then suggest the study of a non-radial Hardy inequality, based on the construction of specific coordinates following from the explicit synthesis of sub-Riemannian geodesics. We prove a sharp weighted non-radial inequality that imply (non-sharp) bounds for the non-radial Hardy constant on homogeneous cones. We underly through the latter a strong difference with respect to the Euclidean case.

Stochastic thermostats for equilibrium sampling

Thu 11 Jul
09:45
MS15
KO-9

Jason Frank (Utrecht University)

A stochastic thermostat of NosÃĬ-Hoover-Langevin type is used to perturb a Hamiltonian system such that almost all orbits sample the Gibbs canonical distribution (modeling constant temperature dynamics). The perturbation is differentiable and its flow can be proven to be ergodic. We discuss some extensions of such thermostats to non-Hamiltonian dynamics and/or non-Gibbs measures. In particular we consider measures derived from observational data, and we discuss some ideas for constructing generic thermostats.

The stochastic limit of backward error analysis of two-scale systems

Wed 10 Jul
10:15
MS30
KO-7

Jason Frank (Utrecht University)

tba

Flat Friedmann-Lemaître-Robertson-Walker and Kasner Big Bang singularities analyzed on the level of scalar waves

Thu 11 Jul
18:00
MS31
KO-12

Anne Franzen (Instituto Superior Técnico, Lisboa)
Co-authors: Artur Alho (IST Lisboa), Grigorios Fournodavlos (Pierre and Marie Curie University)

We consider the wave equation, $\Box_g \psi = 0$, in fixed flat Friedmann-Lemaître-Robertson-Walker and Kasner spacetimes with topology $\mathbb{R}_+ \times \mathbb{T}^3$. We obtain generic blow up results for solutions to the wave equation towards the Big Bang singularity in both backgrounds. In particular, we characterize open sets of initial data prescribed at a spacelike hypersurface close to the singularity, which give rise to solutions that blow up in an open set of the Big Bang hypersurface $\{t = 0\}$. The initial data sets are characterized by the condition that the Neumann data should dominate, in an appropriate L^2-sense, up to two spatial derivatives of the Dirichlet data. For these initial configurations, the $L^2(\mathbb{T}^3)$ norms of the solutions blow up towards the Big Bang hypersurfaces of FLRW and Kasner with inverse polynomial and logarithmic rates respectively. Our method is based on deriving suitably weighted energy estimates in physical space. No symmetries of solutions are assumed.

Learning geometry and statistics from the spectrum of time-dependent dynamics

Thu 11 Jul
11:30
Plenary
HK

Gary Froyland (University of New South Wales, Sydney)

I will discuss spectral approaches to statistical laws and mixing geometry for nonlinear dynamics, before introducing random or nonautonomous dynamical systems and describing recent extensions of spectral methods to the time-dependent setting. Applications to geophysical fluid flows will be also be presented.

Convergence to equilibrium for the equation and dynamic boundary condition of Cahn-Hilliard type

Tue 09 Jul
09:25
CT8
KO-2

Takeshi Fukao (Kyoto University of Education)

Co-authors: Hao Wu (Fudan University)

In this talk, we concerned with the asymptotic behavior of the solution to the equation and dynamic boundary condition of Cahn-Hilliard type with the logarithmic potential. This system is constructed by Cahn-Hilliard system in the bulk and on the boundary, and has a structure of the total mass conservation, namely the volume in the bulk puls the boundary. By the effective usage of the separation property from pure phase, the extended Lojasiewicz-Simon inequality can be applied to prove that the ω-limit set consists only one point which is a stationary solution.

Limit cycle bifurcations in multi-parameter polynomial dynamical systems

Tue 09 Jul
19:00
Poster
KO

Valery Gaiko (NAS Belarus)

We develop new bifurcational geometric methods based on the Wintner–Perko termination principle for the global bifurcation analysis of multi-parameter polynomial dynamical systems. Using these methods, we present, e. g., a solution of Hilbert's Sixteenth Problem on the maximum number and distribution of limit cycles for the Kukles cubic-linear system, the general Liénard polynomial system with an arbitrary number of singular points and Leslie–Gower systems which model the population dynamics in real ecological and biomedical systems. Applying a similar approach, we study also three-dimensional polynomial dynamical systems and, in particular, complete the strange attractor bifurcation scenarios in Lorenz type systems connecting globally the homoclinic, period-doubling, Andronov–Shilnikov, and period-halving bifurcations of limit cycles.

Nonexistence for Some Quasilinear Elliptic Inequalities

Mon 08 Jul
16:30
CT4
KO-1

Evgeny Galakhov (Peoples' Friendship University of Russia (RUDN University))

Co-authors: Olga Salieva (Moscow State Technological University "Stankin")

Note this is a joint talk. We consider the nonlinear partial differential inequality

$$-\Delta_p u \geq a(x)u_+^{q_1} + b(x)u_-^{q_2} \qquad (x \in \mathbb{R}^n)$$

and some its generalizations. Using a modification of the test function method, we establish sufficient conditions for the nonexistence of nontrivial solutions to such inequalities.

Existence of a weak solution to a nonlinear, moving boundary FSI problem

Mon 08 Jul
16:50
CT4
KO-1

Marija Galić (University of Zagreb)

Co-authors: Boris Muha (University of Zagreb)

We consider a nonlinear, moving boundary, fluid-structure interaction problem between an incompressible, viscous fluid flow, and an elastic structure composed of a cylindrical shell supported by a mesh-like elastic structure. The fluid flow is modeled by the time-dependent Navier-Stokes equations in a three-dimensional cylindrical domain, while the cylindrical shell is described by the two-dimensional linearly elastic Koiter shell equations allowing displacements in all three spatial directions. The mesh-like structure is modeled as a one-dimensional hyperbolic net made of linearly elastic curved rods. The fluid and the mesh-supported structure are coupled via the kinematic and dynamic boundary coupling conditions describing continuity of velocity and balance of contact forces at the fluid-structure interface. We prove the existence of a weak solution to this nonlinear, moving boundary problem by using the time-discretization via Lie operator splitting method, Arbitrary Lagrangian-Eulerian mapping and non-trivial compactness result.

Spectral stability of inviscid vortex columns

Tue 09 Jul
10:15
MS21
KO-12

Thierry Gallay (Univ. Grenoble Alpes)

Co-authors: Didier Smets (Sorbonne Université)

Vortex columns are axisymmetric stationary solutions of the 3D incompressible Euler equations, where the velocity of the fluid particles only depends on the distance to the symmetry axis and has no component in the axial direction. The stability of such flows was first investigated by Kelvin in 1880, and the problem benefited from important contributions by Rayleigh in 1880 and 1917. Despite further progress in the 20th century, the only rigorous results that can be found in the literature give necessary conditions for instability under either two-dimensional or axisymmetric perturbations. In a recent work in collaboration with Didier Smets (Paris), we prove under rather general assumptions that columnar vortices are spectrally stable with respect to general three-dimensional perturbations. The proof relies on a homotopy argument, which allows us to restrict the spectral analysis of the linearized operator to a small neighborhood of the imaginary axis in the complex plane.

Calibration Techniques for Uncertainty Quantification in Inverse Problems

Wed 10 Jul
10:15
MS28
KO-12

Alfredo Garbuno Iñigo (Caltech)

Co-authors: Andrew Stuart (Caltech), Tapio Schneider (Caltech)

The calibration of complex models to data is both a challenge and an opportunity. It can be posed as an Inverse Problem. This work focuses on the interface of Ensemble Kalman Inversion (EnKI) , Gaussian process emulation (GPE) and Markov Chain Monte Carlo (MCMC) for the calibration of, and the quantification of uncertainty in, parameters learned from data. The goal is to perform uncertainty quantification in predictions made from complex models, reflecting uncertainty in these parameters, with relatively few forward model evaluations. This is achieved by propagating approximate posterior samples obtained by judicious combination of ideas from EKI, GPE and MCMC. The strategy will be illustrated with idealized models related to climate modeling.

Approximation theorems for parabolic equations and applications

Thu 11 Jul
09:25
CT17
KO-2

María Ángeles García-Ferrero (Max-Planck-Institut für Mathematik in den Naturwissenschaften)

Co-authors: Alberto Enciso (Instituto de Ciencias Matemáticas), Daniel Peralta-Salas (Instituto de Ciencias Matemáticas)

Combining the construction of suitable local solutions to PDEs with appropriate global approximation theorems, we can obtain global solutions to PDEs with prescribed geometric or topological properties. This technique has been used in many contexts involving elliptic equations. In this talk I will focus on showing global approximation theorems for parabolic equations and their use to prove that it is possible to prescribe the movement of the points where a temperature distribution attains local maxima (hot spots), among other applications. This is a joint work with A. Enciso and D. Peralta-Salas (ICMAT, Madrid)

Strong unique continuation for higher order fractional SchrÃűdinger equations

Fri 12 Jul
09:15
MS33
KO-4

María Ángeles García-Ferrero (Max-Planck-Institut für Mathematik in den Naturwissenschaften)

In this talk I will show the strong unique continuation property for solutions of higher order fractional SchrÃűdinger operators, including the case of variable coefficients and the presence of Hardy type gradient potentials. The proof relies on a generalised Caffarelli-Silvestre extension for the higher order fractional Laplacian and on Carleman estimates. I will also discuss applications of the unique continuation results in the context of nonlocal CalderÃşn problems.This is a joint work with Angkana RÃijland.

Radial solutions of scaling invariant nonlinear elliptic equations with mixed reaction terms

Thu 11 Jul
17:10
CT22
KO-5

Marta Garcia-Huidobro (P. Universidad Católica de Chile)

Co-authors: Marie Bidaut-Veron (University of Tours), Laurent Veron (University of Tours)

We establish global properties of positive radial/solutions of $-\Delta u = u^p + M|\nabla u|^{2p/(p+1)}$ in $\mathbb{R}^N$, where $p > 1$ and M is a real parameter. We discuss the existence/non-existence of ground states and singular solutions with an isolated singularity at the origin.

Quasilinear singular SPDEs within regularity structures

Fri 12 Jul
09:15
MS18
KO-7

Máté Gerencsér (IST Austria)

Co-authors: Martin Hairer (Imperial College London)

We discuss solving quasilinear singular SPDEs via a transformation method that enables one to fit the problem in the framework of regularity structures. Our approach has the upside of producing a solution theory to a large (essentially optimal) class of equations. On the other hand, it has a downside of introducing combinatorial complications in the renormalisation procedure âĂŞ we will address some tools that help in handling these. The talk is based in part on joint work with Martin Hairer.

Random dynamical systems for stochastic PDE with nonlinear noise

Fri 12 Jul
09:45
MS18
KO-7

Benjamin Gess (MPI MIS Leipzig)

Co-authors: Ben Fehrman (University Oxford)

In this talk we will revisit the problem of generation of random dynamical systems by solutions to stochastic PDE. Despite being at the heart of a dynamical system approach to stochastic dynamics in infinite dimensions, most known results are restricted to stochastic PDE driven by affine linear noise, which can be treated via transformation arguments. In contrast, in this talk we will address instances of stochastic PDE with nonlinear noise, with particular emphasis on porous media equations driven by conservative noise. This class of stochastic PDE arises in particular in the analysis of stochastic mean curvature motion, mean field games with common noise and is linked to fluctuations in non-equilibrium statistical mechanics.

Instability and uniqueness of the peaked periodic traveling wave in the reduced Ostrovsky equation

Tue 09 Jul
09:15
MS9
KO-8

Anna Geyer (TU Delft)

Co-authors: Dmitry Pelinovsky (McMaster University)

The existence of peaked periodic waves in the reduced Ostrovksy equation has been known since the late 1970's. In this talk I will present a recent result with Dmitry Pelinovsky, in which we answer the long standing open question whether these solutions are stable and prove linear instability of the peaked periodic waves using semi-group theory and energy estimates. Moreover, we prove that the peaked wave is unique and that the equation does not admit HÃűlder continuous solutions, i.e. there are no cusps.

A nonlinear fourth-order approximation of forward-backward parabolic equations

Tue 09 Jul
09:15
MS7
KO-5

Lorenzo Giacomelli (Sapienza University of Rome)

Forward-backward parabolic equations, such as the Perona-Malik equation, are well known to be ill posed. Various types of regularisation have therefore been proposed, such as a pseudoparabolic (PP) and a linear fourth-order (L-IV) one. Interesting numerical experiments, performed on the latter, suggest the occurrence of phenomena which are analogous to spinodal decomposition and coarsening. They are characterized by three different time scales: an initial one, where staircase-type or ramp-type microstructures ("wrinkles") develop in the backward-parabolic region; an intermediate one, during which microstructures coarsen into macroscopic steps; and a final one, where solutions are close to piecewise constant functions, with neighboring plateaus colliding and coarsening.

In the quantitative analysis of such phenomena, both (PP) and (L-IV) suffer from one disadvantage. On one hand, (L-IV) has continuous solutions, in which jumps are replaced by diffuse interfaces; on the other hand, (PP) does not allow jumps to disappear in finite time, hence it can not model coarsening phenomena. In this talk, I will discuss a new, nonlinear fourth-order regularization, introduced together with Michiel Bertsch and Alberto Tesei, which overcomes both disadvantages, allowing for discontinuous solutions whose jumps can both appear and disappear. These features should permit a better understanding and a quantitative description of the aforementioned wrinkling and coarsening phenomena.

Homogenization in randomly perforated domains

Thu 11 Jul
17:30
MS20
KO-9

Arianna Giunti (University of Bonn)

Co-authors: Richard Hoefer (University of Bonn), Juan J.L. Velazquez (University of Bonn)

We consider the homogenization of Poisson and Stokes equations in a bounded domain of $\mathbb{R}^d$, $d > 2$, perforated by random holes. We assume that the holes are generated by a union of properly rescaled balls having random radii and centers. We show that for a large class of stationary probability measures, the homogenized equations are analogous to the case of periodic spherical holes. More precisely, for the Poisson equation, we recover in the homogenization limit an averaged version of the “strange term” established by Cioranescu and Murat (“A strange term coming from nowhere”, (1994)); in the case of Stokes equations, we show that the homogenized solution solves a Brinkmann-type system.

We stress that the main assumption of our setting is that the random radii of the balls generating the holes have finite $(d-2)$-moment ($(d-2)^+$ in the case of Stokes): This condition is minimal in order to ensure that the average of the capacity of the holes is finite, and still allows for the onset of clustering balls with overwhelming probability. This is a joint project with R. Hoefer and J.J.L. Velázquez (University of Bonn).

Path space cochain models for analysis of population dynamics

Tue 09 Jul
10:15
MS29
KO-6

Chad Giusti (University of Delaware)

Co-authors: Darrick Lee (University of Pennsylvania)

The space of time series on a population of observables can be naturally viewed as a path space on the space of population states. This language allows us to characterize various quantitative measures of time series as evaluations of 0-cochains on points in the space. Leveraging this perspective and applying classical cochain models for mapping spaces, we obtain a range of new algebraic and geometric tools for the study of time series. These are of particular interest in the context of inferring details of interaction between the observables in order to model dynamics. Here, we survey the background, starting with Chen’s iterated integral construction, and then describe some initial results about how such tools can be used to study cyclic behavior, sequences of population states that occur at irregular intervals, and causality.

Dynamics of solids in a perfect fluid and vortex systems

Fri 12 Jul
08:45
MS22
KO-10

Olivier Glass (Université Paris-Dauphine)

Co-authors: Christophe Lacave (Université Grenoble Alpes), Alexandre Munnier (Université de Lorraine), Franck Sueur (Université de Bordeaux)

We consider the evolution of several solids in a cavity filled with a perfect incompressible fluid. The solids evolve according to Newton's law, under the influence of the fluid's pressure. The question that is raised is the behaviour of the system when the solids become small, in different regimes. We prove that we obtain several vortex systems in the limit.

Some new results in stochastic homogenization

Fri 12 Jul
09:45
MS20
KO-9

Antoine Gloria (Sorbonne Université)

In this talk I'll present some recent results in quantitative stochastic homogenization.

Nonnegative martingale solutions to the stochastic thin-film equation with Stratonovich noise

Thu 11 Jul
16:30
MS18
KO-7

Manuel Gnann (TU Delft)

Co-authors: Benjamin Gess (Max Planck Institute for Mathematics in the Sciences in Leipzig)

We consider the stochastic thin-film equation $\mathrm{d}u = -\partial_x \left(u^2 \partial_x^3 u\right) \mathrm{d}t + \partial_x \left(u \circ \mathrm{d}W\right)$ with colored Gaussian Stratonovich noise and establish existence of non-negative weak (martingale) solutions. Our method is based on a Kato-Trotter-type decomposition into a deterministic and a stochastic evolution and simplifies a previous proof by Fischer and GrÃijn for a related equation with ItÅD noise. It is discussed why Stratonovich noise appears to be a more natural choice both from the analytic as well as modelling perspective.

Bifurcation of solutions of the Neumann problem

Tue 09 Jul
16:30
CT10
KO-1

Anna Gołębiewska (Nicolaus Copernicus University in Toruń)

Co-authors: Joanna Kluczenko (University of Warmia and Mazury, Olsztyn), Piotr Stefaniak (West Pomeranian University of Technology, Szczecin)

The aim of the talk is to study bifuration of weak solutions of a nonlinear elliptic system with Neumann boundary conditions. We investigate the problem with symmetries of the compact Lie group, considering the invariance of the domain as well as the symmetry of the potential. We use the variational method, studying the critical points of the associated functional. This functional inherits the symmetries of the problem, so its critical points do not have to be isolated. Therefore we study the bifurcation from the critical orbits. We investigate the phenomena of the local and global bifurcation and the existence of unbounded sets of solutions.As the main tool we use the theory of the degree for invariant strongly indefinite functionals and the equivariant Conley index.

A collective coordinate framework to study the dynamics of travelling waves in stochastic partial differential equations

Thu 11 Jul
17:00
MS19
KO-8

Georg Gottwald (University of Sydney)

Co-authors: Madeleine Cartwright (University of Sydney)

We propose a formal framework based on collective coordinates to reduce infinite-dimensional stochastic partial differential equations (SPDEs) with symmetry to a set of finite-dimensional stochastic differential equations which describe the shape of the solution and the dynamics along the symmetry group. We study SPDEs arising in population dynamics with multiplicative noise and additive symmetry breaking noise. The collective coordinate approach provides a remarkably good quantitative description of the shape of the travelling front as well as its diffusive behaviour, which would otherwise only be available through costly computational experiments. We corroborate our analytical results with numerical simulations of the full SPDE. This is joint work with Madeleine Cartwright.

Extreme Event Quantification for Rogue Waves in Deep Sea

Tue 09 Jul
16:00
MS30
KO-7

Tobias Grafke (Warwick University)

A central problem in uncertainty quantification is how to characterize the impact that our incomplete knowledge about models has on the predictions we make from them. This question naturally lends itself to a probabilistic formulation, by making the unknown model parameters random with given statistics. Here this approach is used in concert with tools from large deviation theory (LDT) and optimal control to estimate the probability that some observables in a dynamical system go above a large threshold after some time, given the prior statistical information about the system's parameters and its initial conditions. We use this approach to quantify the likelihood of extreme surface elevation events for deep sea waves, so-called rogue waves, and compare the results to experimental measurements. We show that our approach offers a unified description of rogue wave events in the one-dimensional case, covering a vast range of paramters. In particular, this includes both the predominantly linear regime as well as the highly nonlinear regime as limiting cases, and is able to predict the experimental data regardless of the strength of the nonlinearity.

Imaging with the elliptic Radon transform in 3D

Thu 11 Jul
16:30
MS33
KO-4

Christine Grathwohl (Karlsruhe Institute of Technology (KIT))

Co-authors: Peer Christian Kunstmann (Karlsruhe Institute of Technology), Eric Todd Quinto (Tufts University Medford), Andreas Rieder (Karlsruhe Instutite of Technology)

A well-established method to investigate subsurface material parameters is to generate pressure waves on the surface and measure their reflections returning there at different points.

In this talk, we consider a scanning geometry with constant distance from source to receiver in three space dimensions. After linearisation this situation is modelled by the elliptic Radon transform which integrates over ellipsoids.

As an inversion formula of this transform is unknown we propose a certain imaging operator appropriate to apply the method of the approximate inverse and develop a migration scheme to reconstruct singularities in the speed of sound. Further, by investigating the top order symbol of the imaging operator as a pseudo differential operator we achieve that our reconstructions of the subsurface are relatively independent of the distance to the surface and the offset. Last, we test our implementation with data generated by solving the wave equation numerically.

This is joint work with Peer Christian Kunstmann, Eric Todd Quinto and Andreas Rieder.

Minimality conditions for travelling waves in an anisotropic Smectic C* liquid crystal

Mon 08 Jul
17:10
CT6
KO-3

Michael Grinfeld (University of Strathclyde)

Co-authors: Elaine C. M. Crooks (University of Swansea), Geoff McKay (University of Strathclyde), Damian Wierzbicki (University of Glasgow)

We discuss the use of the Hadeler-Rothe and the Benguria-Depassier variational principles to formulate minimality conditions for travelling fronts in an anisotropic Smectic C* liquid crystal, as well as the use of the Chen-Goldenfeld renormalization group algorithm to compute the minimal speed.

On the restricted three-body problem with crossing singularities

Wed 10 Jul
09:45
MS27
KO-11

Giovanni Federico Gronchi (Universita' di Pisa, Dipartimento di Matematica)

In this talk we deal with the long term behaviour of the solutions of the restricted three-body problem, say Sun-Earth-asteroid, when the osculating Keplerian trajectory of the asteroid can cross the trajectory of the Earth.

Crossings of trajectories correspond to singularities of the averaged Hamilton equations, where the average is made over the two fast Delaunay variables of the asteroid and the Earth. The solutions of the averaged equations with crossing singularities have been studied starting from the 70's by Lidov and Ziglin, who dealt with a particular case, and more recently in a series of papers by myself and different collaborators.

First I'll review what is known about this problem. Then I'll present some new preliminary results, obtained in collaboration with M. Fenucci, concerning the relation between the solutions of the averaged equations and the corresponding components of the solutions of the full equations.

The Edwards-Wilkinson limit of the KPZ equation in d>=2

Fri 12 Jul
09:15
MS20
KO-9

Yu Gu (Carnegie Mellon University)

We will discuss some recent work on the Edwards-Wilkinson limit of the KPZ equation in $d \geq 2$ in a weak disorder regime. A homogenized/renormalized variance shows up in the limit.

Quasi-periodic perturbations of heteroclinic attractor networks in models of bistable perception

Wed 10 Jul
09:15
MS26
KO-10

Antoni Guillamon (Universitat Politècnica de Catalunya)

Bistable perception is characterized by alternation of percepts under a steady sensory input. Alternatively to the profusely used two-attractor models for bistable perception, heteroclinic networks have been considered successfully to model this phenomenon, see [Ashwin-Lavric, 2010]. Trajectories of heteroclinic networks are characterized by long periods in neighbourhoods of saddle points from which they escape thanks to noise. In fact, in bistable perception models, noise plays a leading role to explain the statistics of dominance times of percepts observed in experiments. Noise is meant to model a diversity of inputs impinging on the areas represented in the model. In this talk we consider quasiperiodic perturbations of heteroclinic networks, assuming that the system is receiving events, either internal or from other brain areas, that include only a finite number of (incongruent) frequencies. We show how these systems can achieve good agreement with gamma distributions of the dominance times observed in bistable perception, and we compare these results with those obtained with noise. We present a methodology based on the separatrix map to model the dynamics close to heteroclinic networks with quasi-periodic perturbations. Our methodology considers two different approaches, one based on Melnikov integrals and another one based on variational equations. The perturbed system shows chaotic behaviour while dominance times achieve good agreement with Gamma distributions.

Finite-parameter feedback stabilization of original Burgers' equations and Burgers' equation with nonlocal nonlinearities

Wed 10 Jul
09:25
CT15
KO-3

Serap Gümüş (Koç University)

Co-authors: Varga Kalantarov (Koç University)

In this study, we analyze the problem of local and global stabilization of the original Burgers and the Burgers equation with nonlocal nonlinearities. We propose a feedback control algorithm for stabilizing the solutions of initial-boundary value problem for both equations. We design our feedback control system depending on finitely many Fourier modes.

Small-time fluctuations for conditioned hypoelliptic diffusions

Mon 08 Jul
15:00
MS32
KO-10

Karen Habermann (Hausdorff Center for Mathematics, University of Bonn)

We study the small-time asymptotics for hypoelliptic diffusion processes conditioned by their initial and final positions. After giving an overview of work on small-time asymptotics for sub-Riemannian diffusion bridges, we present recent results on small-time fluctuations for the bridge in a model class of diffusions satisfying a weak HÃűrmander condition, where the diffusivity is constant and the drift is linear. We show that, while the diffusion bridge can exhibit a blow-up behaviour in the small time limit, we can still make sense of suitably rescaled fluctuations which converge weakly. We close by presenting work in progress regarding the point-to-subspace setting.

Weighted norm inequality for maximal function

Tue 09 Jul
19:00
Poster
KO

Rajib Haloi (Tezpur University)

Co-authors: Duranta Chutia (Tezpur University)

In this article, we prove the one weight vector valued norm inequality for the general one sided maximal function. We obtain the necessary and sufficient conditions of the weights. This extends the existing results in literature.

On generalized energy inequality for solutions to Damped Navier-Stokes equations

Mon 08 Jul
17:50
CT5
KO-2

Rajib Haloi (Tezpur University)

Co-authors: Subha Pal (Tezpur University)

In this article, we prove the existence of weak solutions to the damped Navier–Stokes equation with no slip boundary condition in a bounded domain in $\mathbb{R}^3$. We prove that weak solutions obtained by semi-discretization satisfies generalized energy inequality. This extends the existing results in literature.

Noisy Patterns

Tue 09 Jul
19:00
Poster
KO

Christian Hamster (Universiteit Leiden)

Co-authors: Hermen Jan Hupkes (Universiteit Leiden)

In previous work we showed how a stochastic phase adaptation can be used to understand the dynamics of traveling waves in stochastic Reaction-Diffusion equations forced by a single Brownian motion. This poster explains how this technique can be extended to equations forced by translation invariant Wiener processes. This extension is important, as translation invariant noise is most often used in applications. We will mainly focus on understanding the dynamics of the stochastic wave and we will show how it deviates from the deterministic wave. We briefly consider the technical difficulties that arise when studying equations forced by cylindrical Wiener processes.

Bifurcation and phase transition of 1d Brusselator model

Wed 10 Jul
08:45
CT13
KO-1

Jongmin Han (Kyung Hee University)

Co-authors: Taeyoung Ha (National Institute for Mathematical Sciences)

In this talk, we consider the phase transition of 1d Brusselator model via bifurcation analysis. We show the system bifurcates from the trivial solution to an attractor as the control parameter passes through the critical number. We verify the structure of the attractor by the center manifold reduction when the critical eigenvalues are multiple.

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asymptotic stability of radially symmetric solutions of multi-dimensional Burgers equation

Tue 09 Jul
16:00
MS21
KO-12

Itsuko Hashimoto (Kanazawa university)

We consider the asymptotic behavior of radially symmetric solutions for the multi-dimensional Burgers equation on the exterior domain, where the boundary and far field conditions are prescribed. We show that even for the case where the corresponding 1-D Riemann problem for the non-viscous part admits a shock wave, the solution tends toward a linear superposition of stationary and rarefaction waves as time goes to infinity. Furthermore, we show the asymptotic stability of the stationary waves with $\mathbb{R}^n$ perturbed fluid motion. This is the joint work with Prof. Akitaka Matsumura of Osaka university and Prof. Hideo Kozono of Waseda university.

Weak-strong uniqueness for the Navier-Stokes equation for two fluids with surface tension

Mon 08 Jul
14:20
CT2
KO-2

Sebastian Hensel (Institute of Science and Technology Austria (IST))

Co-authors: Julian Fischer (Institute of Science and Technology Austria (IST))

We establish a weak-strong uniqueness principle for the flow of two immiscible, incompressible and viscous fluids with surface tension. As long as there exists a strong solution, every varifold solution - whose global-in-time existence was established by H. Abels (Interfaces Free Bound. 9, 2007) - originating from the same initial condition has to coincide with it. Our result covers the regime of phase-dependent densities and shear viscosities and holds true in two and three spatial dimensions. The key ingredient of our approach is the construction of a relative entropy functional which is capable of controlling the interface error.

Homoclinic orbits and bifurcations in the Circular Restricted Four Body Problem

Wed 10 Jul
09:45
MS14
KO-5

Wouter Hetebrij (Vrije Universiteit Amsterdam)

Co-authors: Jason Mireles James (Florida Atlantic University)

In the Circular Restricted Four Body Problem, we have 3 bodies in an equitriangular configuration and are interested in the movement of a fourth massless body. Depending on the masses of the first three objects, there are 8, 9 or 10 Lagrangian points for the fourth body. The bifurcation diagram exists of a 1-dimensional curve of saddle-node bifurcations and single point where there is a pitchfork bifurcation.If there are 10 Lagrangian points, there exist homo-clinic orbits at the stationary points of the fourth body. In this talk, we will prove that the homo-clinic orbit persists at the saddle-node bifurcations. To show this result, we will present two results.The first result will be a parameterization of the two-dimensional center manifold at the bifurcation point together with its dynamics. Using the conjugate dynamics on the center manifold, we show the existence of a one-dimensional stable and unstable submanifold.The second result will be a parameterization of the two-dimensional stable and unstable manifold together with their dynamics. The parameterization is obtained by computing the (un)stable fibers of the (un)stable submanifolds. Using those two-dimensional manifolds, we show the existence of a homo-clinic orbit at the bifurcation point.

Navier wall law for nonstationary viscous incompressible flows

Fri 12 Jul
09:15
MS22
KO-10

Mitsuo Higaki (University of Bordeaux)

In fluid mechanics, it is a basic subject to understand the mathematical structure of flows near a rough-surfaced wall. The Navier wall law is a method to model a rough boundary as a flat one and to impose an appropriate condition on it reflecting the roughness of the original boundary. In this talk, we consider the two-dimensional Navier-Stokes equations in a half-plane with a small perturbation of order ε, and report the results on the Navier wall law to the initial-boundary value problem.

Stability of planar stationary flows in an exterior domain without symmetry

Tue 09 Jul
08:45
MS21
KO-12

Mitsuo Higaki (University of Bordeaux)

We consider the asymptotic stability of two-dimensional stationary flows to the Navier-Stokes equations in a non-symmetric exterior domain. In an exterior disk case, we have an exact rotating flow due to the symmetry which decays in the scale-critical order $O(|x|^{-1})$, and its local L^2-stability is proved by Maekawa (2017) under the smallness condition. This talk aims at generalizing this result to the case when the domain loses symmetry: we prove the local L^2-stability of the rotating flow in a domain given by a small perturbation to the exterior disk.

Stability of fast fronts in a Ginzburg-Landau equation with additional conservation law

Tue 09 Jul
19:00
Poster
KO

Bastian Hilder (University of Stuttgart)

We study the nonlinear stability of fronts in a Ginzburg-Landau equation with an additional conservation law. This system can be derived as an amplitude equation for pattern forming systems with conserved quantities such as the BÃĪnard-Marangoni problem. The fronts connect the diffusively stable fixed point $(1, 0)$ to the unstable origin and travel with velocity $c \geq 2$.We show the stability of these fronts in the super-critical case $c > 2$ with respect to real perturbations which decay exponentially fast ahead of the front. The proof is based on the use of exponential weights to control the perturbation until it passes the bulk of the front.

Localised radial spots on the free surface of a ferrofluid

Tue 09 Jul
19:00
Poster
KO

Daniel Hill (University of Surrey)

Co-authors: D.J.B. Lloyd (University of Surrey), M.R. Turner (University of Surrey)

In 2005, Richter & Barashenkov (PRL 94.184503, 2005) published experimental evidence for the existence of axisymmetric (radial) spots on the surface of a ferromagnetic fluid, in the so-called Rosensweig instability experiment. This experiment involves a horizontal plate of ferrofluid placed between two Helmholtz coils that produce a uniform vertical magnetic field. The spots were created by placing another smaller electromagnet underneath the plate, locally increasing the applied field strength in the hysteretic region. Notably, these spots persist even after the second electromagnet is removed.

It remains a mystery as to if the existence of these spots is related to an underlying mechanism where they can spontaneously emerge from the flat state. In this presentation, we provide an explanation as to why we believe the spots do emerge from the flat state and sketch out a proof, using radial centre-manifold reduction theory of Scheel (2003), for their existence close to the critical applied magnetic field strength.

A biofilm growth model - A two-fold degenerate reaction-diffusion system

Tue 09 Jul
19:00
Poster
KO

Victor Hissink Muller (Radboud University)

Biofilms are colonies of micro-organisms attached to surfaces in moist environments. These organisms excrete a glue-like substance and multiply, allowing for the growth of a colony. Biofilms are the main life form of bacteria in nature and the description of their behavior is of importance in various fields, e.g. in Medicine and Hydraulic/Environmental Engineering.A deterministic continuum model for the growth of biofilms is formulated as two coupled reaction-diffusion equations, describing the time evolution of the biomass density and nutrient concentration. The biomass equation involves a two-fold degenerate diffusion coefficient that vanishes when the biomass tends to zero and blows up when the biomass density approaches its maximal value. This model motivates the study of degenerate reaction-diffusion equations with singularity. Results on the well-posedness and regularity of solutions of a class of such equations are presented.

Generalized Mandelbrot and Julia sets in a family of planar angle-doubling maps

Tue 09 Jul
15:30
CT12
KO-3

Stefanie Hittmeyer (University of Auckland)

Co-authors: Bernd Krauskopf (University of Auckland), Hinke Osinga (University of Auckland)

We study a planar noninvertible map that acts as a nonanalytic generalization of the complex quadratic family. It maintains the property of angle doubling, but is no longer an analytic map on the complex plane. Rather, the role of the critical point is now played by a critical circle. We generalize the notion of Julia sets to this new setting and show how these invariant sets interact with stable and unstable sets of saddle fixed and periodic points. We employ state-of-the-art numerical techniques to find and characterize new types of Julia sets, which are associated with the behavior of points on the critical circle under iteration. In parameter space this is encoded by the (generalized) Mandelbrot set.

Existence of Blenders in a HÃĽnon-Like Family: Geometric Insights from Invariant Manifold Computations

Tue 09 Jul
19:00
Poster
KO

Stefanie Hittmeyer (University of Auckland)

Co-authors: Bernd Krauskopf (University of Auckland), Hinke Osinga (University of Auckland), Katsutoshi Shinohara (Hitotsubashi University)

A blender is an intricate geometric structure of a diffeomorphism of dimension at least three. Its characterizing feature is that its invariant manifolds behave as geometric objects of a dimension that is larger than expected from the dimensions of the manifolds themselves. We introduce an explicit HÃĽnon-like family of three-dimensional diffeomorphisms and show that it has a blender in a specific parameter regime. Advanced numerical techniques for the computation of one-dimensional stable and unstable manifolds enable us to present images of actual blenders and their associated manifolds as well as strong numerical evidence for the existence of the blender over a larger parameter range. Moreover, we explore the geometry of a blender-like chaotic attractor in the classical HÃĽnon parameter regime.

On the sedimentation of spherical inertialess particles in Stokes flows

Thu 11 Jul
17:00
MS22
KO-10

Richard Höfer (University of Bonn)

Co-authors: Juan J. L. Velázquez (University of Bonn)

We consider the dynamics of an N-particle system of inertialess spherical particles immersed in a Stokes flow with no-slip boundary conditions at the particles. The dynamics is driven by gravity acting on the particles which must be balanced by fluid drag forces. We consider the limit of many small particles in the regime of small volume fraction of the particles but with enough particles such that the dynamics is driven by the interactions between the particles.

In this limit we obtain a transport equation for the particles coupled with a Stokes equations. This macroscopic system resembles the Stokes equations of variable density.

The proof relies on the method of reflections. This method yields a series representation for the solution to the Stokes equations in domains with multiple disconnected boundaries by repeatedly solving an equation when only one of those boundaries is present.

On the existence of solutions to nonlinear equations on metric graphs via energy methods

Tue 09 Jul
16:00
MS6
KO-4

Matthias Hofmann (University of Lisbon, Group of Mathematical Physics)

We consider solutions of nonlinear equations on noncompact metric graphs associated with energy functionals with an L^2-constraint whose prototype form is

$$E(u) = a(u, u) - \int f(u)$$

for a symmetric, sesquilinear form $a(\cdot, \cdot)$ and a suitable function f of which $u \mapsto |u|^p$ would be a model. We explain how the existence of solutions can be obtained via localization methods using spectral properties of the operator A associated with the form $a(\cdot, \cdot)$, and discuss the spectral quantities involved. If A is a SchrÃűdinger operator, $f(u) = |u|^p$ with $2 < p < 6$ and the graph has finitely many edges, then we recover the NLS (nonlinear SchrÃűdinger) functional as for instance considered by Adami, Serra and Tilli [JFA 271 (2016), 201-223] and Cacciapuoti [Contemp. Math. 717 (2018), 155-172], among others.

Focus-focus singularities in semitoric systems and beyond

Fri 12 Jul
09:15
MS13
KO-6

Sonja Hohloch (University of Antwerp)

In this talk, we will give an overview over our most recent results and developments concerning so-called "semitoric systems" — these are completely integrable Hamiltonian systems on four dimensional manifolds whose flow induces an $\mathbb{S}^1 \times \mathbb{R}$-action and whose singularities are nondegenerate and do not admit hyperbolic components. Of particular interest in the study of semitoric systems are invariants arising from focus-focus singularities. For example, coupled spin oscillators and coupled angular momenta are semitoric systems, but there are many more.This talk is based on various joint works with Jaume Alonso, Annelies De Meulenaere, Holger Dullin, and Joseph Palmer.

Simultaneous reconstruction of attenuation and source density under a multibang assumption

Fri 12 Jul
10:15
MS33
KO-4

Sean Holman (University of Manchester)

In this talk I will discuss the problem of simultaneous reconstruction of attenuation and source density from measurements of radiation. This problem occurs in single positron emission tomography (SPECT) when the attenuation map of an object is not known, and in this context is sometimes called the "identification problem". Mathematically the problem is to invert the attenuated Radon transform when the attenuation is not known a priori. Full reconstruction is not possible in general and I will discuss this non-uniqueness. However, the main topic of the talk will be the extent to which reconstruction is possible, from both theoretical and computational points of view, when we assume that the attenuation only takes a finite number of known values. This type of assumption is natural if the object is known to be composed of certain materials each with a known attenuation.

Asymptotics for a class of iterated random cubic operators

Thu 11 Jul
16:30
MS19
KO-8

Ale Jan Homburg (University of Amsterdam)

Co-authors: Uygun Jamilov (Academy of Sciences of Uzbekistan), Michael Scheutzow (Technische Universität Berlin)

I consider a class of cubic stochastic operators that are motivated by models for evolution of frequencies of genetic types in populations, here populations with three mutually exclusive genetic types.

I consider a family of independent and identically distributed maps from this class and treat its long term dynamics, in particular its random point attractors. The long term dynamics of the random composition of maps is asymptotic, almost surely, to equilibria. For generic initial conditions these can be equilibria with one or two or three types present (depending only on the distribution). This is different from the deterministic systems.

A relation between modelled distributions and paracontrolled distributions

Fri 12 Jul
08:45
MS18
KO-7

Masato Hoshino (Kyushu University)

Co-authors: Ismaël Bailleul (Université de Rennes 1)

I will discuss the relation between the theory of regularity structures and the paracontrolled calculus. First I will show the equivalence of admissible models and their paracontrolled representations. Second I will explain a strategy to prove the equivalence of modelled distributions and paracontrolled distributions. This talk is based on a joint work with IsmaÃńl Bailleul.

Understanding and reducing large-scale ODE-based reaction networks based on a novel inputâĂŞresponse index

Thu 11 Jul
16:30
MS25
KO-11

Wilhelm Huisinga (University of Potsdam)

Large-scale mechanistic models of pharmacological relevant processes are increasingly used to study the response of the system to a given stimulus (e.g., a drug). Understanding the inputâĂŞresponse relationship, however, is often a challenging task due to the complexity of the models.

I present a novel state- and time-dependent quantity called the inputâĂŞresponse index that quantifies the importance of state variables for a given inputâĂŞresponse relationship at a particular time. It is based on the concept of time-bounded controllability and observability, and defined with respect to a reference dynamics. In application to human blood coagulation network, the inputâĂŞresponse indices give insight into the coordinated action of specific coagulation factors and about those factors that contribute only little to the response. I demonstrate how the indices can be used to reduce large-scale models in a two-step procedure. In application to the blood coagulation network, this resulted in a reduction from 62 to 8 and 5 state variables, respectively. I further illustrate that the sequence, in which a recursive algorithm eliminates state variables, has an impact on the final reduced model. The inputâĂŞresponse indices are particularly suited to determine an informed sequence.

This is joint work with Jane KnÃűchel (UniversitÃďt Potsdam, current address: Astra Zeneca/Sweden) and Charlotte Kloft (Freie UniversitÃďt Berlin/Germany).

Age-structured models and Distributed Delay Differential Equations

Tue 09 Jul
09:15
MS17
KO-10

Antony Humphries (McGill University)
Co-authors: Tyler Cassidy (McGill University)

By solving along the characteristics age-structured PDE models often result in delay terms in differential equation (DDE) models. If the aging velocity is constant and the maturation age is fixed then a constant discrete delay results. However, in many situations either the maturation rate is variable, or the maturation age itself is randomly distributed. It is then very easy to write down an incorrect DDE. We show how to derive appropriate DDEs in both situations. In the case of variable aging velocity and randomly distributed maturation age we demonstrate how the resulting state-dependent distributed delay DDE can be recast as an ODE using a generalisation of the linear chain technique. We will also discuss the limiting process as the probability density function approaches a delta function and the distributed delay DDE approaches a discrete DDE in a surprising manner.

A global bifurcation theorem and its application

Tue 09 Jul
15:50
CT10
KO-1

Kuo-Chih Hung (National Chin-Yi University of Technology)

We study the global bifurcation and exact multiplicity of positive solutions for the positone multiparameter problem $u''(x) + \lambda f(u) = 0, -1 < x < 1, u(-1) = u(1) = 0$, where $\lambda > 0$ is a bifurcation parameter and $\epsilon > 0$ is an evolution parameter. Under some suitable hypotheses on $f(u)$, we prove that there exists $\epsilon^* > 0$ such that the bifurcation curve is S-shaped for $0 < \epsilon < \epsilon^*$ and is monotone increasing for $\epsilon \geq \epsilon^*$. We give an application for this problem with a class of polynomial nonlinearities $f(u) = -\epsilon u^p + bu^2 + cu + d$ of degree $p \geq 3$ and coefficients $\epsilon, b, d > 0$, $c \geq 0$. Our results generalize those in Hung and Wang (Trans. Amer. Math. Soc. 365 (2013) 1933–1956.)

Existence of homoclinic and stable periodic solutions for a family of delay differential equations.

Tue 09 Jul
10:15
MS17
KO-10

Vera Ignatenko (National Research University Higher School of Economics)

A one-parameter family of Mackey-Glass type delay differential equations is studied. The existence of a solution which is homoclinic to a positive equilibrium solution is shown. The bifurcation of a stable periodic orbit from the homoclinic orbit when a parameter crosses a critical value is discussed. Local techniques are combined with global results for monotone nonlinearities as long as solutions run in a monotonicity region. A Wazewski-type argument using transversality-of-exit properties is applied to obtain the homoclinic solution. A bifurcation theorem due to H.-O. Walther is used. The verification of the assumptions used for the proofs is done numerically for a concrete example. Numerically computed approximations of solutions are shown.

Boundedness, asymptotic behaviour vs. finite-time blow-up for quasilinear Keller-Segel model

Tue 09 Jul
19:00
Poster
KO

Sachiko Ishida (Chiba University)

We deal with a parabolic-parabolic quasilinear Keller-Segel model. It has a blow-up conjecture under $q > m + 2/N$, where m and q represent the rate of diffusion and aggregation, N is dimension. We now give the positive answer of that for any size of $q > 2$. On the other hand, we find the weak asymptotic under the condition of $q < m + 2/N$. This is a joint work with Tomomi Yokota (Tokyo University of Science) and Takahiro Hashira.

Stability of multi-peak symmetric stationary solutions for the Schnakenberg model with periodic heterogeneity

Fri 12 Jul
09:45
CT25
KO-3

Yuta Ishii (Tokyo Metropolitan University)

In this talk, we consider the one-dimensional Schnakenberg model with periodic heterogeneity:

$$\begin{cases} u_t - \varepsilon^2 u_{xx} = d\varepsilon - u + g(x)u^2 v, & x \in (-1,1),\ t > 0, \\ \varepsilon v_t - D v_{xx} = \frac{1}{2} - \frac{c}{\varepsilon} g(x) u^2 v, & x \in (-1,1),\ t > 0, \\ u_x(\pm 1) = v_x(\pm 1) = 0, \end{cases}$$

where $d, c, D > 0$ are given constants, $\varepsilon > 0$ is sufficiently small, and $g(x)$ is a given positive function. Let $N \geq 1$ be an arbitrary natural number. We assume that $g(x)$ is a periodic and symmetric function, i,e., $g(x) = g(-x)$ and $g(x) = g(x + 2N^{-1})$. Moreover, we assume that $g(x)$ is C^3 function. We study the stability of N-peak stationary symmetric solutions. In particular, we are interested in the effect of the periodic heterogeneity $g(x)$ above on their stability. We rigorously give a linear stability analysis and reveal the effect of the periodic heterogeneity on the stability of N-peak solution. In particular, we investigate that how N-peak solutions is stabilized or destabilized by the effect of periodic heterogeneity compared with the case $g(x) = 1$.

Chaotic trajectories of adiabatically perturbed systems with bifurcations

Thu 11 Jul
08:45
CT17
KO-2

Alexey Ivanov (Saint-Petersburg State University)

We study an adiabatically perturbed natural Lagrangian system with Lagrangian

$$L(q, \dot{q}, \varepsilon t) = \frac{1}{2}|\dot{q}|^2 - V(q, \varepsilon t) \tag{2}$$

on a compact Riemannian manifold $\mathcal{M}$. The potential $V(q, \tau) \in C^2(\mathcal{M} \times \mathbb{R})$ is assumed to be periodic in τ with period 1, while the parameter ε is supposed to be small. Introducing slow time $\tau = \varepsilon t$ the equations of motion in the extended phase space read as

$$\ddot{q} = -D_q V(q, \tau), \quad \dot{\tau} = \varepsilon \tag{3}$$

and can be considered as a slow-fast system. Setting $\varepsilon = 0$ one gets the "frozen" system, where τ becomes a parameter. We suppose that the slow manifold $\Sigma_\tau = \{q \in \mathcal{M} : D_q V(q, \tau) = 0\}$ undergoes a bifurcation at some values of the parameter τ. Under this assumption we examine the existence of multi-bump chaotic trajectories which approximate different branches of the manifold Σ_τ on different intervals of time. The main ingredient for construction of such trajectories are the periodicity of the potential V and transversal connecting orbits of model systems which discribe the behaviour near bifurcations. To prove the existence of the orbits we apply variational methods together with Newton-Kantorovich method. The results are illustrated by examples with saddle-centre and pitchfork bifurcations.

Mathematical Tales of Fairy Circles

Tue 09 Jul
19:00
Poster
KO

Olfa Jaibi (Leiden University)

Co-authors: Arjen Doelman (Leiden University), Martina Chirilus-Bruckner (Leiden University), Ehud Meron (Ben Gurion University)

Dryland ecosystems exhibit intriguing self-organising mechanisms in order to account for the strong plant competition for limited resources, especially water. These mechanisms typically manifest themselves in the form of vegetation patterns, ranging from bare-soil gaps in uniform vegetation to vegetation stripes and vegetation spots. A fascinating example of gap patterns is the so-called fairy circle phenomenon, found in Namibia and recently in Australia. Fairy circles are circular barren gaps in grasslands of significant size, a few meters in diameter, that form nearly-periodic patterns on large, landscape scales. Mechanisms for the appearance of this phenomenon in Namibia and in Australia, and corresponding mathematical reaction-diffusion models, have recently been proposed by Zelnik et al. [PNAS(2015)] and by Getzin et al. [PNAS(2016)]. The underlying mathematical model that describes these patterns is of (singularly perturbed) reaction-diffusion type. Unlike the more widely studied (homoclinic pulse-type) banded vegetation patterns, fairy circles have an underlying multi-front structure. We present a mathematical analysis of the model proposed for Namibian fairy circles. The mathematical approach is along the lines of dynamical systems theory (particularly geometric singular perturbation theory) and is accompanied by numerical simulations of the full model.

Solitary waves with Kuwabara-Kono numerical dissipation

Thu 11 Jul
08:45
MS11
KO-6

Guillaume James (Inria Grenoble Rhône-Alpes and Laboratoire Jean Kuntzmann)

Co-authors: Kirill Vorotnikov (Inria Grenoble Rhône-Alpes), Bernard Brogliato (Inria Grenoble Rhône-Alpes)

We describe a new approach for the numerical simulation of Newtonian dynamical systems subject to dissipative forces proportional to the time-derivative of conservative forces. The general method is applied to the simulation of impacts in dissipative granular chains, a class of highly nonlinear and spatially discrete systems that supports coherent structures such as damped solitary waves. These systems can be modeled by nonlinear lattices with interactions between neighbors described by the Kuwabara-Kono model, a nonsmooth (not Lipschitz continuous) extension of Hertz contact that accounts for viscoelastic damping. We describe a systematic method to construct time-discretizations of the nondissipative Hertz law having a tailored numerical dissipation matching the physical dissipation at different orders. This allows us to simulate dissipative impacts with good accuracy without including the nonsmooth viscoelastic component in the contact force. Different types of wave phenomena (such as the formation of solitary waves with oscillatory tails or oscillator synchronisation in a Newton's cradle) are accurately captured by implicit schemes with tailored numerical dissipation, even for relatively large time steps.

Bifurcation results for a nonlinear model of a suspension bridge with variable stiffness

Tue 09 Jul
10:05
CT7
KO-1

Jakub Janoušek (University of West Bohemia)

We present our recent bifurcation results concerning a one-dimensional non-damped PDE model of a suspension bridge with spatially non-constant stiffness parameter. That is, we assume the restoring force of the bridge's cables being concentrated near the cable stays, whereas being almost none in between. When compared to a similar model with constant stiffness, this approach shows an improvement e.g. in the bridge's uniqueness behaviour. We work in weighted spaces and use standard tools, such as Banach contraction theorem and Rabinowitz or Dancer global bifurcation theorem.

Validated computation of infinite dimensional stable manifolds in a PDE

Mon 08 Jul
17:30
MS1
KO-4

Jonathan Jaquette (Brandeis University)

Co-authors: Jason Mireles James (Florida Atlantic University), Jan Bouwe van den Berg (VU Amsterdam)

In this talk we discuss a validated computational method for obtaining error estimates on the infinite dimensional stable manifold of non-trivial equilibria in parabolic PDEs. Our approach combines the parameterization method âĂŞ which can provide high order approximations of finite dimensional manifolds with validated error bounds âĂŞ together with the Lyapunov-Perron method âĂŞ which is a powerful technique for proving the existence of (potentially infinite dimensional) invariant and inertial manifolds.

To construct our approximation, we decompose the stable manifold into three coordinates: a slow part, a fast-but-finite part, and an infinite tail part. We use the parameterization method to approximate the slow-stable manifold, and the associated unstable and fast-but-finite vector bundles. This allows us to define a nonlinear change of coordinates which takes our nonlinear PDE to a system where we have largely removed the nonlinear terms in the slow stable part âĂŞ effectively widening our spectral gap âĂŞ and can then apply the Lyapunov-Perron method, obtaining validated error bounds on our approximation. As an example, we apply this technique to the 1D Swift-Hohenberg equation.

Rotating spirals in oscillatory media with nonlocal coupling

Wed 10 Jul
10:15
MS5
KO-4

Gabriela Jaramillo (University of Houston)

We consider an abstract oscillating chemical reaction with a fast component that can be eliminated adiabatically. As a result, this fast variable can be viewed as a nonlocal diffusive process and one can model this reaction using a system of integro-differential equations. However, the nonlocal character of the equations prevents the use of standard techniques from spatial dynamics, like construction of a center manifold and the use of normal form theory.We therefore turn to methods from functional analysis and perturbation theory to study this system. In particular, we derive Fredholm properties for the relevant convolution operators and use Lyapunov-Schmidt reduction to show existence of rotating spiral solutions.

Some applications of geometric singular perturbation theory to control systems

Mon 08 Jul
17:00
MS8
KO-7

Hildeberto Jardon (Technical University of Munich)

Fast-slow systems, also known as singularly perturbed ordinary differential equations, are a classical topic in control theory having a wide range of applications including (the control of) nonlinear electric circuits, robots, power systems and smart grids, among many others. One of the classic geometric techniques to control fast-slow systems is the composite control approach, in which controllers are designed independently for the fast and the slow dynamics, and then the sum of such controllers is valid for the full system. The aforementioned approach relies on the assumption of Normal Hyperbolicity. Once normal hyperbolicity is lost, the composite control cannot be used anymore.

In this talk we shall show how geometric singular perturbation theory, and more specifically the blow-up method, can be used in combination with control techniques in order to stabilize non-hyperbolic points of fast-slow systems. We will also describe some potential new directions in which geometric singular perturbation theory can be used to tackle fast-slow control systems characterized by loss of normal hyperbolicity.

Reducibility and fractalization of invariant curves

Angel Jorba (University of Barcelona)

Co-authors: Marc Jorba-Cuscó (University of Barcelona), Joan Carles Tatjer (University of Barcelona)

Tue 09 Jul
09:15
MS12
KO-9

In this talk we will focus on invariant curves of quasi-periodically forced maps depending on a parameter. It is known that, in some situations, the invariant curve can undergo a fractalization procedure that may lead to the destruction of the curve. In the talk we will discuss the role of the (lack of) reducibility of the invariant curve in some simple examples of fractalization.

Gravitational spin Hall effect for Maxwell fields

Jérémie Joudioux (Albert Einstein Institute, Max Planck institute for Gravitational Physics)

Thu 11 Jul
17:30
MS31
KO-12

It is well known that photons, as particles, follow null geodesics in General Relativity. The corresponding wave dynamic is modelled by the Maxwell equations. The actual motion of the photon can be recovered, at least locally, by considering high-frequency solutions to the Maxwell equations. Nonetheless, it is well-known that the dynamics of wave packets can differ sensibly from the motion of the actual particles. One of this effect, known as the spin Hall effect, has been described for Maxwell equations propagating in a medium and observed mid-00. This can be explained by the spin degree of freedom of the particle interacting with the medium in which it propagates. In this collaboration, we propose to extend this notion of spin Hall effect to Maxwell field propagating on a curved background. The effective equation of motion describing the evolution of the wave packet can be compared with the equations of motions of spinning particles in General Relativity. We are in particular trying to develop a covariant approach to the construction of a WKB Ansatz for Maxwell field on curved backgrounds. This is a collaboration with L. Andersson (AEI), M. Oancea (AEI), C. Paganini (Monash), I. Dodin (Princeton Plasma Physics Laboratory), and D. Ruiz (Sandia Laboratory).

Dynamics on Planar Lattices

Mia Jukic (Leiden University)

Co-authors: Hermen Jan Hupkes (Leiden University)

Tue 09 Jul
19:00
Poster
KO

We study dynamical systems posed on planar lattices. Throughout the talk we will explore the impact that the spatial topology of the lattice has on the dynamical behaviour of solutions. More speci

cally, we are interested in the behavior of deformed planar waves which arise as solutions to the Nagumo LDE. In contrast to previous work, the initial perturbation from the flat planar wave need only be bounded. We will make a connection between the evolution of the interface region and the solution of a discrete mean curvature ow with a drift term.

A priori estimate for the first eigenvalue of the p-Laplacian

Ryuji Kajikiya (Saga University)

Thu 11 Jul
17:10
CT21
KO-3

We study the first eigenvalue of the p-Laplacian under the Dirichlet boundary condition. For a convex domain, we give an a priori estimate for the first eigenvalue in terms of the radius d of the maximum ball contained in the domain. We prove that the first eigenvalue diverges to infinity as $p \to \infty$ if the domain is convex and $d \leq 1$. Moreover, we show that in the annulus domain $a < |x| < b$, the first eigenvalue diverges to infinity if $b - a \leq 2$ and converges to zero if $b - a > 2$.

STOCHASTIC CONTROL OF MEASURE-VALUED MARTINGALES WITH APPLICATIONS TO ROBUST PRICING AND SKOROKHOD EMBEDDING PROBLEMS

Tue 09 Jul
09:45
MS34
KO-11

Sigrid Källblad (KTH Royal Institute of Technology)

We consider a stochastic control problem where the controlled processes are (probability) measure-valued martingales (MVMs). We consider the problem in a weak formulation where the MVMs appear as solutions to certain (controlled) MVM-valued SDEs for which we prove existence of solutions. We then show that our control problem satisfies the Dynamic Programming Principle and that the associated value function is a viscosity solution in a certain sense to a corresponding HJB equation. A key motivation for the study of control problems featuring MVMs is that a number of interesting probabilistic problems can be formulated as optimisation problems over such processes; we illustrate this by applying our results to optimal Skorokhod embedding problems as well as robust pricing problems. The talk is based on joint work with A. Cox, M. Larsson and S. Svaluto.

MHD equations in a bounded domain

Tue 09 Jul
10:25
CT9
KO-3

Maria Kania-Błaszczyk (Institute of Mathematics, University of Silesia)

We consider the Dirichlet boundary value problem for the incompressible magnetohydrodynamical (MHD) system

$$\begin{aligned}
u_t - \nu\Delta u + u\cdot\nabla u &= -\nabla p + b\cdot\nabla b, \quad x\in\Omega\subset\mathbb{R}^N,\ t>0, && (4)\\
b_t - \eta\Delta b + u\cdot\nabla b &= b\cdot\nabla u, \quad x\in\Omega\subset\mathbb{R}^N,\ t>0, && (5)\\
div\, u &= div\, v = 0, && (6)\\
u &= 0, \quad b=0 \quad on\ \partial\Omega, && (7)\\
u(0,x) &= u_0(x), \quad x\in\Omega, && (8)\\
b(0,x) &= b_0(x), \quad x\in\Omega, && (9)
\end{aligned}$$

in a bounded domain $\Omega\subset\mathbb{R}^N$ with C^2 boundary, where $N=2,3$. Here u is the velocity of the fluid flow and b is the magnetic field. These functions are the vector-valued functions of $x\in\Omega$ and $t\geq 0$. The total pressure $p=p(t,x)$ is real-valued function of $x\in\Omega$ and $t\geq 0$. The constant $\nu>0$ is the viscosity of the fluid and $\eta>0$ is the magnetic diffusivity.Using Dan Henry's semigroup approach and Giga-Miyakawa estimates we construct global in time, unique solutions to fractional approximations of the MHD system in the base space $(L^2(\Omega))^N\times(L^2(\Omega))^N$. Solution to MHD system are obtained next as a limits of that fractional approximations.[1] M.B. Kania, MHD equations in a bounded domain, submitted;[2] Y. Giga, T. Miyakawa, Solutions in L_r of the Navier-Stokes Initial Value Problem, Arch. Rational Mech. Anal., 89 (1985), 267-281.

The non-linear hardening model and some properties

Tue 09 Jul
09:45
CT9
KO-3

Risei Kano (Kochi University)

In this talk, we discuss the parabolic problem form the hardening phenomena. The unknown functions u and σ describe the displacement and stress, respectively in the one-dimensional interval $(0,L)$. Our problem means the hardening problem that the materials are harden by plasticity. That is derived from the hardening model by Visintin (2006), and the perfect plasticity model by Duvaut-Lions (1976).

In the perfect plasticity model, the function that is threshold value in the plastic deformation, is a constant. In this talk, we discuss the solvability for the above model with the threshold function depending upon time or unknown function, based on the idea of Duvaut-Lions (1976). The problem equipped with the constraint set depend on the unknown function, is called quasi-variational inequality. The solvabilities of quasi-variational inequality have been dealt with in some papers.

Theory and Applications of delayed passage through Hopf bifurcations in reaction-diffusion equations

Tue 09 Jul
10:15
MS8
KO-7

Tasso Kaper (Boston University)

This talk is on joint work with Theo Vo and Ryan Goh about the applications and theory of the newly-discovered phenomenon of delayed onset of oscillations in slow passage through Hopf bifurcations in reaction-diffusion equations. Space-time buffer curves will be identified, along with a formula to calculate them, and these space-time buffer curves are the PDE analogs of buffer points from the theory of delayed Hopf bifurcations in analytic ODEs. The examples include the CGL equation, the Hodgkin-Huxley PDE, and the Brusselator PDE.

Linearized stability for abstract size-structured population equations with delay

Tue 09 Jul
10:05
CT8
KO-2

Nobuyuki Kato (Kanazawa University)

We deal with abstract evolution equations with delay in Banach spaces related to nonlinear size-structured population models with delay and spatial diffusion, and investigate the stability of steady states. We use a modified version of the theory of linearized stability for nonlinear evolution equations and establish the exponential stability of steady states by the method of linearization.

Gevrey asymptotic properties of slow manifolds

Mon 08 Jul
14:30
MS8
KO-7

Karel Kenens (Hasselt University)

Co-authors: Peter De Maesschalck (Hasselt University)

In geometric singular perturbation theory, Fenichel manifolds are typically only finitely smooth. Better local smoothness properties can be achieved in an analytic setting. Under the condition that no singularities in the slow flow are present, there exist manifolds allowing a Gevrey-1 asymptotic expansion. When the slow flow does have a singularity, there are cases, including when the singularity is a node or focus, where Fenichel manifolds can be found being 1-summable in a certain direction.

A state-dependent delay equation with chaotic solutions

Wed 10 Jul
10:05
CT13
KO-1

Benjamin Kennedy (Gettysburg College)

We exhibit a scalar-valued state-dependent delay differential equation $x'(t) = f(x(t - d(x_t)))$ that has a chaotic solution. This equation has continuous (semi-strictly) monotonic negative feedback, and the quantity $t - d(x_t)$ is strictly increasing along solutions. Joint work with Yiran Mao and Erik Wendt.

Spectral geometry of quantum graphs via surgery principles

Tue 09 Jul
08:45
MS6
KO-4

James Kennedy (University of Lisbon)

"Surgery" on a (metric) graph means making a small, generally local, change to its structure: for example, joining two vertices, lengthening an edge, or maybe removing an edge and reinserting it somewhere else.

We will introduce a number of sharp new surgery principles which allow one to control the eigenvalues of the Laplacian on a metric graph with any of the usual vertex conditions (natural, Dirichlet or delta). We will illustrate how these principles can be used to give new proofs and sharper versions of existing "isoperimetric"-type eigenvalue estimates by sketching a result which interpolates between the theorems of Nicaise and Band-LÃľvy for the first non-trivial eigenvalue of the Laplacian with natural vertex conditions.

This is based on joint work with Gregory Berkolaiko, Pavel Kurasov and Delio Mugnolo.

A database approach for rigorous falsification of dynamical models

Thu 11 Jul
16:30
CT19
KO-1

Shane Kepley (Rutgers)

For many physical systems, modeling the dynamics requires understanding the system parameters. Often these parameters are high dimensional or difficult to measure making this a difficult task. To further complicate matters, collecting data in real world examples may be expensive so often data is also sparse. In this talk we will present a generally applicable combinatorial approach to studying dynamics which aims to overcome some of these issues.

The method works by rigorously computing a database of possible observable dynamics which can be queried to exclude potential models based on observed data. The computations are efficient enough to handle higher dimensional systems, and the coarseness of the dynamic invariants makes the computations robust with respect to noise. The method does not require simulation or experimental data to generate this database.

We will demonstrate the approach using a recent example in which we did a complete study of hysteresis for all switching systems with 3-dimensional phase space and up to a 30-dimensional parameter space. Surprisingly, this study led to biological insights that were apparently unknown in the field of systems biology despite the fact that no laboratory experiments needed to be performed. Finally, we will describe some recent advances focused on extending this methodology to other physical systems.

On spectral properties of a pair of particles on the half-line

Tue 09 Jul
09:15
MS6
KO-4

Joachim Kerner (FernUniversität in Hagen)

In this talk we consider an interacting two-particle system moving on the positive half-line. Allowing for a very large class of pairing potentials, we subsequently study the spectrum of the two-particle Hamiltonian. After characterising the essential part of the spectrum we prove, as a main result, that there exist a finite number of bounds states below the essential spectrum. Even more, for a specific potential, we are able to prove that there exists exactly one such eigenvalue. We stress on the importance of the geometry of the two-particle configuration space and point out applications in solid-state physics.

Bifurcations of Lagrangian fibrations of Kovalevskaya-type integrable Hamiltonian systems.

Thu 11 Jul
17:00
MS13
KO-6

Vladislav Kibkalo (Lomonosov Moscow State University)

Kovalevskaya integrable case (in rigid body dymanics) and its analogs realize a multi-parametric family of integrable Hamiltonian systems with 2 degrees of freedom. Their Lagrangian fibrations contain various types of both degenerate and nondegenerate singularities and their bifurcations that correspond to continuous change of parameters. We will discuss their topological types and some connections with global topological invariants, e.g. the Fomenko-Zieschang invariant of Liouville foliations (Lagrangian foliations with singularities) on isoenergy 3-submanifolds. This work was supported by the Russian Science Foundation grant (project No. 17-11-01303).

On static solutions of the Maxwell-Born-Infeld field equations with point sources

Thu 11 Jul
16:30
MS31
KO-12

Michael Kiessling (Rutgers University)

It is proved that the quasi-linear elliptic PDE of the electrostatic Born-Infeld field theory has a unique finite-energy solution in Euclidean space for any finite number of point charge sources. The solution is real analytic away from these point sources. The results have a re-interpretation in terms of asymptotically flat maximal spacelike hyper-surfaces in Minkowski spacetime having finitely many light cone singularities.

An Existence of the solution to neutral stochastic functional differential equations

Tue 09 Jul
19:00
Poster
KO

Young-Ho Kim (Changwon Naitonal University)

In this presentation, we deal with an existence of solution toneutral stochastic differential equations. First discuss anexistence solution of the stochastic differential equation underweakened Hölder condition, a weakened linear growth condition,and a contractive condition. In the process of attestation, we usedthe boundary inequality.

Singular behaviour in quasilinear diffusion

Tue 09 Jul
09:45
MS7
KO-5

John King (University of Nottingham)

Formal results on aspects of singularity evolution in quasilinear diffusion will be described.

Asymptotic analysis of simple stochastic models for gene regulatory processes

Wed 10 Jul
09:45
MS24
KO-6

John King (University of Nottingham)

The application of formal asymptotic approaches to specific model problems relevant to the autoregulation of gene expression will be described.

Prandtl-Reuss model without safe-load conditions

Mon 08 Jul
14:00
CT3
KO-3

Konrad Kisiel (Warsaw University of Technology, Faculty of Mathematics and Information Science)

We will discuss the existence theory to the well-known Prandtl-Reuss model of elasto-perfect plasticity with possible disturbance of nonlinearity by a globally Lipschitz function.

For a given body and applied forces, the aim of the model is to find the displacement vector field u and the inelastic deformation tensor ϵ^p. For the Prandtl-Reuss model it is assumed that the inelastic constitutive equation which describes ϵ^p is given by a differential inclusion, where the right hand side is the subgradient of the indicator function of the set of admissible stresses K.

Since 80âĂŹs (R. Temam, G. Anzellotti, S. Luckhaus) it is well known that if one assume so-called safe-load conditions then it is possible to obtain a solution (u, ϵ^p) such that inelastic constitutive equation is satisfied in the sense of measures. However, safe-load conditions are very difficult to check in applications. Therefore, the natural question is: If safe-load conditions are necessary to obtain the existence of a solution to the Prandtl-Reuss model of elasto-perfect plasticity?

The main purpose of this talk is to answer this question. Namely, we were able to prove that, if applied force (Neumann boundary data) is not too large (upper bound depends on the set of admissible stresses K), then there is no need to use any type of safe-load conditions.

Equilibria and oscillations of a regulated two–gene model

Tue 09 Jul
17:00
MS17
KO-10

Gabor Kiss (Queen's University Belfast)

We investigate the number of equilibria and the dynamics of a two–gene system with an autoregulatory feedback loop. We show that the number of equilibria of the studied planar system of non–linear ordinary differential equations depends on the system parameters. We also provide numerical evidence for bistability, the existence unstable periodic orbits and indicators of existence of orbits homoclinic to an equilibrium. Finally, we partially describe the effects of time delay on the dynamics.

From noise-sustained structures to nonlinear absolute instability

Mon 08 Jul
15:00
MS8
KO-7

Edgar Knobloch (University of California at Berkeley)

A subcritical pattern-forming system with nonlinear advection in a bounded domain is recast as a slow-fast system in space and studied using a combination of geometric singular perturbation theory and numerical continuation. Two types of solutions describing the possible location of stationary fronts are identified, whose origin is traced to the onset of convective and absolute instability when the system is unbounded. The former are present only for nonzero upstream boundary conditions and provide a quantitative understanding of noise-sustained structures in systems of this type. The latter correspond to the onset of a global mode and are present even with zero upstream boundary condition. The role of canard trajectories in the nonlinear transition between these states is clarified and the stability properties of the resulting spatial structures are determined. Front location in the convective regime is highly sensitive to the upstream boundary condition and its dependence on this boundary condition is studied using a combination of numerical continuation and Monte Carlo simulations of the partial differential equation. Statistical properties of the system subjected to random or stochastic boundary conditions at the inlet are interpreted using the deterministic slow-fast spatial-dynamical system. This is joint work with D Avitabile, M Desroches and M Krupa.

Control of a degenerate parabolic equation: minimal time and geometric dependance

Mon 08 Jul
18:00
MS32
KO-10

Armand Koenig (Université Côte d'Azur)

Co-authors: Michel Duprez (Sorbonne Universités)

One of the degenerate parabolic equation whose controllability has been extensively studied is the Grushin equation

$$(\partial_t - \partial_x^2 - x^2\partial_y^2)f(t,x,y) = u(t,x,y)\mathbf{1}_\omega \quad (t,x,y) \in [0,T]\times\Omega,$$

where $\Omega = (-1,1)\times\mathbb{T}$ and $\omega \subset \Omega$. Contrasting with the heat equation, the null controllability of this equation depends on the domain ω and the time T. For instance, it is known that if the control domain is a vertical band $\omega = (a,b)\times\mathbb{T}$ with $0 < a < b$, then null-controllability holds only if $T > a^2/2$. We will give sharp results on the minimal time of null-controllability for a large class of control domain ω generalizing the previous results.

Stability and bifurcations of homoclinic stripe patterns near a saddle-node bifurcation

Tue 09 Jul
19:00
Poster
KO

David Kok (Leiden University)

Co-authors: Arjen Doelman (Leiden University)

Plant growth in desert-like conditions exhibits spatial patterns such as waves, dots and stripes. The time evolution of this vegetation can be modeled by the Gierer-Meinhardt equations. a set of reaction-diffusion equations describing a system of an activator (water) and an inhibitor (vegetation). In this model the localized stripe pattern is described as a one-dimensional pulse solution that is translation invariant in the second spatial direction. Unfortunately, however, it can be shown that stripe patterns of this type are unstable with respect to Turing type instabilities along the stripe, despite experimental confirmation of their existence.We study a class of singularly perturbed reaction-diffusion systems that generalize the one-dimensional Gierer-Meinhardt equations. Using geometrically singular perturbation theory we show that, aside from the slow-fast single loop homoclinic pattern, these systems can exhibit a (slow-fast) double front solution as well. When extended to two spatial dimensions both patterns can be seen as localized stripe solutions, but the double front stripe can be expected to be stable with respect to the Turing instability, which we investigate with an Evans function approach.It is the subject of the present study to understand this transition between these two types of stripe patterns, with particular focus on the (dis)appearance of the lateral Turing instability.

Riemann-Hilbert problem and singularity formation in the localized induction approximation

Fri 12 Jul
09:05
CT23
KO-1

Piotr Kokocki (Nicolaus Copernicus University in Toruń)

We are concern with the differential equation of the form

$$z_t = -k_s n - \frac{1}{2}k^2 T, \quad t, s \in \mathbb{R},$$

where z is the flow of regular curves living in the complex plane, s is the arc-length parameter, T is the field of tangent vectors, $n := iT$ is the oriented normal vector field and k is the curvature defined by $T_s = kn$. The equation is called a localized induction approximation (LIA) and can be considered as the geometric flow, whose evolution is similar to the contour dynamics of a vortex patch subjected to the 2D Euler equation. Our aim is to show the existence of a regular family of self-similar solutions for (LIA), which develops a spiral singularity at finite time. To be more precise, we prove that for any $a \in (-\frac{\pi}{2}, \frac{\pi}{2})$ and $\mu \in \mathbb{R}$, there are $\theta^+, \theta^- \in [0, 2\pi)$ and a self-similar solution $z^{\mu,a}$ such that $\theta^+ - \theta^- = 2a$ and $\lim_{t\to 0} z^{\mu,a}(t) = z_0^{\mu,a}$, where

$$z_0^{\mu,a}(s) := \begin{cases} \dfrac{s}{\sqrt{1+4\mu^2}} e^{i(\theta^- - 2\mu \log|s|)} \chi_{(-\infty,0)}(s), & s > 0, \\ \dfrac{s}{\sqrt{1+4\mu^2}} e^{i(\theta^+ - 2\mu \log s)} \chi_{(0,+\infty)}(s), & s < 0. \end{cases}$$

The method of the proof is to use an appropriate Riemann-Hilbert problem to find a solutions $z^{\mu,a}$ in a class of self-similar functions, whose profiles are purely imaginary solutions of the second Painlevé equation

$$u''(x) = xu(x) + 2u^3(x) + i\mu.$$

On some versions of the coincidence degree theory

Tue 09 Jul
19:00
Poster
KO

Sergey Kornev (Professor, Department of Physics and Mathematics, Voronezh State Pedagogical University, Voronezh, Russian Federation)

Co-authors: Ekaterina Getmanova (Department of Physics and Mathematics, Voronezh State Pedagogical University, Voronezh), Lilia Korneva (Department of Physics and Mathematics, Voronezh State Pedagogical University, Voronezh)

In the theory of topological degree of multivalued maps (multimaps) the topological and geometric properties of their values play an important role. First of all, let us mention the property of convexity of values. This property is also very significant in the continuous selection theorems (see, for example, the classical Michael theorem). However, in many applications of multimaps that naturally arise, for example, in the theory of differential equations and inclusions, the property of convexity is not fulfilled.

In the present talk we consider random multimaps of two classes. The first class consists of multimaps which can be presented as the compositions of random multimaps having random continuous approximations and continuous single-valued maps. The second class consists of random multimaps which are the compositions of random multimaps having random continuous selections and continuous single-valued maps.

We present the notion of the random topological degree in finite dimensional and normed spaces for multimaps of these classes and describe its basic properties. Then we define the random coincidence topological degree for pairs consisting of above random multimaps and linear Fredholm operators and consider its properties. Acknowledgments. The research is supported by the Ministry of Education and Science of the Russian Federation (project No. 1.3464.2017/4.6) and the joint Taiwan MOST - Russia RFBR (project No. 17-51-52022).

On some generalizations of the multivalent guiding functions method

Thu 11 Jul
16:30
CT21
KO-3

Sergey Kornev (Professor, Department of Physics and Mathematics, Voronezh State Pedagogical University, Voronezh, Russian Federation)

Co-authors: Yulia Bezmelnitsyna (Department of Physics and Mathematics, Voronezh State Pedagogical University, Voronezh), Lilia Korneva (Department of Physics and Mathematics, Voronezh State Pedagogical University, Voronezh)

Let (Ω, Σ, μ) be a complete probability space and $I = [0, T]$. We consider the periodic problem for a random differential equation of the form:

$$z'(\omega, t) = f\big(\omega, t, z(\omega, t)\big), \quad \text{for a.e. } \ t \in I, \quad (1)$$

$$z(\omega, 0) = z(\omega, T), \qquad (2)$$

for all $\omega \in \Omega$, where $f \colon \Omega \times I \times \mathbb{R}^n \to \mathbb{R}^n$ is a given map.In order to study of problem (1)-(2) we introduce the method of random multivalent guiding functions. Let us mention that the method of guiding functions was developed by A.M. Krasnoselskii and A.I. Perov for the investigation of periodic oscillations in dynamical systems governed by differential equations. In the present talk we introduce the notions of random strict and generalized multivalent guiding functions and use them to prove some existence theorems of random periodic solutions to problem (1)-(2).Moreover, we generalized the method of random multivalent guiding functions to the non-smooth case and apply them to the investigation of random periodic problem (1)-(2).Acknowledgments. The research is supported by the Ministry of Education and Science of the Russian Federation (project No. 1.3464.2017/4.6) and the joint Taiwan MOST - Russia RFBR (project No. 17-51-52022).

Slow-fast systems in cell biology: new challenges for GSPT

Mon 08 Jul
15:30
MS8
KO-7

Ilona Kosiuk (TU Wien)

Systems with discontinuous vector fields arise in biological and engineering applications. GSPT has been applied to singularly perturbed problems obtained by smoothing of given discontinuous vector fields across surfaces of discontinuity.

In this talk I will discuss the application of GSPT to systems, which are smooth for $\varepsilon > 0$, but limit onto non-smooth variants, when $\varepsilon = 0$. Hence, extra difficulties arise in the analysis of $\varepsilon \to 0$ limit as Fenichel theory is not applicable in some regions of the phase space.

This challenge is caused by the occurrence of small parameters in Michaelis-Menten type- and Hill terms, which are commonly found in ODE systems arising in cell biology.

Mathematical model for rotational motion of shape memory alloy ring partially within hot water

Tue 09 Jul
19:00
Poster
KO

Chiharu Kosugi (Japan Women's University)

Co-authors: Toyohiko Aiki (Japan Women's University)

We can easily observe that a ring of shape memory alloy string fixed with pulleys rotates at high speed when we put the ring partially in hot water. Our aims of research on this phenomenon are to construct a mathematical model and to confirm that numerical solutions of the model show high speed rotational motion. For achievement of the aims there are at least three difficulties. The first difficulty is mathematical description for shape memory effects. Precisely, dynamics of the string ring is represented by kinetic equations with strain and stress. However, for shape memory alloy materials the relationship between strain and stress is not a normal function, and the relationship is given as a hysteresis loop. Therefore, it is a crucial step to describe the relationship, mathematically. The second one is treatment for pulleys, since for existence of them we must impose obstacle problems into kinetic equations. The third one is to develop a numerical scheme to kinetic equations including several nonlinear terms. In this presentation we give our mathematical model for shape memory alloy string rings and numerical solutions of its simplified model, namely, as a first step of this research project, we are trying to get numerical solutions to kinetic equations for elastic materials with pulleys.

Multi-bump Solutions in Parabolic Problem with the p-Laplacian.

Fri 12 Jul
09:25
CT24
KO-2

Lukas Kotrla (University of West Bohemia)

Co-authors: Jiri Benedikt (University of West Bohemia), Petr Girg (University of West Bohemia), Peter Takac (Universitat Rostock)

Let $p > 1$ and $\Omega \subset \mathbb{R}^N$, $N \geq 1$, is bounded domain with a $C^{1+\mu}$-boundary $\partial\Omega$, $\mu \in (0,1)$.We consider following quasilinear parabolic problem

$$\begin{array}{rcllll} \frac{\partial}{\partial t}u - \Delta_p u & = & q(x)u^\alpha & \text{for} & (x,t) \in \Omega \times (0,T)\ , \\ u(x,0) & = & 0 & \text{for} & x \in \Omega\,, \\ u(x,t) & = & 0 & \text{for} & (x,t) \in \partial\Omega \times (0,T)\ , \end{array}$$

where $\Delta_p\, u \stackrel{\text{def}}{=} \operatorname{div}\left(|\nabla u|^{p-2}\nabla u\right)$ denotes p-Laplace operator, $\alpha \in (0,1)$ is a given number,$0 < T < +\infty$, and the potential $q(x) \in C(\overline{\Omega})$ is nonnegative, and there exists $x_0 \in \Omega$ such that $q(x_0) > 0$.

Our aim is to show that the above stated problem possesses a solution with compact support in Ω. This solution is obtained by monotone iterations starting from a nontrivial nonnegative subsolution. The crucial part of the proof is to construct a suitable supersolution with compact support.

Large deviations for weakly coupled two-scale jump-diffusion systems

Mon 08 Jul
15:00
MS34
KO-11

Richard Kraaij (Delft University of Technology)

Co-authors: Mikola Schlottke (Eindhoven University of Technology)

In the talk, I will consider general weakly coupled Markovian slow-fast systems. Both the slow, as the fast system can be of jump type, diffusion type or a mixture.

Given exponential ergodicity of the fast process, and regularity properties of the Donsker-Varadhan rate functional, the large deviation principle for the slow process will follow from a 'uniform comparison principle in the fast variable' for the Hamilton-Jacobi equation corresponding to the slow variable, as well as a basic growth condition on this Hamiltonian.

This talk is based on joint work with Mikola Schlottke (Eindhoven, The Netherlands)

Applications of techniques in mathematics and statistics to study human seizures.

Thu 11 Jul
08:45
MS26
KO-10

Mark Kramer (Boston Univeristy)

Epilepsy the propensity toward recurrent, unprovoked seizure is a devastating disease affecting 65 million people worldwide. Understanding and treating this disease remains a challenge, as seizures manifest through mechanisms and features that span spatial and temporal scales. In this talk, we will examine some aspects of this challenge through the analysis and modeling of human brain voltage activity recorded simultaneously across microscopic and macroscopic spatial scales. We will focus on two proposals: (1) that human seizure terminate in a specific dynamical mechanism, and (2) that rapidly propagating waves of activity sweep across the cortex during seizure. In each case, we will describe a corresponding computational model to propose specific mechanisms that support the observed spatiotemporal dynamics.

Pulse train dynamics in an excitable laser with delayed optical feedback

Tue 09 Jul
16:30
MS17
KO-10

Bernd Krauskopf (University of Auckland)

Co-authors: Soizic Terrien (University of Auckland), Neil Broderick (University of Auckland), Anirudh Pammi (Centre de Nanosciences et de Nanotechnologies, Univ. Paris-Sud), Sylvain Barbay (Centre de Nanosciences et de Nanotechnologies, Univ. Paris-Sud)

When excitable systems are coupling to themselves or to each other, they receive feedback with a delay time that is considerably larger than the pulse length. This may lead to very interesting pulsing dynamics. We demonstrate this here with an excitable micropillar laser with a feedback loop, or external cavity, generated by a regular mirror, which has been shown experimentally to be able to sustain trains of optical pulses. These can be triggered largely independently by optical perturbations injected into the laser, and they are then sustained simultaneously via feedback from the external cavity. A bifurcation analysis of a rate-equation model shows that the system has a number of periodic solutions with different numbers of equally spaced pulses as its only attractors. Hence, although coexisting pulse trains can seem independent on the timescale of the experiment, they correspond to very long transient dynamics. We determine the switching dynamics by studying the associated basins of attraction, which demonstrates that timing is everything when it comes to triggering or erasing pulse trains.

Identifying critical parameters for singular perturbation reductions of reaction networks and population models

Mon 08 Jul
16:30
MS8
KO-7

Niclas Kruff (RWTH Aachen)

Chemical reaction networks are often given by systems of ODEs including a bunch of parameters. In general these systems are not in standard form, i.e. slow and fast reactions are not given a priori, even if the system admits a slow /fast separation. In order to identify this separation into slow and fast part, Tikhonov Fenichel parameters (TFP) were introduced. By definition small perturbations of those TFPs induce singular perturbation reductions in the sense of Tikhonov and Fenichel. We will present algorithmic approaches to obtain necessary and sufficient conditions for TFP candidates and finally how to compute singular perturbation reductions. Some examples are given to illustrate the approach.
Moreover, we will briefly address the multiscale approach and the corresponding notion of nested TFP values which are related to an embedding of lower dimensional invariant manifolds in higher dimensional invariant manifolds of the reaction networks.

This talk reports on recent work by and with

1. Alexandra Goecke, Christian Lax, Sebastian Walcher (RWTH Aachen).
2. Volkmar Liebscher (UniversitÃďt Greifswald).
3. Elisenda Feliu and Carsten Wiuf (University of Copenhagen).

QUALITATIVE PROPERTIES OF SOLUTIONS OF THE BOUSSINESQ EQUATIONS WITH MIXED BOUNDARY CONDITIONS

Mon 08 Jul
14:40
CT2
KO-2

Petr Kučera (CTU, faculty of civil engineering)

Co-authors: Petra Vacková (Czech Technical University in Prague)

We deal with the system of the non–steady Boussinesq equations with mixed boundary conditions. We study the existence and uniqueness of a solution of this system. Suppose that the system is solvable with some given data (the initial velocity and the right hand side). We prove that there exists a unique solution of this system for all data which are small perturbations of the previous ones.

Symplectic invariants of typical degenerate orbits of integrable systems

Thu 11 Jul
18:00
MS13
KO-6

Elena Kudryavtseva (Moscow State University)

We study parabolic orbits with resonances (also known as Kalashnikov's typical rank-1 singularities) and the singular fibres containing these orbits (known as cuspidal tori) for Lagrangian fibrations on symplectic 4-manifolds. An important property of parabolic orbits is their stability under small integrable perturbations (Kalashnikov 1998, Zung 2000). This is one of the reasons why such orbits can be observed in many examples of integrable Hamiltonian systems.

It is well known that, from the smooth point of view, all parabolic orbits of a given resonance $k : n$ are equivalent, i.e. any two parabolic orbits with the same resonance admit fibrewise diffeomorphic neighbourhoods. The same is true for cuspidal tori.

We show that, in contrast to non-degenerate singular orbits (of elliptic, hyperbolic and focus-focus types), there exist parabolic orbits which are locally fibrewise diffeomorphic, but not symplectomorphic. Furthermore, all symplectic invariants of parabolic orbits (with a given resonance) can be expressed in terms of action variables. Finally, we show that the only symplectic semi-local invariant of a cuspidal torus (with a given resonance) is the canonical integer affine structure on the base of the corresponding singular Lagrangian fibration.

The talk is based on a joint work with A. Bolsinov and L. Guglielmi (2018).

This research was supported by the Russian Science Foundation (project No. 17-11-01303).

Nonlocal PDE and Modulation Equations

Mon 08 Jul
14:00
MS10
KO-8

Christian Kuehn (Technical University of Munich)

Nonlocal equations have recently appeared in a wide variety of contexts in the theory of differential equations and we shall explain several surprising situations, where they appear. Then we consider modulation equations arising from a variety of PDE models involving convolution kernels. We are going to show how to prove approximation of the original PDE for the quadratic and cubic nonlinear cases.

Patterns and Waves for SPDEs

Thu 11 Jul
08:45
MS2
KO-5

Christian Kuehn (Technical University of Munich)

In this talk, I shall report on recent progress in stochastic partial differential equations (SPDEs) and their pattern formation. After a brief review regarding solution concepts, we shall discuss techniques for the analysis and computation of stationary solutions for SPDEs. This includes bifurcations and related scaling laws, as well as associated numerical algorithms. Then we proceed to explain, what one may mean with a 'stochastic travelling wave' and state results for the Nagumo and FitzHugh-Nagumo SPDEs.

CNN-based Solution Scheme of Diffusion PDEs with Applications in Image Processing

Thu 11 Jul
09:45
CT18
KO-3

Sanjeev Kumar (Indian Institute of Technology Roorkee)
Co-authors: Mahima Lakra (Indian Institute of Technology Roorkee)

This work develops improved computational schemes for solving various partial differential equations (PDEs) based image processing models by cellular neural network (CNN). In particular, these diffusion-based PDEs are modeled with improved coefficients to achieve various tasks in imaging applications. The stability, high-precision, convergence and lowest-possible memory requirement are assured by the proposed CNN paradigm. Here, the template of CNN model is established in such a way that each element will change in each iteration to give a stable solution after a fixed diffusion time. The simulation results show the effectiveness of the proposed CNN-based solution method on various PDE models.

A novel chaos based approach in conjunction with Pairing Function for Image Encryption

Tue 09 Jul
19:00
Poster
KO

Sanjeev Kumar (Indian Institute of Technology Roorkee)

Co-authors: Farhan Musanna (Indian Institute of Technology Roorkee)

For secure transmission of digital images, existing cryptographic algorithms transform these coherent structures into a noise like or texture like appearance. One obvious inference that an adversary can make is that the noise-like texture is a cipher and not the original one. This can prompt him to apply his cryptanalysis on the cipher and can gain information about the original image. To curb this loophole, this article proposes an efficient algorithm that produces a visually coherent and meaningful image, to convince the adversary that the original image was never encrypted and what he intercepts is actually the original one. The algorithm consists of first permutation-substitution architecture for obtaining the partial cipher. The permutation is done by the Arnold-3D map, and the substitution is done by utilizing the solution of the Lorenz attractor to be implemented in our diffusion scheme. The replacement of this partial cipher is done with the approximation part of the reference image obtained by applying multi-resolution singular value decomposition on the reference image. The pixels of the partial cipher are embedded into the reference image as 4 to 1 pixel encoding using Cantor-like pairing function. Simulation results and security analysis demonstrate excellent encryption performance of the proposed concept and system.

Global existence of a solution of a two-scale model describing moisture transport in porous materials

Mon 08 Jul
14:20
CT3
KO-3

Kota Kumazaki (Nagasaki University)

In this talk, we consider a new two-scale problem which is given as mathematical model for moisture transport in concrete materials. Our model consists of a diffusion equation for the relative humidity in the entire of concrete (macro domain) and a free boundary problem describing the relationship between the relative humidity and the degree of saturation in infinitely pores (micro domain). In our model, each pore (micro domain) is considered a one dimensional interval attached to each point in the macro domain, and touches the air in the macro domain at one of the edge of the interval. The structures of the micro domains are unknown, and this is a significant feature of our model to emphasize. In this talk, we discuss the existence and uniqueness of a solution globally in time to our model.

Effect of abrupt change of the wall temperature in the kinetic theory

Tue 09 Jul
10:05
CT9
KO-3

Hung-Wen Kuo (National Cheng Kung University)

We consider a semi-infinite expanse of a rarefied gas bounded by an infinite plane wall. The temperature of the wall is T_0, and the gas is initially in equilibrium with density ρ_0 and temperature T_0. The temperature of the wall is suddenly changed to T_w at time $t = 0$ and is kept at T_w afterward. We study the quantitative short time behavior of the gas in response to the abrupt change of the wall temperature on the basis of the linearized Boltzmann equation. Our approach is based on a straightforward calculation of the exact formulas derived by Duhamel's integral. Our method allows us to establish the pointwise estimates of the microscopic distribution and the macroscopic variables in short time. We show that the short-time solution consists of the free molecular flow and its perturbation, which exhibits logarithmic singularities along the characteristic line and on the boundary.

Time discretization and error estimate for a nonlinear phase field system in general domains

Thu 11 Jul
09:05
CT18
KO-3

Shunsuke Kurima (Tokyo University of Science)

Co-authors: Shunsuke Kurima (Department of Mathematics, Tokyo University of Science), Pierluigi Colli (Dipartimento di Matematica F. Casorati, Università di Pavia)

We consider a nonlinear phase field system under homogeneous Neumann boundary conditions in a general domain. This system is a generalization of the Caginalp phase field model and it has been studied by many authors in the case of bounded domains. However, for unbounded domains the analysis of the system seems to be at an early stage. In this talk we study the existence of solutions by employing a time discretization scheme and passing to the limit as the time step goes to zero. Moreover, we can prove the uniqueness of the solution, as well as an interesting error estimate for the difference between continuous and discrete solutions.

Comparison of solutions of some pairs of nonlinear wave equations

Fri 12 Jul
09:45
CT24
KO-2

Gamze Kuruk (Sabancı University)

We will present recent results regarding comparisons of solutions of some pairs of nonlinear wave equations in asymptotic regimes determined by two parameters measuring nonlinear and dispersive effects. In the literature, there are some works on comparisons between the Camassa-Holm (CH) equation and the Euler equation in the scope of fluid dynamics. We consider the same problem within the scope of nonlocal elasticity and show that the CH equation can be formally derived from the Double Dispersion (DD) equation as long wave limit. Moreover, we prove that the solutions of the CH equation are well approximated by corresponding solutions of the DD equation. Conversely, we show that any solution of the DD equation can be written as the sum of right and left going solutions of the CH equations up to a small error. This work is the extension of the results obtained for the Improved Boussinesq equation in [1]-[3]. References: [1] Erbay H.,Erbay S., Erkip A. Derivation of Camassa-Holm Equations for elastic waves, Physics Letters A, 379 (2015), 956-961. [2] Erbay H.,Erbay S., Erkip A. The Camassa-Holm Equation as the long wave limit of the Improved Boussinesq Equation and of a class of nonlocal wave equations, Discrete and continuous Dynamical Systems, Volume 36, Number 11 (2016), 6101-6116. [3] Erbay H.,Erbay S., Erkip A., On the Decoupling the Improved Boussinesq equation into two uncoupled Camassa-Holm equations, Discrete and Continuous Dynamical Systems, Vol 7, 6 (2017), 3111-3122.

Design of large scale optimization algorithms from stochastic non-smooth dynamics perspectives

Mon 08 Jul
11:30
Plenary
HK

Rachel Kuske (Georgia Tech)

Co-authors: Emmanouil Daskalakis (UBC), Felix Herrmann (Georgia Tech)

Computations in machine learning, inverse problems, data fitting, and approximations rely heavily on optimization algorithms with stochastic and non-smooth features. Dynamical systems perspectives are increasingly important for algorithm design and performance. We highlight a combination of perspectives from stochastic nonlinear dynamics, control systems, and coherence resonance points that provide insight for algorithm improvement motivated by real world limitations. The theoretical requirements for convergence are not necessarily met In the realistic setting where the problem is large scale, overdetermined and inconsistent. Then the algorithms face challenges analogous to the chattering phenomena in non-smooth control problems. Viewing iterations of the algorithm as coupled systems of equations for large and small entries, we identify an efficient modified dynamic algorithm that removes the chatter and drives faster convergence, particularly for noisy, large scale, compressible problems which require sub-sampling and a limited number of data passes. The dynamical systems perspective also points to value for streaming (online) applications, automatic optimization of thresholds, and connections to other dynamical systems perspectives in seeking optimal search directions.

Homogenization, linearization and large-scale regularity for nonlinear elliptic equations

Fri 12 Jul
10:15
MS20
KO-9

Tuomo Kuusi (University of Helsinki)

Co-authors: Scott Armstrong (CIMS), Sam Ferguson (CIMS)

We will consider nonlinear, uniformly elliptic equations with variational structure and random, highly oscillating coefficients satisfying a finite range of dependence, and discuss the corresponding homogenization theory. We will recall basic ideas how to get quantitative rates of homogenization for nonlinear uniformly convex problems. After this we will discuss our recent work, jointly with S. Armstrong and S. Ferguson, proving that homogenization and linearization commute in the sense that the linearized equation (linearized around an arbitrary solution) homogenizes to the linearization of the homogenized equation (linearized around the corresponding solution of the homogenized equation). These results lead to a better understanding of differences of solutions to the nonlinear equation. As a consequence, we obtain a large-scale Lipschitz-type estimate for differences of solutions and consequently improve the regularity of the homogenized Lagrangian.

Long time and small obstacle problem for the 2D Navier-Stokes equations

Thu 11 Jul
18:00
MS22
KO-10

Christophe Lacave (Université Grenoble Alpes)

Co-authors: Sylvain Ervedoza (Université de Toulouse), Matthieu Hillairet (Université de Montpellier), Takéo Takahashi (INRIA Nancy)

We consider rigid bodies moving under the influence of a viscous fluid and we study the asymptotic as the size of the solids tends to zero. In a bounded domain, if the solids shrink to “massive” pointwise particles, we obtain a convergence to the solution of the Navier-Stokes equations independently to any possible collision of the bodies with the exterior boundary. In the case of “massless” pointwise particles, the energy equality is not sufficient anymore to derive a uniform estimate for the velocity of the solid. Our basic remark is that the small obstacle limit is related to the long-time behavior though the scaling property of the Navier-Stokes equations $u^\epsilon(t,x) = \epsilon^{-1}u^1(\epsilon^{-2}t, \epsilon^{-1}x)$. Hence, we derive $L^p - L^q$ decay estimates for the linearized equations in the exterior of a unit disk. We then apply these estimates to treat the massless pointwise particle. These works are in collaboration with S. Ervedoza, M. Hillairet and T. Takahashi.

L^1 Well-posedness for semilinear heat equations.

Mon 08 Jul
18:10
CT4
KO-1

Robert Laister (UWE Bristol)

Co-authors: Mikolaj Sierzega (University of Warsaw)

I will present some results on the local existence and uniqueness of solutions for semilinear heat equations of source type with L^1 initial data, subject to minimal structural conditions on the source term f. Our techniques rely only upon monotonicity properties of the equation and provide for subsidiary results on the comparison and regularity of solutions. The local existence conditions on f are sharp (necessary and sufficient) with respect to the class of positive solutions.

Space-Time Finite Element Methods for Parabolic Initial-Boundary Value Problems

Mon 08 Jul
16:30
MS3
KO-5

Ulrich Langer (Johannes Kepler University Linz)

Co-authors: Andreas Schafelner (Johannes Kepler University Linz)

We consider locally stabilized, conforming finite element schemes on completely unstructured simplicial space-time meshes for the numerical solution of parabolic initial-boundary value problems with variable, possibly discontinuous in space and time coefficients. Discontinuous coefficients, non-smooth boundaries, changing boundary conditions, non-smooth or incompatible initial conditions, and non-smooth right-hand sides can lead to non-smooth solutions. For instance, in electromagnetics, permanent magnets cause line-delta-distributions in the source term in 2d quasi-magnetostatic simulations of electrical machines.

We present new a priori and a posteriori error estimates for low-regularity solutions. In order to avoid reduced convergence rates appearing in the case of uniform mesh refinement, we also consider adaptive refinement procedures based on residual a posteriori error indicators and functional a posteriori error estimators. The latter provides guaranteed upper bounds on the error. The huge system of space-time finite element equations is then solved by means of GMRES preconditioned by space-time algebraic multigrid. In particular, in the 4d space-time case that is 3d in space, simultaneous space-time parallelization can considerably reduce the computational time.

The contact line problem in wave-structure interactions

Wed 10 Jul
09:45
MS23
KO-8

David Lannes (IMB, Université de Bordeaux et CNRS)

Co-authors: Tatsuo Iguchi (Keio University), Guy Métivier (Université de Bordeaux)

The contact line in wave-structure interactions is the curve (or points if the horizontal dimension is equal to one) where the surface of the fluid meets the solid structure. Its motion is a free boundary problem and we will investigate it in two different contexts, both for shallow-water models: - the shoreline problem for the nonlinear shallow water and Green-Naghdi equations. In this case, the solid structure is the bottom topography, and the contact line is therefore the shoreline, the place where the water depth vanishes. Its motion is governed by a standard kinematic equation, and the difficulty is to handle the degenerascy due to the cancellation of the water-depth. This is a joint work with G. MÃľtivier. - The shallow water equations with a floating object. Here, we consider the contact line with a floating object. The equation governing the motion of the contact line is then non standard and turns out to be fully nonlinear. This is a hyperbolic free boundary problem reminiscent of the problem of stability of shocks, but with one additional derivative loss that requires the development of new tools. This is a joint work with T. Iguchi.

Waves interacting with a partially immersed obstacle in the Boussinesq regime

Thu 11 Jul
16:30
MS22
KO-10

David Lannes (IMB, Université de Bordeaux et CNRS)

Co-authors: Didier Bresch (Université de Savoie Mont Blanc), Guy Métivier (Université de Bordeaux)

This talk is devoted to the derivation and mathematical analysis of a wave-structure interaction problem which can be reduced to a transmission problem for a Boussinesq system. Initial boundary value problems and transmission problems in dimension d= 1 for 2 x 2 hyperbolic systems are well understood. However, for many applications, and especially for the description of surface water waves, dispersive perturbations of hyperbolic systems must be considered. We consider here a conguration where the motion of the waves is governed by a Boussinesq system (a dispersive perturbation of the hyperbolic nonlinear shallow water equations), and in the presence of a fixed partially immersed obstacle. We shall insist on the differences and similarities with respect to the standard hyperbolic case, and focus our attention on a new phenomenon, namely, the apparition of a dispersive boundary layer. In order to obtain existence and uniform bounds on the solutions over the relevant time scale, a control of this dispersive boundary layer and of the oscillations in time it generates is necessary. This analysis leads to a new notion of compatibility condition that is shown to coincide with the standard hyperbolic compatibility conditions when the dispersive parameter is set to zero.

The conditioning of variational data assimilation with correlated observation errors

Thu 11 Jul
09:15
MS28
KO-12

Amos Lawless (University of Reading)

Co-authors: Jemima Tabeart (University of Reading), Sarah Dance (University of Reading), Nancy Nichols (University of Reading), Joanne Waller (University of Reading)

Variational data assimilation is used on a daily basis within numerical weather prediction, combining the latest observational data with numerical models to estimate the current state of the atmosphere. It formulates the problem as the minimisation of a weighted nonlinear least-squares objective function, in which the fit to the observations is balanced against the fit to a previous model forecast, with covariance matrices weighting the different sources of information. Until recently most operational weather centres have assumed that the errors in the observations are uncorrelated. However, this is not always true, especially when considering multichannel satellite data, and it is becoming more important to specify observation error correlations. In this work we look at the effect this has on the conditioning of the optimization problem. In the context of a linear system we develop theoretical bounds on the condition number of the problem in the presence of correlated observation errors. We show that the condition number is very dependent on the minimum eigenvalue of the observation error correlation matrix. Since in practice such matrices are derived from samples, the estimated covariances are routinely ill-conditioned and require modification before they can be used in assimilation. We present new theory for two existing methods for improving the rank and conditioning of a multivariate sampled error covariance matrix: ridge regression, and the minimum eigenvalue method.

On the Cauchy problem for the Muskat equation in Sobolev spaces.

Thu 11 Jul
09:45
MS23
KO-8

Omar Lazar (Universidad de Sevilla)

Co-authors: Thomas Alazard (ENS PARIS-SACLAY)

The Muskat equation modelises the dynamic of the interface between two incompressible and immiscible fluids with different densities. I will present a new local existence result in homogeneous Sobolev spaces. This is based on a joint work with Thomas Alazard.

On the equivalence of minimum time and minimum norm control

Wed 10 Jul
08:45
CT14
KO-2

Alina Lazu (Gh. Asachi Technical University of Iasi)

We study the equivalence between the minimum time and minimum norm control problems in an abstract general setting, which covers most linear systems encountered in applications; in particular, boundary control systems. We impose very few hypotheses which are rather natural, such as the null controllability of the system. This is a joint work with Prof. Ovidiu Carja ("Al. I. Cuza" University of Iasi).

Geometrically higher order unfitted space-time FEM

Mon 08 Jul
17:00
MS3
KO-5

Christoph Lehrenfeld (University of Göttingen)

Co-authors: Fabian Heimann (University of Göttingen), Janosch Preuss (University of Göttingen)

Two major issues in the design and realization of higher order unfitted finite element methods on time-dependent level set domains are time integration and accurate numerical integration. We present an approach which allows for a higher order accurate and robust time integration for domains that are prescribed by level set functions. The approach is based on parameter mappings of the background mesh. We combine this approach with a space-time discretization to obtain robust and provable higher order methods in space and time. The space-time method, its conception, implementational aspects, a priori error estimates and numerical results will be discussed.

Numerical analysis of nonlinear wave equations with dynamic boundary conditions

Thu 11 Jul
09:15
MS2
KO-5

Jan Leibold (Karlsruhe Institute of Technology (KIT))

Co-authors: Marlis Hochbruck (Karlsruhe Institute of Technology (KIT))

In this talk we consider nonlinear acoustic wave equations with dynamic boundary conditions. In contrast to standard boundary conditions, as of Dirichlet or Neumann type, dynamic boundary conditions do not neglect the momentum of the wave on the boundary. The mathematical modeling of such effects leads to an evolution equation in the interior domain Ω coupled to an evolution equation on the boundary $\partial\Omega$. An example is the following equation with kinetic boundary conditions

$$\begin{aligned} u_{tt} - \Delta u &= |u|u && \text{in } (0,T)\times\Omega, \\ u_{tt} + \partial_n u + u - \Delta_{\partial\Omega} u &= |u|^2 u && \text{on } (0,T)\times\partial\Omega. \end{aligned}$$

Here, $\Delta_{\partial\Omega}$ denotes the Laplace-Beltrami operator.

In the talk we discuss suitable space and time discretizations of such equations and present recent error results and numerical experiments.

Minimal and nodal partitions on quantum graphs

Tue 09 Jul
09:45
MS6
KO-4

Corentin Léna (University of Stockholm)

In the last decade, the study of nodal domains for laplacian eigenfunctions has been connected to the theory of minimal partitions for spectral functionals. There is now a well developed theory for two-dimensional domains. I will present recent results for analogous problems on quantum graphs, emphasizing the connection with nodal sets of eigenfunctions. This is joint work with J. Kennedy, P. Kurasov and D. Mugnolo.

Systems of stochastic reaction diffusion equations

Thu 11 Jul
17:30
MS18
KO-7

Marta Leocata (Institut Camille Jordan, Université Lyon 1)

Co-authors: Julien Vovelle (ENS de Lyon)

We study the existence, and the eventual regularity, of solutions to systems of stochastic reaction diffusion equations under some specific structure hypotheses (which imply preservation of positivity and control of an entropy in particular). Joint work with Julien Vovelle.

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3 d.o.f. integrable Hamiltonian systems: semi-local structures and bifurcations

Fri 12 Jul
08:45
MS13
KO-6

Lev Lerman (Lobachevsky State University of Nizhny Novgorod)

One of the standing problems in the theory of integrable Hamiltonian systems (IHS) is to classify main structures of low dimensional IHS in 2, 3, and 4 degrees of freedom. This includes semi-local description of the Liouville fibrations for nondegenerate singularities (rank 0), semi-local nondegenerate singularities of rank 1, 2, and 3. Such classification unavoidably requires studying bifurcations due to the fact that singular orbits of the related Poisson action (of dimension lesser than the half of the manifold dimension) are met in families. This implies that if one moves along the family an orbit being more degenerate (in transverse direction) than neighboring orbits can be met and hence one may expect branching the family. Also bifurcations are met at the study of families of integrable systems, then parameters of the family play a similar role. It is important to stress that common tool to study integrable systems uses some assumptions on the linearized system at the singularity (like to be a Cartan algebra for the related set of commuting integrals, etc). Such properties are usually violated at the bifurcation and one needs to use another tool to study the related orbit structure. We intend to discuss these themes for 3 degree of freedom integrable Hamiltonian systems. Transitions through degenerate orbits are studied using integrable normal forms.

Rigorous integration for some infinite dimensional dynamical systems

Mon 08 Jul
18:00
MS1
KO-4

Jean-Philippe Lessard (McGill University)

In this talk we introduce recent general methods to rigorously compute solutions of infinite dimensional Cauchy problems. The idea is to expand the solutions in time using Chebyshev series and use the contraction mapping theorem to construct a neighbourhood about an approximate solution which contains the exact solution of the Cauchy problem. We apply the methods to some partial differential equations (PDEs) and delay differential equations (DDEs).

How to implement interactions with time delay in the SchrÃűdinger equation?

Mon 08 Jul
15:00
CT1
KO-1

Matthias Lienert (University of Tuebingen)

Usually, interaction terms in the SchrÃűdinger equation are potentials, leading to simultaneous interactions. However, the theory of relativity dictates that interactions must occur with a time delay, proportional to the inter-particle distance. How does one implement such a time delay in the SchrÃűdinger equation? Here we show that this can be achieved using Dirac's concept of a multi-time wave function, i.e., a wave function $\psi(x_1, ..., x_N)$ with N spacetime arguments $x_i = (t_i, \mathbf{x}_i) \in \mathbb{R}^4$ for N particles. Generalizing the integral version of the SchrÃűdinger equation to the relativistic case naturally leads to a Volterra-type integral equation for ψ. In this novel equation, time delay plays an important role. Here we discuss the structure of the equation and outline a proof for the global existence of solutions for particular cases. We furthermore show how the solution spaces get parametrized (namely by solutions of the non-interacting equations). While the topic has arisen in mathematical physics, we would like to present it to an audience of specialists in functional differential equations here as it shows that time delay could play a fundamental role also in quantum physics – thereby opening up a range of new research problems and possible new applications of functional differential equations in addition to classical physics (where FDEs are more common).

Multi-time wave equations

Tue 09 Jul
19:00
Poster
KO

Matthias Lienert (University of Tuebingen)

Usually, PDEs on manifolds with multiple time directions (such as ultrahyperbolic equations) are thought of as difficult and often problematic, and there is little physical reason to consider them. However, in quantum physics, one routinely considers wave functions on configuration spaces such as $\mathbb{R}^{3N}$, and their natural generalization to relativity is configuration spacetime (e.g. $\mathbb{R}^{4N}$). Here, we outline the theory of wave functions on configuration spacetime, i.e., $\psi(x_1, ..., x_N)$, $x_i \in \mathbb{R}^4$, also called "multi-time wave functions". We show that, under the right circumstances, a system of N evolution equations, one for each time coordinate x_i^0, leads to a well-posed Cauchy problem with initial data on Σ^N where $\Sigma \subset \mathbb{R}^4$ is a Cauchy surface. Besides the well-posedness, several further new questions occur, e.g., boundary value problems on configuration spacetime boundaries as well as the question how to implement interaction effects between the different coordinates x_i. While these questions have originated in mathematical physics, we would here like to introduce PDE theorists to the topic of multi-time wave equations.

Existence of solutions for the perturbed fourth-order Kirchhoff type elliptic equations

Tue 09 Jul
19:00
Poster
KO

Hueili Lin (Chang Gung University)

The elliptic equation $-M(\int_\Omega |\nabla u|^2 \, dx)\triangle u = f(x,u) in \Omega$ is related to the stationary problem

$$\rho \frac{\partial^2 u}{\partial t^2} - (\frac{\rho_0}{h} + \frac{E}{2L}(\int_0^L \left|\frac{\partial u}{\partial x}\right|^2 dx))\frac{\partial^2 u}{\partial x^2} = 0.$$

It is an extension for the classical D'Alembert's wave equation for free vibrations of elastic strings. In this poster, we consider the following perturbed fourth-order Kirchhoff type elliptic equation: let $M : [0, \infty) \to R$ be a continuous function, $f : \Omega \times R \to R$ be a Caratheodory function, and

$$\begin{cases} \triangle^2 u - M(\int_\Omega |\nabla u|^2 \, dx)\triangle u + \mu u = \lambda f(x,u) \quad in\Omega; \\ u = \triangle u = 0 on \partial\Omega, \end{cases}$$

where λ, $\mu > 0$, $\Omega \subset R^N$ is a bounded domain with smooth boundary $\partial\Omega$. By using the variational methods and critical point theory, we investigate the existence of nontrivial solution for this equation.

Singular Optimal Control of a 1-D Parabolic-Hyperbolic Degenerate Equation

Mon 08 Jul
17:30
MS32
KO-10

Pierre Lissy (Université Paris-Dauphine)

Co-authors: Morgan Morancey (Université Aix-Marseille), Dario Prandi (Centrale-Supélec)

We consider the controllability of a strongly degenerate parabolic equation with a degenerate one-order transport term. Despite the strong degeneracy, we prove a result of well-posedness and null controllability with a Dirichlet boundary control that acts on the degenerate part of the boundary. Then, we study the uniform controllability in the vanishing viscosity limit and prove that the cost of the control explodes exponentially fast in small time and converges exponentially fast in large time in some adapted weighted norm. The main tools used are a spectral decomposition involving Bessel functions and their zeros, some usual results on admissibility of scalar controls for diagonal semigroups, and the moment method of Fattorini and Russell. This is a joint work with Mamadou Gueye (Universidad Tecnina Federico Santa Maria).

Approximating invariant slow manifolds and fast fibers in nonstandard slow-fast systems

Mon 08 Jul
17:30
MS8
KO-7

Ian Lizarraga (University of Sydney)

This talk concerns the computational singular perturbation (CSP) method, which has been used in chemical kinetics to categorize reactions by their characteristic timescales. We discuss how to adapt the CSP method to iteratively approximate the slow manifold and fast fibers of dynamical systems with nonstandard timescale splitting. In such systems, there need not be an explicit global separation of slow and fast components throughout the phase space, reflecting the observation that physical systems often distinguish fast versus slow mechanisms and reactions rather than fast versus slow variables.Along with giving the first examples of CSP applied to genuinely nonstandard systems, we recast the CSP step as a refinement of a natural factorization that can be constructed for a class of nonstandard slow-fast vector fields.

Invasion Fronts Outside the Homoclinic Snaking Region in the Planar Swift-Hohenberg Equation

Thu 11 Jul
10:15
MS2
KO-5

David Lloyd (University of Surrey)

We investigate the depinning of fronts near the homoclinic snaking region, involving a spatially periodic cellular pattern embedded in a quiescent state, in the two-dimensional Swift-Hohenberg equation. We focus on stripes (parallel, oblique and perpendicular), almost planar, and cellular hexagon depinning fronts. We show that invading depinning fronts select both a far-field wavenumber and a propagation wavespeed whereas we expect retreating depinning fronts come in one-parameter families. Employing a far-field core decomposition, we derive a boundary value problem for the invading depinning fronts that we numerically solve and use path-following routines. We then carry out a numerical investigation of the stripe, almost planar, and hexagon depinning fronts. It is found that in 2D, parallel stripe fronts propagate faster than oblique stripe fronts that travel faster than perpendicular stripe fronts. We find that depinning stripe fronts may regain transverse stability in the two-dimensional Swift-Hohenberg equation with a cubic-quintic nonlinearity if they travel above a critical speed. Furthermore, we find that hexagon invasion fronts that propagate in just one direction, select two far-field wavenumbers of a distorted hexagon as well as the front propagation speed. Finally, we compare the depinning fronts with time simulations of fully localised patches of hexagons and stripes to understand patch invasion.

After the Honeymoon, the Divorce: Unexpected Outcomes of Disease Control Measures

Tue 09 Jul
19:00
Poster
KO

Alun Lloyd (North Carolina State University)

We lack effective vaccines for many infections, so disease control measures often instead attempt to directly reduce transmission. As an example, the main control measure for the the mosquito-borne dengue virus has been mosquito control, e.g. by spraying insecticide aimed at adult insects. In this talk we discuss counter-intuitive behavior that can result when such control measures are employed for a transient period against an endemic infection. Building on an observation in a recent study of Okamoto et al., we demonstrate the epidemiologically-troubling result that there can be time windows over which the total number of disease cases can exceed the number that would have occurred if no intervention had been employed: accumulation of susceptibles during the control can lead to a large outbreak following the end of the control. This outbreak can be so severe that all the benefit accrued during control can be overcome. We show that this phenomenon can occur in a broad class of infection models and discuss public health implications, including for clinical trials of proposed control measures.

An asymptotic preserving multilevel Monte Carlo method for particle based simulation of kinetic equations

Tue 09 Jul
19:00
Poster
KO

Emil Loevbak (KU Leuven - FWO)

Co-authors: Giovanni Samaey (KU Leuven), Stefan Vandewalle (KU Leuven)

Classical particle based simulations of hyperbolic transport equations suffer from severe stiffness as they approach their diffusive limit, i.e., the number of collisions approaching infinity for a finite velocity. The resulting time step constraints cause simulations costs to become prohibitive. In [1], a new Monte Carlo scheme was developed that avoids this time step constraint, at the cost of introducing a bias in the simulated model. In [2], we applied the Multilevel Monte Carlo method [3] to a simplified two speed version of this scheme, as a bias reduction method. In this talk, we will present an extension of this work where we simulate the continuous speed version of the scheme. We will also present some new insights into level placement strategies when simulating these schemes. References: [1] G. Dimarco, L. Pareschi and G. Samaey. Asymptotic-Preserving Monte Carlo methods for transport equations in the diffusive limit. SIAM Journal on Scientific Computing, 40: A504âĂŞA528, 2018. [2] E. LÃÿvbak, G. Samaey, S. Vandewalle. A Multilevel Monte Carlo Asymptotic-Preserving Particle Method for Kinetic Equations in the Diffusion Limit. arXiv:1902.04347, 2019. [3] M.B. Giles. Multilevel Monte Carlo Path Simulation. Operations Research, 56(3):607-617, 2008.

Rayleigh-Benard heat convection problem for the micropolar fluid and Navier–Stokes models

Mon 08 Jul
16:30
CT5
KO-2

Grzegorz Łukaszewicz (University of Warsaw)

Co-authors: Piotr Kalita (Jagiellonian University), Jose Langa (Universidad de Sevilla)

We compare the micropolar fluid model – describing fluids with microstructure, and the Navier-Stokes model – describing homogeneous fluids, in the context of the Rayleigh–Benard heat convection problem. Our aim is to show that the presence of microstructure makes the fluid flow more stable and also decresaes heat convection. The results are expressed in terms of upper estimates of the critical Rayleigh number, the dimension of the global attractor, and the Nusselt number, respectively, for both models.

Hyperbolic expansions with arbitrary limit shape

Thu 11 Jul
09:45
MS27
KO-11

Ezequiel Maderna (Universidad de la República)

Co-authors: Ezequiel Maderna (Universidad de la República)

A well-known fact in the classical N-body problem is that if we normalize by the size of the configuration a completely parabolic motion, then the normalized configuration converge to the set of central configurations. We will show that there is no such restriction for motions with positive energy. Moreover, we will show the existence of hyperbolic motions with arbitrarily chosen limit shape, and this for any given initial configuration of the bodies. The energy level $h > 0$ of the motion can also be chosen arbitrarily. The proof uses variational methods and represents a new application of Marchal's theorem, whose main use in recent literature has been to prove the existence of periodic orbits. Joint work with A.Venturelli.

Calculus and flows on logarithmic lattices

Fri 12 Jul
09:25
CT23
KO-1

Alexei Mailybaev (IMPA, Rio de Janeiro)

Co-authors: Alexei Mailybaev (IMPA, Rio de Janeiro), Ciro Campolina (IMPA, Rio de Janeiro)

We consider logarithmically spaced lattices $\mathbb{L} = \{\pm\lambda^n,\ n \in \mathbb{Z}\}$ for some spacing factor $\lambda > 1$ and their generalizations to higher dimensions, $\mathbb{L}^d$. The motivation is to define functional spaces, which may serve for the study of multi-scale properties of PDEs such as, e.g., Navier–Stokes equations.The technique is to define basic operations, which allow to sum, multiply and differentiate fields on such lattices and satisfy basic properties of the usual calculus. It turns out that such constructions are only possible for a discrete set of spacing factors, including 2, golden mean, etc. We provide a classification of such spaces.Then, we can study the evolution of flows on logarithmical lattices governed by equation of motions formally identical to their PDE analogues. For example, one can study PDEs describing fluid flows. The advantage is that the logarithmic model covers a large range of scales with much fewer degrees of freedom, while it automatically preserves nontrivial features of the original PDEs such as symmetries and conservation laws. Such application to the problem of a finite-time blowup for the incompressible 3D Euler equations was recently reported by the authors in [PRL 121, 064501 (2018)]. We will discuss further implications of this approach for the theory of differential equations and applications.

Spontaneously stochastic solutions in dynamical systems with singularities

Thu 11 Jul
08:45
MS15
KO-9

Alexei Mailybaev (IMPA, Rio de Janeiro)

Co-authors: Alexei Mailybaev (IMPA, Rio de Janeiro), Theodore Drivas (Princeton University), Artem Raibekas (UFF, Rio de Janeiro)

We consider a class of dynamical systems described by ordinary differential equations with an isolated singularity, where the singularity is characterized by the lack of Lipschitz continuity. Singularities are common in applications both for ODEs (e.g., particles collisions) and PDEs (e.g., finite-time blowup). The fundamental obstacle is that solutions cannot be continued past the singularity uniquely: typically, there are infinitely many solutions. A physically motivated way to proceed is to define a regularization limit, such as vanishing viscosity or noise. It turns out that there are structurally stable situations when such a limit is not sensitive to a particular form of the regularization. This is explained by the analysis of attractors for the rescaled (non-singular) dynamical system and their ergodic properties. What is even more surprising is that solutions in this limit may become probabilistic (spontaneously stochastic) with the unique probability measure past the singularity. We will present rigorous results and discuss applications of this phenomenon.

Equations of Linear Non-Radial Oscillations of Gaseous Stars

Tue 09 Jul
09:05
CT9
KO-3

Tetu Makino (Yamaguchi University)

The linearized operator for non-radial oscillations of spherically symmetric self-gravitating gaseous stars is analyzed in view of the functional analysis. The evolution of the star is supposed to be governed by the Euler-Poisson equations under the equation of state of the ideal gas, and the motion is supposed to be adiabatic. We consider the case of not necessarily isentropic, that is, not barotropic motions. Basic theory of self-adjoint realization of the linearized operator is established. Some problems in the investigation of the concrete properties of the spectrum of the linearized operator are proposed. The detailed of discussion can be found in the preprint ArXiv:1902.03675.

Nonlocal solutions of parabolic equations

Luisa Malaguti (University of Modena and Reggio Emilia)

Co-authors: Irene Benedetti (University of Perugia), Valentina Taddei (Univesity of Modena and Reggio Emilia)

Mon 08 Jul
15:00
MS16
KO-9

The paper deals with second order parabolic equations on bounded domains with Dirichlet conditions in arbitrary Euclidean spaces. Their interest comes from being models for describing reactionâĂŞdiffusion processes in several frameworks. A linear diffusion term in divergence form is included which generates a strongly elliptic differential operator. A further linear part, of integral type, is present which accounts of nonlocal diffusion behaviours. The main result provides a unifying method for studying the existence and localization of solutions satisfying nonlocal associated boundary conditions. The Cauchy multipoint and the mean value conditions are included in this investigation. The problem is transformed into its abstract setting and the proofs are based on the homotopic invariance of the LerayâĂŞSchauder topological degree. A bounding function (i.e. Lyapunov-like function) theory is developed, which is new in this infinite dimensional context. It allows that the associated vector fields have no fixed points on the boundary of their domains and then it makes possible the use of a degree argument.

On Some Important q-calculus Results in Quantum Geometry with Applications

Thu 11 Jul
17:30
CT19
KO-1

Olaniyi Maliki (Michael Okpara Federal University, Umudike Nigeria)

Co-authors: Chisom Onwuegbulam (Abia State University, Uturu)

We study the concept of q-calculus in quantum geometry. This involves the q-differential and q-integral operators. With these we study the basic rules governing q-calculus as compared with the classical Newton-Leibnitz calculus, and obtain some important results. We introduce the reduced q-differential transform method (RqDTM) to solve a q-diffusion partial differential equation. The analytical solution obtained is shown to correspond to that of the classical diffusion equation when q = 1.

Localization and landscape functions on quantum graphs

Tue 09 Jul
17:00
MS6
KO-4

Anna Maltsev (Queen Mary University of London)

I will discuss localization and other properties of eigenfunctions of the Schrodinger operator on quantum graphs. The motivation is to understand how graph structure impacts eigenfunction behavior. I will present two estimates based on the Agmon method to show that a tree structure aids the exponential decay at energies below the essential spectrum. I will furthermore present adaptations of the landscape function approach, well-established for $\mathbb{R}^n$, to quantum graphs and its limitations. In our context, a "landscape function" $\Upsilon(x)$ is a function that controls the localization properties of normalized eigenfunctions $\psi(x)$ through a pointwise inequality of the form $|\psi(x)| \leq \Upsilon(x)$. The connectedness of a graph can present a barrier to the existence of universal landscape functions in the high-energy regime, as we demonstrate with simple examples. However, at low and moderate energies landscape functions can be made explicit. This talk is based on joint work with Evans Harrell.

Some nonlinear models for crime with theoretical and applied results

Tue 09 Jul
15:30
CT11
KO-2

Raul Manasevich (University of Chile)

In this talk we begin by reviewing some nonlinear pde results for crime based on repeated and near repeat victimization to continue with concrete applications of these concepts to predict victimization for police and also for malls chains. Tools we use come from elliptic systems, parabolic systems, for the theoretical results, and machine learning like support vector machines and neuronal networks for the applications.

Counter-propagating wave patterns in a swarm model with memory

Tue 09 Jul
08:45
MS9
KO-8

Angelika Manhart (Imperial College London)

Hyperbolic transport-reaction equations are abundant in the description of movement of motile organisms. I will focus on a system of four coupled transport-reaction equations that arises from an age-structuring of a species of turning individuals. Modeling how the behavior depends on the time since the last reversal introduce a memory effect. The highlight consists of the analysis of counter-propagating traveling waves, patterns which have been observed in bacterial colonies: We find two families of interacting traveling waves whose discontinuous profiles remain unchanged, but whose composition is modified by the oncoming wave. I will discuss the explicit construction of such waves, show stability results and simulations.

Can computers learn how animals flock?

Mon 08 Jul
16:30
MS29
KO-6

Angelika Manhart (Imperial College London)

Co-authors: John Nardini (NC State University), Kathleen Storey (University of Michigan), Lori Ziegelmeier (Macalester College), Dhananjay Bhaskar (Brown University), Chad Topaz (Williams College)

Collective behavior is common in biology, impressive examples include flocks of birds or schools of fish. In this study use modern techniques to take a fresh look at a classical model: The DâĂŹOrsogna model, which is a powerful agent-based framework, describing self-propelled individuals that interact through tunable attractive and repulsive forces. We analyze simulations of the DâĂŹOrsogna model using a topological tool known as the CROCKER plot, which captures the persistent homology of particle positions and velocities over time. The generated topological data is used as input for machine learning techniques, both supervised and unsupervised, in order to classify emergent behavior and to predict the used model parameters. We compare the classification performance of topological features with a more traditional parameter identification approach, involving the calculation of order parameters that describe global properties (avg. angular momentum, polarization, etc.) of swarms.

Asymptotic analysis of regularly varying solutions of half-linear differential equations

Mon 08 Jul
14:00
MS16
KO-9

Jelena Manojlovic (University of Nis, Faculty of Science and Mathematics)

Co-authors: Takasi Kusano (Hiroshima University, Department of Mathematics, Faculty of Science)

We present results on the asymptotic behavior of eventually positive solutions of half-linear differential equation

$$(p(t)|x'|^{\alpha}\mathrm{sgn}\ x')' + q(t)|x|^{\alpha}\mathrm{sgn}\ x = 0\,,$$

with q be continuous functions which may take both positive and negative values in any neighborhood of infinity and p be positive continuous functions satisfying one of conditions

$$\int_a^{\infty} \frac{ds}{p(s)^{1/\alpha}} = \infty \quad \text{or} \quad \int_a^{\infty} \frac{ds}{p(s)^{1/\alpha}} < \infty\,.$$

With the help of Karamata theory of regular variation, asymptotic formulas for generalized regularly varying solutions will be established.

(In)Stability of travelling waves in a model of haptotaxis

Tue 09 Jul
16:30
MS9
KO-8

Robert Marangell (University of Sydney)

Co-authors: Kristen Harley (unknown), Peter van Heijster (Queensland University of Technology), Graeme Pettet (unknown), Timothy Roberts (University of Sydney), Martin Wechselberger (University of Sydney)

I will consider the spectral stability of travelling waves found in a model of haptotaxis. In the process I will apply Liénard coordinates to the linearised stability problem and develop a new method for numerically computing the Evans function and point spectrum of a linearised operator associated with a travelling wave. I will show the instability of non-monotone waves (type IV) and numerically establish the stability of the monotone ones (types I-III).

Stability of stratified equatorial flows in spherical coordinates

Fri 12 Jul
10:05
CT25
KO-3

Calin Martin (University of Vienna)

Co-authors: David Henry (University College Cork)

We present a new exact solution to the geophysical fluid dynamics governing equations for inviscid and incompressible flows in the equatorial region of the ocean. The novelty of this new solution is that it accommodates a general fluid stratification: the density may vary both with depth and with latitude. Using a short-wavelength stability analysis we prove that certain flows defined by our exact solution are stable for a certain choice of the density distribution.

Energy level approach to monodromy

Thu 11 Jul
16:30
MS13
KO-6

Nikolay Martynchuk (FAU Erlangen-Nürnberg)

Co-authors: Henk Broer (University of Groningen), Konstantinos Efstathiou (University of Groningen)

Hamiltonian monodromy was introduced by Duistermaat as the first obstruction to the existence of global action-angle coordinates in integrable Hamiltonian systems. Since then, monodromy was observed in various concrete examples of integrable systems of physics and classical mechanics. This invariant was also generalised in several different directions, including quantum mechanics and scattering theory.

In this talk, we show that Hamiltonian monodromy of an integrable system with a circle action can be computed by applying Morse theory to the Hamiltonian of the system. The main idea behind this result goes back to F. Takens. We explain it in detail on a few examples. Connections of the result to some of the existing approaches to monodromy will also be discussed.

This is a report on a joint work with H.W. Broer and K. Efstathiou.

Asymptotic profiles of solutions and propagating terrace for a free boundary problem of nonlinear diffusion equation with positive bistable nonlinearity

Thu 11 Jul
17:30
CT22
KO-5

Hiroshi Matsuzawa (National Institute of Technology, Numazu College)

Co-authors: Yuki Kaneko (Waseda University), Yoshio Yamada (Waseda Univeraity)

In this talk, I will treat propagating phenomena in a free boundary problem of nonlinear diffusion equation : $u_t = u_{xx} + f(u)$ $(t > 0,\ 0 < x < h(t))$ where $h(t)$ is the unknown free boundary which is determined by the Stefan condition of the form $h'(t) = -\mu u_x(t, h(t))$. In [Du-Lin, 2010], this type of problem was introduced as a model which describes the spreading of new or invasive species. From this work, propagating phenomena in the free boundary problems attract more and more attention of mathematicians. Among the various studies on the free boundary problems, recent work [Du-Matsuzawa-Zhou, 2014] showed that the profile of any spreading solution(which corresponds to the success of invasion) approaches a traveling wave solution associated with the free boundary problem, which was introduced by [Du-Lou, 2015] and is called *semi-wave*.

In this talk, I will give some recent study on propagation profiles of solutions for the free boundary problem of reaction-diffusion equation with some class of multi-stable nonlinearity. In particular, under certain condition, the profile of the spreading solution approaches a so-called *propagating terrace*. I will also present a result about radially symmetric solutions in high space dimensions.

Nonlinear stability of high-energy solitary waves in Fermi-Pasta-Ulam-Tsingou chains

Thu 11 Jul
09:45
MS11
KO-6

Karsten Matthies (University of Bath)

Co-authors: Michael Herrmann (TU Braunschweig)

The dynamical stability of solitary lattice waves in non-integrable FPUT chains is a long standing open problem and has been solved only in the KdV limit, in which the waves propagate with near sonic speed, have large wave length, and carry low energy. In this talk I explain a similar result in a complementary asymptotic regime of fast and strongly localized waves with high energy. I show that the spectrum of the linearized FPUT operator contains asymptotically no unstable eigenvalues except for the neutral ones that stem from the shift symmetry and the spatial discreteness. Then high-energy waves are linearly stable and nonlinear stability in some orbital is granted by the general, non-asymptotic part of works by Friesecke-Pego and Mizumachi. For the linear stability we first refine two-scale techniques that relate high-energy wave to a nonlinear asymptotic shape ODE and provide accurate approximation formulas. This yields the existence, local uniqueness, smooth parameter dependence, and exponential localization of fast lattice waves for potentials with algebraic singularity. Then we study the crucial eigenvalue problem in exponentially weighted spaces removing unstable essential spectrum. All proper eigenfunctions can asymptotically be linked to unique normalized solutions of the linearized shape ODE, which disproves the existence of unstable eigenfunctions in the symplectic complement of the neutral ones.

The hidden landscape of localization

Thu 11 Jul
13:45
Plenary
HK

Svitlana Mayboroda (University of Minnesota)

Complexity of the geometry, randomness of the potential, and many other irregularities of the system can cause powerful, albeit quite different, manifestations of localization: a phenomenon of confinement of waves, or eigenfunctions, to a small portion of the original domain. In the present talk we show that behind a possibly disordered system there exists a clear structure, referred to as a landscape function, which predicts the location and shape of the localized eigenfunctions, a pattern of their exponential decay, and delivers accurate bounds for the corresponding eigenvalues in the range where, for instance, Weyl law notoriously fails. We will discuss main features of this structure universally relevant for all elliptic operators, as well as specific applications to the Schrodinger operator with random potential and to the Poisson-Schrodinger drift-diffusion system governing carrier distribution and transport in semiconductor alloys.

Nonlocal interfacial dynamics in biological systems

Wed 10 Jul
08:45
MS5
KO-4

Scott McCalla (Montana State University)

Co-authors: James von Brecht (CSULB)

Biological pattern formation has been extensively studied using reaction-diffusion and agent based models. In this talk we will discuss nonlocal pattern forming mechanisms in the context of bacterial colony formation and surface striping on animals with an emphasis on arrested fronts. This will lead to a novel nonlocal framework to understand the interfacial motion in biological systems. We will then use this approach to model an interesting bacterial phenomenon, and to understand simple microscopic requirements for flat stripe solutions to persist in nature. We will then examine moving defect patterns in the nonlocal framework.

Quantifying Zebrafish Patterns: A Study of Pattern Variability and Robustness

Mon 08 Jul
17:30
MS29
KO-6

Melissa McGuirl (Brown University)

Co-authors: Alexandria Volkening (Mathematical Biosciences Institute, Ohio State University), Bjorn Sandstede (Brown University)

Zebrafish (Danio rerio), a model organism for the study of early development and genetic disease, are characterized by their black and yellow stripes. Mutants and other members of the Danio genus exhibit a range of different patterns. Our goal is to quantify these patterns to better understand the underlying cellular and genetic mechanisms behind pattern variability in zebrafish. In this talk, we present a suite of tools with roots in topological data analysis and machine learning that we developed for zebrafish pattern quantification. We apply our methods to study zebrafish patterns simulated from the agent-based model developed by A. Volkening and B. Sandstede. Our results differentiate pattern variability across early stage mutations and identify key model parameters and underlying mechanisms which, upon perturbation, lead to pattern breakdowns. The methods developed here provide a new direction for quantifying biological patterns and studying mathematical models of pattern formation.

A consistent framework for stochastic representation of large-scale geophysical flows

Wed 10 Jul
09:15
MS30
KO-7

Etienne Memin (INRIA)

In this talk, I will describe a formalism, called modelling under location uncertainty (LU), to derive in a systematic way large-scale stochastic representations of fluid flows dynamics that enables to take into accountthe inherent uncertainty attached to the flow evolution. The uncertainty introduced here is described through a random field and aims at representing principally the small-scale effects that are neglected in the large-scale evolution model. The resulting large-scale dynamics is built from a stochastic representation of the Reynolds transport theorem. This formalism enables, in the very same way as in the deterministic case, a physically relevant derivation (i.e. from the usual conservation laws) of the sought evolution laws. We will in particular show how to derive systematically stochastic representation of geophysical flow dynamics and how reduced order stochastic dynamical systems can be derived as well. We will give several examples of simulations obtained by such system and how they can be used in different contexts. In the quasi-geostrophic case, we will in particular focus on the quantities conserved by this modeling (total energy) and a modified potential vorticity that involves the effect of the unresolved scales.

Oscillations in a cAMP signaling model for cell aggregation – a geometric analysis

Tue 09 Jul
19:00
Poster
KO

Zhouqian Miao (Vienna University of Technology)

We study a singularly perturbed model for a cyclic adenosine monophosphate (cAMP) signaling system that controls aggregation of the amoeboid microorganism Dictyostelium discoideum. The model, which is based on a classical model due to Martiel and Goldbeter, takes the form of a planar system of ordinary differential equations with two singular perturbation parameters which manifest very differently: while one parameter encodes the separation of scales between the slow and fast variables, the other induces a non-uniformity in the corresponding vector field in the singular limit. We apply geometric singular perturbation theory and the desingularisation technique known as “blow-up" to construct a family of attracting, periodic (relaxation-type) orbits; in the process, we elucidate the novel singular structure of the model, and we describe in detail the resulting oscillatory dynamics

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Regularity of SchrÃűdinger's functional equation

Tue 09 Jul
08:45
MS34
KO-11

Toshio Mikami (Tsuda University)

We discuss the continuity and the measurability of the solution to SchrÃűdinger's functional equation, with respect to space, kernel and marginals, provided the space of all Borel probability measures is endowed with the weak or strong topology. This is important since it solves a class of the mean field PDEs. We also construct a convex function of which the moment measure is a given probability measure, by the zero noise limit of a class of stochastic optimal transportation problems.

The parameterization method, transverse intersections, and computer assisted proof in celestial mechanics

Mon 08 Jul
14:30
MS1
KO-4

Jason Mireles James (Florida Atlantic University)

I will discuss strategies for combining the parameterization method for invariant objects with tools from validated numerics and functional analysis to solve some problems in celestial mechanics.

The fast signal diffusion limit in a minimal Keller–Segel system under smallness conditions for initial data

Thu 11 Jul
09:45
CT17
KO-2

Masaaki Mizukami (Tokyo University of Science)

The subject of this work is to construct a new approach to a parabolic-elliptic Keller-Segel system from its parabolic-parabolic case, and to use the parabolic-parabolic case as a step to establish new results in the parabolic-elliptic case. More precisely, this work deals with convergence of a solution for the parabolic-parabolic Keller-Segel system

$$\begin{cases} (u_\lambda)_t = \Delta u_\lambda - \chi\nabla\cdot(u_\lambda\nabla v_\lambda) & \text{in } \Omega\times(0,\infty),\\ \lambda(v_\lambda)_t = \Delta v_\lambda - v_\lambda + u_\lambda & \text{in } \Omega\times(0,\infty)\end{cases}$$

to that for the parabolic-elliptic Keller-Segel system

$$\begin{cases} u_t = \Delta u - \chi\nabla\cdot(u\nabla v) & \text{in } \Omega\times(0,\infty),\\ 0 = \Delta v - v + u & \text{in } \Omega\times(0,\infty)\end{cases}$$

as $\lambda \searrow 0$, where Ω is a bounded domain in $\mathbb{R}^n$ $(n \geq 2)$ with smooth boundary, $\chi, \lambda > 0$ are constants.

Space-time localisation for the dynamic Φ^4_3 model

Thu 11 Jul
18:00
MS18
KO-7

Augustin Moinat (University of Warwick)
Co-authors: Hendrik Weber (University of Bath)

We prove an a priori bound for solutions of the dynamic Φ^4_3 equation. This bound provides a control on solutions on a compact space-time set only in terms of the realisation of the noise on an enlargement of this set, and it does not depend on any choice of space-time boundary conditions. For large scales we use a PDE argument based on the maximum principle, which is connected to small-scale Schauder estimates by a solution-dependent regularisation procedure. The fact that our bounds do not depend on space-time boundary conditions makes them useful for the analysis of large scale properties of solutions. This result can be used in a compactness argument to construct solutions on the full space and their invariant measures.

Algebraic structure study of vector fields near the triple-zero bifurcation point

Tue 09 Jul
09:25
CT7
KO-1

Fahimeh Mokhtari (Department of Mathematics, Faculty of Sciences, Vrije Vrije Universiteit Amsterdam)
Co-authors: Jan Sanders (VU Amsterdam)

In this talk, a review will be given of the developments in the last decade concerning the classification of unique normal forms in 3D nilpotent problems.This work generalizes the work on the Bogdanov-Takens bifurcation and its unique normal form, which took off with the papers of Baider and Sanders (1991-92). Here the application of the Jacobson-Morozov theorem led to a systematic approach to computing the unique normal form in a number of cases. Some of the subcases of the 2D double-zero bifurcation analysis are still open.One can imagine that the complications of analyzing the 3D triple-zero bifurcation are rather challenging. Nevertheless, progress has been made in the last decade and it is time to list what has been done and what still needs to be done.We apply the JacobsonâĂŞMorozov theorem to embed this class of three dimensional vector fields into an $\mathfrak{sl}_2$-triple. Three irreducible families are produced this way.The first task is to find the structure constants of these families. In this talk, we also show how the Clebsch-Gordan formula is employed to find explicit formulas for the structure constants. We demonstrate that these families can generate some Lie sub-algebras with respect to the triple-zero bifurcation point, thereby creating smaller subproblems that can be studied independently in their own right (like the Hamiltonian case in the 2D analysis).Further, we discuss possible generalizations toward a general n-dimensional theory.

KAM theory and long time dynamics around finite gap solutions of KdV equations

Tue 09 Jul
15:30
MS12
KO-9

Riccardo Montalto (University of Milan)

In this talk I will consider quasi-linear Hamiltonian perturbations of the KdV equation. It is well known that the KdV equation possesses family of (large) quasi-periodic solutions. For the quasi-linear perturbations of the KdV, i will present two results:1) an existence result of quasi-periodic solutions close to the finite gap solutions of the KdV 2) A stability result for the Cauchy problem for initial data close to the finite gaps.

Necessary Condition for Local Controllability

Wed 10 Jul
09:05
CT14
KO-2

Clément Moreau (Inria)
Co-authors: Laetitia Giraldi (Inria), Pierre Lissy (Université Paris-Dauphine), Jean-Baptiste Pomet (Inria)

Local controllability around an equilibrium is an important notion within control theory. Necessary or sufficient conditions for small-time local controllability (STLC) have been much investigated in the last decades. Some powerful sufficient conditions have been stated; however, most necessary conditions for STLC are more specific and deal with scalar-input control systems, among which a necessary condition proved by Sussmann in 1983. The purpose of this talk is to present how to extend this necessary condition to a particular class of systems with two controls, in which the field associated to the second control vanishes at the equilibrium point. In this case, the second control may allow better local controllability in some sense, provided the control vector fields verify a Lie bracket hypothesis. We prove this result using the Chen-Fliess series, and apply it to the example of a magnetic micro-swimmer model.

Topology of saddle atoms-bifurcations for the billiards in non-convex domains

Tue 09 Jul
19:00
Poster
KO

Viktor Moskvin (Moscow State University)

A billiard is a dynamical system in which a particle alternates between motion in a straight line and specular reflection from a boundary. We used FomenkoâĂŹs theory [1] to describe topology of joint integrable surfaces. In this report we are going to discuss billiards with nonconvex angles bounded by arcs of several confocal conics [2]. The integral trajectory of the flow going into a singular point can not be extend for the all values of the parameter (time). In contrast to the classical case of complete flows, the regular leaves of the Liouville foliation are the spheres with handles and punctures, rather than Liouville tori.

Thm. (V.Moskvin, 2018) Consider billiard Ω on the plane. Let $\Sigma_1, \ldots, \Sigma_N$ be a full partition of billiard Ω. 2-dimmensional singular fiber of 3-dimmensional atom can be algorithmically constructed of $(4N)$ disks $I \times I$ and (n) 1-dimmensional graphs, here $n \leq 4N - 1$.

This work was supported by the program “Leading Scientific Schools” (grant no. NSh-6399.2018.1, Agreement No. 075-02-2018-867)[1] A.V. Bolsinov and A.T. Fomenko, Integrable Hamiltonian Systems. Geometry, Topology, Classification., Chapman/ Hall/CRC, Boca Raton, 2004. [2] V. Dragovic, M. Radnovic, Pseudo-integrable billiards and arithmetic dynamics, Journal of Modern Dynamics, Volume 8, No. 1, 2014, 109-132 p.

Nonpersistence of periodic orbits, homoclinic orbits, first integrals, and commutative vector fields in perturbed systems

Wed 10 Jul
09:05
CT13
KO-1

Shoya Motonaga (Kyoto University)
Co-authors: Kazuyuki Yagasaki (Kyoto University)

Determination of whether periodic orbits, homoclinic orbits, firstÂăintegrals or commutative vector fields persist under perturbationsÂăis one of the most important problems in the field of dynamical systems.ÂăIn this talk, we give several theorems on necessary conditions for theirÂăpersistence in general perturbed systems. Moreover, we consider periodic perturbations of one-degree-of-freedom Hamiltonian systems andÂădescribe some relationships between our results and the standardÂăMelnikov method for periodic orbits and homoclinic orbits.

Existence and regularity for the non-linear Koiter shell interacting with the $3d$ incompressible fluid

Mon 08 Jul
17:10
CT4
KO-1

Boris Muha (Department of Mathematics, Faculty of Science, University of Zagreb)
Co-authors: Sebastian Schwarzacher (Charles University, Prague)

We study the unsteady Navier Stokes equations in three dimensions interacting with a non-linear flexible shell of Koiter Type. The latter one constitutes a moving part of the boundary of the physical domain of the fluid. This leads to a coupled system of non-linear PDEs with the moving boundary. We study weak solution to the corresponding fluid-structure interaction (FSI) problem. We introduce new methods that allow to prove higher regularity estimates for the shell. Due to the improved regularity estimates it is then possible to extend the known existence theory of weak solutions to the FSI problem with non-linear Koiter shell.

Interacting manifolds and recurrent dynamics near a slow-fast Shilnikov homoclinic bifurcation

Tue 09 Jul
09:45
CT7
KO-1

Jose Mujica (Universidad Tecnica Federico Santa Maria)

We study a three-dimesional slow-fast system having a saddle-focus equilibrium p that undergoes a singular Hopf bifurcation and has a two-dimensional unstable manifold $W^u(p)$ and a one-dimensional stable manifold $W^s(p)$. There is a global return mechanism in the system, which allows for the existence of recurrent dynamics in the form of mixed-mode oscillations (MMOs) for parameter values where the unstable manifold $W^u(p)$ interacts with a repelling slow manifold. The system encompasses the Koper model for an idealized chemical reaction, which shows evidence of having a Shilnikov homoclinic bifurcation involving slow and fast motion. We detect and identify two such Shilnikov orbits and describe their interactions with the MMOs created in interactions between the manifolds mentioned above. Furthermore, we study the overall dynamics organized by these global orbits. This involves the computation of the invariant manifolds of a saddle periodic orbit to reveal different sources of recurrent dynamics, including the existence of a chaotic attractor. To this end, we compute the manifolds via the continuation of a suitable two-point boundary value problem with the software AUTO.

Existence of solutions for mathematical model of brewing Sake and some properties of solutions

Mon 08 Jul
14:40
CT3
KO-3

Yusuke Murase (Meijo University)

A. Ito and Y. Murase constructed mathematical model which represents brewing process of Japanese Sake in 2014. The original mathematical model is configured 15 PDEs and a constraint conditions. In abstractly, the model corresponds to quasi-variational inequalities. We showed an existence result for simple-type model with regularized constraint conditions in the paper in 2014. At this time, we study the simple model without regularization. In this talk, I'll show you an existence result of weak solutions for our simple model with original constraint conditions, some properties for weak solutions, and some numerical simulations.

Inverse scattering transform for the integrable nonlocal nonlinear SchrÃűdinger equation

Tue 09 Jul
15:30
MS11
KO-6

Ziad Musslimani (Florida State University)

A nonlocal nonlinear SchrÃűdinger (NLS) equation was recently introduced in Phys.Rev.Lett. 110, 064105 (2013) and shown to be an integrable infinite dimensional Hamiltonian evolution equation. In this talk we present a detailed study of the inverse scattering transform of this nonlocal NLS equation. The direct and inverse scattering problems are analyzed. Key symmetries of the eigenfunctions and scattering data and conserved quantities are discussed. The inverse scattering theory is developed by using a novel left-right RiemannâĂŞHilbert problem. The Cauchy problem for the nonlocal NLS equation is formulated and methods to find pure soliton solutions are presented; this leads to explicit time-periodic one and two soliton solutions. A detailed comparison with the classical NLS equation is given and brief remarks about nonlocal versions of the modified KortewegâĂŞde Vries and sine-Gordon equations are made.

Nonuniqueness of solution for a sytem of nonlinear Volterra type integral equations

Tue 09 Jul
19:00
Poster
KO

Wojciech Mydlarczyk (Department of Computer Science, Faculty of Fundamental Problems of Technology, Wroclaw University of Science and Technology)

For Volterra type integral equation: $u(t) = \int_0^t k(t-s, u(s))ds$, where a kernel $k(t,u) \geq 0$ is monotonic, continuous and satisfies $k(t,0) \equiv 0$ we observe that either it has only a trivial solution $u(t) \equiv 0$ or besides the trivial solution it has also a nontrivial maximal solution $\bar{u}(t) > 0$ and all other solutions are of the form: $u_c(t) = u(t-c)$ for $t > c$ and equal to 0 otherwise. Using the monotonicity methods we show that a similar interesting phenomenon of nonuniqueness of solution is observed also in the case of chosen systems of Volterra integral equations

$$\begin{cases} u(t) = \int_0^t k(t-s, u(s), v(s))ds \\ v(t) = \int_0^t h(t-s, u(s), v(s))ds \end{cases}$$

We describe solutions of such systems and give their properties focusing on their blowing up behaviour.

Threshold solutions for semilinear heat equations with polynomial decay initial data

Fri 12 Jul
10:05
CT24
KO-2

Yuki Naito (Ehime University)

We consider the asymptotic behavior of solutions of the Cauchy problem for the semilinear heat equation $u_t = \Delta u + u^p$ for $t > 0$ with $u(x, 0) = \phi(\alpha, x)$, where α is a parameter and ϕ has the polynomial decay at $|x| = \infty$ for each fixed α. We study the case where initial data have the critical polynomial decay $|x|^{-2/(p-1)}$ at $|x| = \infty$, and discuss the behavior of solutions by means of the potential well with forward self-similar transformation. In particular, we are interested in the behavior of the threshold solutions between global existence and blow-up.

Period two solutions of distributed delay differential equations

Tue 09 Jul
09:45
MS17
KO-10

Yukihiko Nakata (Department of Mathematical Sciences, Shimane University)

The existence of periodic solutions has been studied in the literature of delay differential equations. In particular, scalar differential equations with discrete delay such as the WrightâĂŹs equation as a famous example, have been intensively studied. In this presentation, we focus on differential equations with distributed delay, not discrete delay, and discuss the existence of periodic solutions of delay differential equations. We show that a class of distributed delay differential equations has periodic solutions with period two (where the maximum delay is normalized to be one). Main idea of the proof is to deduce a second order ordinary differential equation by the Kaplan and Yorke type ansatz. We also show that some differential equations with distributed delay have periodic solutions expressed in terms of the Jacobi elliptic functions.

Comparison of integer-order and fractional-order chaotic systems from the stability viewpoint

Wed 10 Jul
09:25
CT13
KO-1

Luděk Nechvátal (Institute of Mathematics, Brno University of Technology)

Many (integer-order) chaotic nonlinear systems are nowadays quite well explored, in particular, various (in)stability scenarios depending on the system's parameters have been reported. Switching to fractional-order counterparts of the studied systems and considering the fractional order as varying, then the order can be viewed as an additional control/bifurcation parameter, hence, the dynamics is in some sense enriched. In general, decreasing the fractional order (towards zero) causes a damping effect (a chaotic system tends to evolve more regularly). In this contribution, we focus on the Lorenz, RÃűssler and Chen systems and point out some similarities/discrepancies between the dynamics of the standard (integer-order) and fractional-order versions. Especially, the issue of a fractional Hopf bifurcation is discussed.

Random walk approximations to sub-Riemannian diffusions

Mon 08 Jul
14:30
MS32
KO-10

Robert Neel (Lehigh University)

We study a variety of geometrically-motivated random walks on sub-Riemannian manifolds and their diffusion limits under parabolic scaling, which give, via their infinitesimal generators, second-order operators on the manifolds. A primary motivation is the lack of a canonical sub-Laplacian in sub-Riemannian geometry, and thus we are particularly interested in the relationship between the infinitesimal generators, the geodesic structure, and operators which can be obtained as divergences with respect to various choices of volume.

This talk is based on joint work with Ugo Boscain, Luca Rizzi, and Andrei Agrachev.

Product Limit Law in ASEP

Fri 12 Jul
09:15
MS19
KO-8

Peter Nejjar (IST Austria)

We consider the asymmetric simple exclusion process (ASEP) on $\mathbb{Z}$ with an initial data such that in the large time particle density $\rho(\cdot)$ a discontinuity at the origin is created, where the value of ρ jumps from zero to one, but $\rho(-\varepsilon), 1-\rho(\varepsilon) > 0$ for any $\varepsilon > 0$. We consider the position of a particle x_M macroscopically located at the discontinuity, and show that its limit law has a cutoff at the origin. Inside the discontinuity region, we show that a discrete product limit law arises, which bounds from above the fluctuations of x_M in the general ASEP, and equals them in the totally ASEP. Sending $M \to \infty$ we obtain a product of Tracy-Widom GUE distributions.

Characterizing Pattern Forming Systems with Topological Data Analysis

Tue 09 Jul
09:15
MS29
KO-6

Rachel Neville (The University of Arizona)

Complex spatial-temporal patterns can be difficult to characterize quantitatively. In particular, distinguishing between visually similar patterns formed under different conditions is challenging. These small differences are detectable by persistent homology. We describe how persistent homology can be used as a low-dimensional quantitative summary of topological structure of dynamic data. These summaries retain a remarkable amount of information that allows for the investigation of the influence of nonlinear parameters, classification of data by parameters, and study of defect evolution.

Linear inviscid damping and enhanced viscous dissipation of shear flows via conjugate operator method

Tue 09 Jul
16:30
MS21
KO-12

Toan Nguyen (Penn State University)
Co-authors: Emmanuel Grenier (ENS de Lyon)

I shall present a joint work with E. Grenier, F. Rousset, and A. Soffer where we introduce an Hamiltonian approach, inspired by the conjugate operator method, to prove the inviscid damping and the enhanced viscous dissipation, with sharp decay in time for monotone shear flows.

Quasi periodic coorbital motions

Wed 10 Jul
09:15
MS27
KO-11

Laurent Niederman (Universite Paris Sud)
Co-authors: Philippe Robutel (Observatoire de Paris), Alexandre Pousse (Observatoire de Paris)

The motions of the satellites Janus and Epimetheus around Saturn are among the most intriguing in the solar system since they exchange their orbits every four years.

In a recent paper (arXiv 1806.07262), we give a rigorous proof of the existence of quasi-periodic orbits of this kind in the three body plane planetary problem thanks to KAM theory.

We will discuss extensions of these results to get lagrangian tori in the same problem.

On the eigenvalues in the spectral bands for carbon nanotubes with impurities

Tue 09 Jul
19:00
Poster
KO

Hiroaki Niikuni (Maebashi Institute of Technology)

In this talk, we discuss the spectra of Schrödinger operators on carbon nanotubes with impurities from the point of view of the theory of quantum graphs. In the case of periodic Schrödinger operators on carbon nanotubes without impurities, it is known that the spectrum the spectrum consists of infinitely many spectral bands and the set of eigenvalues with infinite multiplicities. In this talk, we give a finite number of impurities expressed as the δ vertex conditions to the operator. As a result, we obtain additional eigenvalues embedded in the spectral bands. Furthermore, we have an estimate from below of the number of embedded eigenvalues in each spectral bands for a suitable strength of δ vertex conditions.

In this talk, we deal with symmetric impurities with respect to xy-plane and rotation. Due to the rotational symmetry, we obtain a unitary equivalence between our operator and the direct sum of a finite number of Schrödinger operators on the degenerate carbon nanotube. Furthermore, we utilize the space-symmetry on xy-plane and decompose those operators as the direct sum of the reduced operators on half size degenerate carbon nanotube with the Dirichlet and Newmann boundary condition. After those decomposition, we examine the estimate from below of the number of eigenvalues in the spectral gaps of each reduced operator. Finally, we show that those eigenvalues are embedded in the spectral bands of other reduced operators.

2D versus 1D Shallow Water equations

Wed 10 Jul
08:45
MS23
KO-8

Pascal Noble (Institut de Mathématiques de Toulouse)

In this talk, I will present a derivation of section averaged 1D shallow water type equations from the full 2D shallow water equations. The model is proved to be consistent. I will propose several numerical validations, in particular computation of backwater curves and illustrate the non consistency of some 1D shallow water models derived under the assumption that velocity profile is flat in the cross stream direction. This is joint work with J.-P. Vila and V. Michel-Dansac.

Min-max representations of viscosity solutions of Hamilton-Jacobi equations

Mon 08 Jul
14:00
MS34
KO-11

Pierre Nyquist (KTH Royal Institute of Technology)

Co-authors: Boualem Djehiche (KTH Royal Institute of Technology), Henrik Hult (KTH Royal Institute of Technology)

Motivated by the task to design efficient Monte Carlo methods for rare-event simulation, we consider the problem of finding viscosity subsolutions to first order evolutionary Hamilton-Jacobi equations that arise in the theory of large deviations. We derive a duality between the MaÃśÃľ potential and the action functional for convex and state-dependent Hamiltonians and use this duality to find min-max representations of viscosity solutions of corresponding Hamilton-Jacobi equations. These representations then naturally suggest classes of subsolutions that are useful in the context of rare-event simulation.

Some optimization problems for fractional order feedback control systems

Wed 10 Jul
09:25
CT14
KO-2

Valeri Obukhovskii (Voronezh State Pedagogical University)

We consider some optimization problems for a class of feedback control systems governed by fractional order semilinear differential inclusions in a Banach space. As example, optimization problems for a time-fractional diffusion type system which include as a particular case the same problems for a controlled process of fractional heat transfer are presented.

Existence theorem of PDE model of pattern formalization with some hysterical switching mechanism and its application to heterocyst differentiation of Terrestrial Cyanobacteria of Nostochineae

Tue 09 Jul
15:50
CT11
KO-2

Isamu Ohnishi (Hiroshima University)

We are concerned with PDE model of pattern formalization with some hysterical switching mechanism and its application to heterocyst differentiation of Terrestrial Cyanobacteria of Nostochineae. This type of cyanobacteria has BNF (biological nitrogen fixation), which is playing an important role in boreal forest in Northern California or Scandinavian peninsula through mutual symbiosis between terrestrial cyanobacteria of Nostochineae and feather mosses in boreal forest. If Nitrogen is less than a certain value, then BNF switch turns on. At this time, some of cells make differentiation to Heterocyst cells and in these cells cyanobacteria produces chemically more active nitrogen from stable nitrogen molecules (N_2). Then, at that time, a kind of pattern formalization occurs. In this talk, I'll elucidate part of the mechanism by use of PDE model. In the future, I would like to connect such a macro-scale pattern formalization with Cell-level metabolic system to comprehend the whole system mathematically, and this (and together with another my poster presentation of this kind of metabolic system in this conference Equadiff2019) are a first step to the end.

Hysterical Bifurcation Structure of modified Asakura-Honda model and its application to Circadian Rhythm and Biological Nitrogen fixation in a cell of Cyanobacteria

Tue 09 Jul
19:00
Poster
KO

Isamu Ohnishi (Hiroshima University)

A model system of ordinary differential equations describing cyanobacteriaâĂŹs circadian rhythm by use of a binary digit of memory induced by multiple covalent modification in a cell level is considered. It is mathematically rigorously proved that this system possesses bifurcation structure of hysteresis type in 1-site model. We apply it to the cyanobacterial circadian rhythm to make comparisons between some important biochemical experimental results and our simulations. These show very good agreement to elucidate theoretically fine skeleton structure with memory reinforcement effect in cell level of cyanobacteria.

(Key Words: CyanobacteriaâĂŹs circadian rhythm; Binary digit of memory; Multiple covalent modification; Cell level; Bifurcation structure.)

References:

[1] Isamu Ohnishi, Standard model of a binary digit of memory with multiple covalent modifications in a cell. J. Pure Appl. Math. Vol 2 No 1, pp1-11(2018)

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A structure-preserving scheme for the Cahn-Hilliard equation with a dynamic boundary condition

Thu 11 Jul
10:05
CT18
KO-3

Makoto Okumura (Osaka university)

We propose a structure-preserving scheme for the one-dimensional Cahn-Hilliard equation with a dynamic boundary condition using the discrete variational derivative method (DVDM). The dynamic boundary condition includes the time derivative and has been introduced to incorporate boundary effects on the order parameter u. Also, DVDM is a numerical method for designing schemes for PDEs and proposed by Furihata. DVDM schemes inherit conservative or dissipative properties from the original PDEs in a discrete sense. From the perspective of numerical computation, the properties often lead us to stable computation. Hence, if the designed schemes retain the properties in a discrete sense, then the schemes are expected stable.In this approach, how to discretize the energy which characterizes the equation, it is essential. Modifying the conventional manner and using another summation-by-parts formula, we can use a standard central difference operator as an approximation of an outward normal derivative on the discrete boundary condition. In this talk, we show that our proposed scheme has a unique solution under a condition independent of a space mesh size Δx. Moreover, we give the error estimate between the exact solution and the numerical solution of our scheme.

Ejection-collision orbits in the restricted three-body problem

Merce Olle (Universitat Politecnica De Catalunya)

Co-authors: Jaume Soler (University Politecnica de Catalunya), Oscar Rodriguez (University Politecnica de Catalunya)

Thu 11 Jul
09:15
MS27
KO-11

We analyse the ejection-collision (EC) orbits of the planar restricted three body problem. An EC orbit is an orbit that ejects from the big primary, does an excursion and collides with it. For any value of the mass parameter $\mu \in (0, 0.5]$ and sufficiently big values of the Jacobi constant, there are exactly four EC orbits. We check their existence and extend numerically these four orbits for $\mu \in (0, 0.5]$ and for smaller values of the Jacobi constant. We introduce the concept of n-ejection-collision orbits (n-ECO) and we explore them numerically for $\mu \in (0, 0.5]$ and a suitable range of values of the Jacobi constant. Finally, an analytical proof of their existence is outlined.

Traveling chimera states

Oleh Omel'chenko (University of Potsdam)

Mon 08 Jul
17:30
CT6
KO-3

We report recent results about the traveling chimera states observed in a ring of nonlocally coupled phase oscillators with broken reflection symmetry of the coupling kernel. These states manifest themselves as coherence-incoherence patterns moving along the ring. As the coupling asymmetry grows they undergo a sequence of transformations, which can be explained using the continuum limit integro-differential equation, called the Ott-Antonsen equation. In the context of this equation the chimera states are described by smooth traveling wave solutions. Using the mathematical methods from the PDE and integral equations theory we carry out asymptotic analysis of these traveling waves, describe an algorithm for their numerical continuation and explore the spectrum of the corresponding linearized equation. We show that traveling chimera states can lose their stability via fold and Hopf bifurcations. Some of the Hopf bifurcations turn out to be supercritical resulting in the observation of modulated (breathing) traveling chimera states.

Oscillation and non-oscillation criteria for certain two-dimensional system of non-linear ordinary differential equations

Zdeněk Opluštil (Institute of Mathematics,Faculty of Mechanical Engineering, BUT)

Tue 09 Jul
19:00
Poster
KO

We consider the system of non-linear differential equations

$$u' = g(t)|v|^{\frac{1}{\alpha}} \operatorname{sgn} v, \quad v' = -p(t)|u|^{\alpha} \operatorname{sgn} u,$$

where $\alpha > 0$, $g : [0, +\infty[\to [0, +\infty[$, and $p : [0, +\infty[\to \mathbb{R}$ are locally integrable functions. New oscilatory and non-oscillatory criteria are established for this system.

A particular case of the considered system is so-called "half-linear" equation

$$\left(r(t)|u'|^{q-1} \operatorname{sgn} u'\right)' + p(t)|u|^{q-1} \operatorname{sgn} u = 0,$$

where $q > 1$, $p, r : [0, +\infty[\to \mathbb{R}$ are continuous functions and r is positive. (alternatively it is referred as "equation with the scalar q-Laplacian"). In the oscillation theory, there are many interesting results for this equation, among other we generalize some of them.

On Fractional Models of Viscoelastic Fluids

Vladimir Orlov (Voronezh State University)

Thu 11 Jul
09:25
CT16
KO-1

We consider the mathematical models of dynamics of viscoelastic fluids with constitutive relations which contain fractional derivatives. We establish the existence of weak solutions of the corresponding initial-boundary value problems. In the planar case we prove the uniqueness of weak solutions and establish strong solvability of some fractional models. The approximative-topological method and nonlinear functional analysis are used.

This is a joint work with V.G. Zvyagin.

Robust chaos: a tale of blenders, their computation, and their destruction

Wed 10 Jul
09:45
CT13
KO-1

Hinke Osinga (The University of Auckland)

Co-authors: Stephanie Hittmeyer (The University of Auckland), Bernd Krauskopf (The University of Auckland), Katsutoshi Shinohara (Hitotsubashi University)

A blender is an intricate geometric structure of a three- or higher-dimensional diffeomorphism. Its characterising feature is that its invariant manifolds behave as geometric objects of a dimension that is larger than expected from the dimensions of the manifolds themselves. We introduce a family of three-dimensional HÃĨnon-like maps and study how it gives rise to an explicit example of a blender. The map has two saddle fixed points. Their associated stable and unstable manifolds consist of points for which the sequence of images or preimages converges to one of the saddle points; such points lie on curves or surfaces, depending on the number of stable eigenvalues of the Jacobian at the saddle points. We employ advanced numerical techniques to compute one-dimensional stable and unstable manifolds to very considerable arclengths. In this way, we not only present the first images of an actual blender but also obtain a convincing numerical test for the blender property. This allows us to present strong numerical evidence for the existence of the blender over a larger parameter range, as well as its disappearance and geometric properties beyond this range. We will also discuss the relevance of the blender property for chaotic attractors.

Localized oscillations in inhomogeneous FPU lattices

Thu 11 Jul
10:15
MS11
KO-6

Panayotis Panayotaros (Universidad Nacional Autonoma de Mexico)

We study localization in quartic FPU lattices with a site-dependent number of interacting neighbors. The system is derived from "elastic lattice" models used to study protein vibrations. Earlier theoretical and numerical work on model 1-D lattices and 3-D lattices obtained from protein crystallographic data suggest the possibility of stable localized oscillations in regions of higher density. We will present recent results on linear localized modes and other spectral properties of the graph Laplacian appearing in of some relevant finite and infinite 1-D lattices, as well as applications to Birkhoff normal forms leading to nonlinear localized oscillations.

Global stability for nonlinear wave equations with multi-localized initial data

Thu 11 Jul
17:00
MS31
KO-12

Federico Pasqualotto (Princeton University)

Co-authors: John Anderson (Princeton University)

The existing theory for establishing global stability of nonlinear wave equations requires initial data to be small and localized around a point. In this work, we initiate the study of the global stability of nonlinear wave equations with non-localized data. In particular, we extend the classical theory to data localized around several points. The core of our argument lies in a close inspection of the geometry of two interacting waves emanating from different localized sources. We show bilinear estimates to control such interaction, by means of a physical space method. We finally use a modified version of the classical Klainerman-Sobolev inequality, which takes into account the special structure of the data. This is joint work with John Anderson (Princeton University).

Dynamics of advection-diffusion equations with a non-linear boundary condition

Mon 08 Jul
17:30
MS35
KO-12

Antoine Pauthier (University of Minnesota)
Co-authors: Arnd Scheel (University of Minnesota)

In 2016, Goh et al studied wavenumber selection in pattern formation for the one-dimensional Swift-Hohenberg equation. Starting from a constant rest rest, these can be observed by introducing a triggering instability moving at a given speed $c > 0$. The transition between the rest state and the forming pattern is determined by a strain-displacement relation between the wave number of the forming pattern and the shift induced by the boundary condition. For $c \ll 1$, at leading order it can be derived by the phase-diffusion relation

$$\begin{cases} \partial_t u = \partial_{xx} u - c\partial_x u & x > 0,\ t > 0 \\ \partial_x u = K(u) & x = 0,\ t > 0 \end{cases}$$

where u is the phase-shift and the selected wave-number K is a periodic function. The purpose of this talk is to investigate the dynamics induced by this advection-diffusion equation with non-linear boundary condition. If The nonlinear condition is constant sign, say $K > 0$, there is no admissible stationary solution, and the dynamics is driven by a time decreasing, $x-$increasing solution, periodic modulo the period of K, therefore defined for all time t. We first prove the existence of such a periodic solution in the case $K > 0$. We then analyze the limiting case $\min K \to 0$ and prove that the corresponding solution converges either to a stationary solution or to a heteroclinic connection between two stationary solutions, and classify global in time solutions with range between two steady states.

Michaelis-Menten from an In Vivo Perspective: Open Versus Closed Systems

Thu 11 Jul
18:00
MS25
KO-11

Lambertus Peletier (Mathematical Institute, Leiden University)

Traditionally, Michaelis-Menten type reactions are studied in an in vitro environment, i.e., they are viewed as closed systems. On- and off-rate constants are usually determined in such systems. However, in modelling pharmacological processes, which involving enzymatic processes, such binding properties are used in an in vivo environment. In this lecture we discuss how the classical Michaelis-Menten dynamics is modified in the transition from an in vitro to in vivo environment.

Unstable drift of spectrally stable shifted states on star graphs

Tue 09 Jul
15:30
MS6
KO-4

Dmitry Pelinovsky (McMaster University)

When the coefficients of the cubic terms match the coefficients in the boundary conditions at a vertex of a star graph and satisfy a certain constraint, the nonlinear Schrodinger (NLS) equation on the star graphcan be transformed to the NLS equation on a real line. Such balanced star graphs appeared in the context of reflectionless transmission of solitary waves. The steady states can be translated along the edges of a balanced star graph with a translational parameter and are referred to as the shifted states. When the star graph has exactly one incoming edge and several outgoing edges, the steady states are spectrally stable if their monotonic tails are located on the outgoing edges. These spectrally stable states are degenerate minimizers of the action functional with the degeneracy due to the symmetry of the NLS equation on a balanced star graph. Nonlinear stability of these spectrally stable states has been an open problem. We prove that these spectrally stable states are nonlinearly unstable because of the irreversible drift along the incoming edge towards the vertex of the star graph. When the shifted states reach the vertex as a result of the drift, they become saddle points of the action functional, in which case the nonlinear instability leads to their destruction.

Existence and nonexistence of degenerate phase-shift multibreathers in Klein-Gordon models via dNLS approximation.

Mon 08 Jul
16:30
CT6
KO-3

Tiziano Penati (University of Milan)

We study the existence of, low amplitude, phase-shift multibreathers for small values of the linear coupling in Klein-Gordon chains with interactions beyond the classical nearest-neighbor (NN) ones. We examine initially the necessary persistence conditions of the system derived by the so-called Effective Hamiltonian Method, in order to seek for unperturbed solutions whose continuation is feasible. In the presence of degeneracy, this method does not allow us to determine if they constitute true solutions of our system. In order to overcome this obstacle, we follow a different route. By means of a Lyapunov-Schmidt decomposition, we are able to establish that the bifurcation equation for our models can be considered, in the small energy and small coupling regime, as a perturbation of a corresponding, beyond nearest-neighbor, discrete nonlinear Schrödinger equation. There, nonexistence results of degenerate phase-shift discrete solitons can be demonstrated by an additional Lyapunov-Schmidt decomposition, and translated to our original problem on the Klein-Gordon system. In this way, among other results, we can prove nonexistence of four-sites vortex-like waveforms in the zigzag Klein-Gordon model.

Nonlocal equations in perforated domains

Thu 11 Jul
17:30
CT20
KO-2

Marcone Pereira (Universidade de São Paulo)
Co-authors: Julio Rossi (Universidad de Buenos Aires)

In this talk, we analyze the asymptotic behavior of nonlocal problems widely used in the modeling of diffusion or dispersion processes. We consider an integral-differential equation, with nonsingular kernel, in a limited domain Ω from which we remove subsets that we call holes. We deal with Neumann conditions in the holes setting Dirichlet outside of Ω. Assuming the weak convergence of the family of functions which represents such holes, we analyze the limit of the solutions of the equations obtaining the existence of a limit problem. In the case where the holes are removed periodically, we observe that the critical radius is of order of the typical cell size (which gives the period). Finally we study the behavior of these problems when we resize their kernel with the objective of approaching local partial differential equations discussing peculiarities.

Personalized brain network models in clinical translation

Fri 12 Jul
09:45
MS25
KO-11

Spase Petkoski (Aix-Marseille University)

Over the past decade we have demonstrated that the fusion of subject-specific structural information of the human brain with mathematical dynamic models allows building biologically realistic brain network models, which have a predictive value, beyond the explanatory power of each approach independently. The network nodes hold neural population models, which are derived using mean field techniques from statistical physics expressing ensemble activity via collective variables. Our hybrid approach fuses data-driven with forward-modeling-based techniques and has been successfully applied to explain healthy brain function and clinical translation including stroke and epilepsy. Here we illustrate the workflow along the example of epilepsy and reconstruct personalized connectivity matrices of human epileptic patients using Diffusion Tensor weighted Imaging. During a seizure, paroxysmal activity propagates through large brain networks, which comprise brain regions that are not necessarily epileptogenic. Stability analyses of propagating waves provide a set of indices quantifying the degree of epileptogenicity and provide guidance in the presurgical evaluation of epileptogenicity based on electrographic signatures in intracerebral electroencephalograms. The example of epilepsy underwrites the predictive value of personalized large-scale brain network models.

On the co-existence of maximal and whiskered KAM tori in the three-body problem

Tue 09 Jul
08:45
MS12
KO-9

Gabriella Pinzari (University of Padova)

In the phase space of the three-body problem there is a small region where maximal and whiskered tori seem to co-exist. I shall discuss a strategy of proof of this. The talk is based on a paper published on JMP, 2018 and current work in progress.

Computer-assisted existence and multiplicity proofs for semilinear elliptic boundary value problems

Mon 08 Jul
14:00
MS1
KO-4

Michael Plum (Karlsruhe Institute of Technology (KIT))

For semilinear elliptic boundary value problems on bounded or unbounded domains, a general computer-assisted method for proving the existence of a solution in a âĂIJcloseâĂİ and explicit neighborhood of an approximate solution, computed by numerical means, is proposed. To achieve such an existence and enclosure result, we apply BanachâĂŹs fixed-point theorem to an equivalent problem for the error, i.e., the difference between exact and approximate solution. The verification of the conditions posed for the fixed-point argument requires various analytical and numerical techniques, in particular the computation of eigenvalue bounds for the linearization at the approximate solution. The method is used to prove existence and multiplicity results for various specific examples where purely analytical methods had not been successful.

Weak solutions for some compressible multicomponent fluid models

Mon 08 Jul
15:00
CT2
KO-2

Milan Pokorny (Charles University)

Co-authors: Antonin Novotny (University of Toulon)

We investigate a "viscous" version of a "simple" bi-fluid model described in [1] whose "non-viscous" version is derived in [2]. The goal is to show existence of weak solutions for large initial data on an arbitrarily large time interval. We achieve this goal by transforming the model to an academic system which resembles to the compressible Navier-Stokes equations, with however two continuity equations and a momentum equation endowed with pressure of complicated structure dependent on two variable densities. The new "academic system" is then solved by an adaptation of the Lions-Feireisl approach for solving compressible Navier-Stokes equation, completed with several observations related to the DiPerna–Lions transport theory inspired by [3] and [4].

[1] D. Bresch, B. Desjardins, J.-M. Ghidaglia, E. Grenier, M. Hilliairet. Multifluid models including compressible fluids. Handbook of Mathematical Analysis in Mechanics of Viscous Fluids, Eds. Y. Giga et A. Novotny (2018), pp. 52.

[2] M. Ishii, T. Hibiki. Thermo-fluid dynamics of two-phase flow. Springer Verlag (2006).

[3] D. Maltese, M. Michalek, P.B. Mucha, A. Novotny, M. Pokorny, E. Zatorska. Existence of weak solutions for compressible Navier-Stokes equations with entropy transport. J. Differential Equations 261, 4448–4485, 2016.

[4] A. Vasseur, H. Wen, C. Yu. Global weak solution to the viscous two-fluid model with finite energy. arXiv: 1704.07354.

Data Assimilation and Kernel Reconstruction for Neural Field Dynamics

Wed 10 Jul
08:45
MS26
KO-10

Roland Potthast (University of Reading)

Data assimilation is concerned with state estimation in dynamical systems. Methods such as three-dimensional or four-dimensional variational data assimilation have a long history and are used with large success in operational centers. Today, ensemble data assimilation and particle filters are methods which attract a lot of attention.

The reconstruction of unknown parts of some dynamical system such as structural functions or connectivity is a basic task of inverse problems, medical imaging and nondestructive testing. Here, we study the reconstruction of the neural connectivity kernel within a neural field given the full dynamical evolution. Kernels are non-local and model both short-range and long-range signal processing in living neural tissue.

We formulate an iterative data assimilation inversion method, where the activity fields of of some neural tissue is reconstructed from non-local measurements and the kernel is reconstructed given the reconstruction of the activity. This approach is iterated in the sense that the first guess for the state reconstruction can be improved based on the kernel reconstruction of step two. We provide a description of the method, numerical examples and also the basic elements of a convergence proof of the iteration when the measurement error tends to zero.

Weyl law for singular Laplace-Beltrami operators

Mon 08 Jul
17:00
MS32
KO-10

Dario Prandi (CNRS)

Co-authors: Yacine Chitour (L2S, CentraleSupelec), Luca Rizzi (CNRS, Institut Fourier, Grenoble)

In this talk we present recent results on the asymptotic growth of eigenvalues of the Laplace-Beltrami operator on singular Riemannian manifolds, where all geometrical invariants appearing in classical spectral asymptotics are unbounded, and the total volume can be infinite. Under suitable assumptions on the curvature blow-up, we show how the presence of the singularity influences the WeylâĂŹs asymptotics. Finally, we present a procedure to construct metrics with prescribed Weyl law, with a non-classical leading term.

Existence of infinitely many solutions for the Einstein-Lichnerowicz system

Fri 12 Jul
10:15
MS31
KO-12

Bruno Premoselli (Université Libre de Bruxelles (ULB))

We will consider in this talk the Einstein-Lichnerowicz system of equations. It originates in General Relativity as a way to determine initial-data sets for the evolution problem. This system takes the form of a strongly coupled, supercritical, nonlinear system of elliptic PDEs. We will investigate its blow-up properties and show that, under some assumptions on the physics data, it possesses a non-compact family of solutions. This family of solutions will be constructed by combining toplogical methods with a finite-dimensional reduction approach; due to the non-variational structure of the system, the latter has to be carried on in strong spaces and relies of a priori blow-up estimates that we shall describe.

Stability and Nonlinear Waves in Damped Driven Rotating Shallow Water Models

Tue 09 Jul
19:00
Poster
KO

Artur Prugger (University of Bremen)

Co-authors: Jens Rademacher (University of Bremen)

In the investigations of currents in the ocean and atmosphere, large scale phenomena are of primary interest. Linear waves in different geophysical flow models often characterise these motions. Nevertheless the small scale regime has important effects on the large scale and thus cannot be neglected. A major problem is to determine adequate damping and driving terms that respect energy balances and subscale features. We investigate some models of this kind with a focus on modifications of the single-layer and two-layer rotating shallow water equations. We are particularly interested in finding and analysing nonlinear waves and therefore we investigate special solutions with zero material derivative as well as stability and bifurcation behavior from linear waves. Numerical tools are also used in order to study the stability and bifurcations in these models. This project is part of TRR 181 'Energy transfers in Atmosphere and Ocean' funded by the German Research Foundation (DFG).

Numerical validation of Hopf bifurcation in Kuramoto-Sivashinki PDE

Wed 10 Jul
09:15
MS14
KO-5

Elena Queirolo (Vrije Universiteit Amsterdam)

Numerical validation allows to rigorously prove some local properties of a system, such as the existence and local uniqueness of a solution branch or, in this case, the existence of a bifurcation.In this talk, we consider the Kuramoto-Sivashinki PDE in one dimension

$$u_t = -\lambda u_{xxxx} - u_{xx} + 2uu_x,$$

with periodic boundary conditions in space, undergoes a Hopf bifurcation at $\lambda \approx 0.13$. This bifurcation is first computed numerically and then rigorously validated. The rigorous proof is given by the interaction between the radii polynomial approach and a blow up procedure, that allows to rewrite the Hopf bifurcation in such a way as to avoid its singularity. Applying rigorous continuation on the blowed up system, it is possible not only to validate the existence of the Hopf bifurcation, but also to follow the time and space periodic branch generated at the Hopf bifurcation.

Accumulation of eigenvalues for traveling waves and scale separation

Fri 12 Jul
09:45
MS2
KO-5

Jens Rademacher (University of Bremen)
Co-authors: Paul Carter (University of Arizona), Björn Sandstede (Brown University)

In this talk a new phenomenon for traveling waves in slow-fast systems is presented: the accumulation of eigenvalues as the scale-separation increases. We identify the set of accumulation points, referred to as the 'slow absolute spectrum' analytically and present numerical examples. In particular, the phenomenon occurs in pulse solutions of the famous FitzHugh-Nagumo equations and in general relates to canard explosions and pulse-replication.

This is joint work with Paul Carter (Arizona) and BjÃűrn Sandstede (Brown).

Asymptotic analysis of the nonsteady micropolar fluid flow in a curved pipe

Mon 08 Jul
17:10
CT5
KO-2

Marko Radulovic (University of Zagreb, Faculty of Science, Department of Mathematics)
Co-authors: Igor Pazanin (University of Zagreb, Faculty of Science, Department of Mathematics)

In this talk, we present an asymptotic model for the nonsteady flow of a micropolar fluid in a thin (or long) curved pipe [1]. Using Germano's reference system to describe the pipe's geometry, we write the micropolar fluid equations in curvilinear coordinates, construct a second order asymptotic expansion, study the boundary layers in space and provide the rigorous justification of the model via error estimate. This work is an extension of the model derived for the nonsteady flow of a micropolar fluid in a thin undeformed pipe [2]. Due to the practical importance of the micropolar fluid model in biomedicine and blood flow modeling, the talk will be focused on the mathematical as well as engineering aspects of the model. [1] I. PaÅ¿anin, M. RaduloviÄĞ, Asymptotic analysis of the nonsteady micropolar fluid flow through a curved pipe, Applicable Analysis (2018), doi:10.1080/00036811.2018.1553036, pp. 1-48. [2] M. BeneÅą, I. PaÅ¿anin, M. RaduloviÄĞ, Rigorous derivation of the asymptotic model describing a nonsteady micropolar fluid flow through a thin pipe, Computers and Mathematics with Applications 76 (9) (2018), doi:10.1016/j.camwa.2018.07.047, pp. 2035-2060.

Towards bifurcations of complex dimensions

Tue 09 Jul
15:30
CT10
KO-1

Goran Radunovic (University of Zagreb)

Co-authors: Michel L. Lapidus (University of California, Riverside), Goran Radunovic (University of Zagreb), Darko Zubrinic (University of Zagreb)

It is known that at the moment when a limit cycle is born from a weak focus in a Hopf-Takens bifurcation, the Minkowski dimension of any associated spiral trajectory jumps from trivial, i.e., 1 to nontrivial, i.e. a rational number of the form $\frac{4k}{2k+1}$ where the integer k is the multiplicity of the weak focus. For a given set, its complex dimensions are defined as the poles of the associated fractal distance zeta function and provide a far-reaching generalization of the classical notion of the Minkowski dimension. The higher-dimensional theory of complex dimensions has been developed in the recent extensive research monograph by the co-authors. One defines the order of a given complex dimension as the order of the pole of the associated fractal zeta function. We show on a geometric example of a fractal nest the effect of merging of two simple complex dimensions of order one into a single complex dimension of order 2. This is interesting since the fractal nest can be considered as a geometric simplification of a focus trajectory of a dynamical system. We conjecture that this effect of merging of several complex dimensions into a single one can give new insights into bifurcations of dynamical systems.

Entirely Out of Character? Dispersive Dynamics in the Moving Frame

Mon 08 Jul
15:30
MS10
KO-8

Daniel Ratliff (Loughborough University)

The Whitham modulation equations (WMEs) are a set of first order quasilinear PDEs governing the secondary dynamics of wavetrains. These are dispersionless, and it has been a long-standing problem as to how such features are incorporated. However, it will be shown that whenever the WMEs are hyperbolic, dispersion is always hidden within them - one simply waits long enough and moves with a speed of one of its characteristics. This takes the form of the Korteweg-de Vries equation, whose coefficients are universal in the sense that these are tied solely to abstract properties of the Lagrangian density.

A secondary tale then emerges: can properties of the characteristic suggest a different set of dynamics? The answer turns out to be yes, and this talk will highlight such features and the nonlinear dispersive dynamics which are associated to these. In particular, we identify properties which lead to the two-way Boussinesq and Gardner equations emerging instead.

Stability of the transmission plate equation with a delay term in the boundary feedback

Mon 08 Jul
14:20
CT1
KO-1

Salah-Eddine Rebiai (University of Batna 2)

Co-authors: Wassila Ghecham (University of Batna 2), Fatima Zohra Sidi Ali (University of Batna 2)

We consider a system of transmission of plate equation with moment feedback control that contains a delay term and that acts on the exterior boundary. First, we prove under some assumptions that the closed-loop system generates a C0-semigroup of contractions on an appropriate Hilbert space. Then, under further assumptions, we show that the closed-loop system is exponentially stable. To establish this result, we introduce a suitable energy function and prove an observability estimate.

Gibbs-non-Gibbs transitions and shocks

Tue 09 Jul
16:00
MS34
KO-11

Frank Redig (Delft University of Technology)

Gibbs-non-Gibbs transitions have been studied for lattice spin systems, as well as for mean-field systems. They are believed to be related to a dynamical phase transition in the most probable trajectory of a system conditioned to arrive at an improbable state at later time T>0 (nature versus nurture).The phenomenon can be viewed with the help of path-space large deviation theory as a change of regularity of the time-dependent rate function. Because the time-dependent rate function solves a Hamilton-Jacobi equation, these changes in regularity are natural to expect. In a simple context of a dynamics of independent Brownian motions starting from a mean-field model with phase transition, we illustrate how this change in regularity is related to non-uniqueness of optimal trajectories conditioned to arrive at a given state at time T. For the case of the Ornstein -Uehlenbeck process we also show a "nature versus nurture" transition.Finally, we sketch a possible generalization of this Hamilton-Jacobi approach to the lattice spin case.Based on joint work with F Wang, R Kraaij, W van Zuijlen.

Dimension-like properties and almost periodicity for cocycles generated by variational inequalities with delay

Mon 08 Jul
14:40
CT1
KO-1

Volker Reitmann (St. Petersburg State University)

Co-authors: Mikhail Anikushin (St. Petersburg State University), Andrey Romanov (St. Petersburg State University)

We consider a microwave heating problem given by a coupled system of Maxwell's equation and the heat equation [3]. It is assumed that the boundary conditions are controlled with delay [4]. Under certain assumptions this problem is interpreted as variational inequality with delay and the existence of a cocycle attractor is shown. We derive some dimension-like properties of this cocycle attractor such as fractal dimension and topological entropy [2] and investigate the topological structure of this cocycle attractor in the case of almost periodic controls or perturbations [1].

[1] Anikuschin, M.M.: On the Smith Reduction Theorem for Almost Periodic ODE's Satisfying the Squeezing Property. Russian Journal of Nonlinear Dynamics, (submitted).

[2] Egorova, V.E.: Estimation of Topological Entropy for Cocycles with Cellular Automaton as a Base System. Journal Differential Equations and Control Processes, 4, 2018 (Russian).

[3] Popov, S.A., Reitmann, V. and Skopinov, S.N.: Boundedness and finite-time stability for multivalued doubly-nonlinear evolution systems generated by a microwave heating problem. (Accepted for publication)

[4] Romanov, A.O.: On Properties of Solutions of Delayed Maxwell's System with a Thermal Effect. International Student Conference in Saint-Petersburg State University, 2018.

The Viscous Surface Wave Problem with Generalized Surface Energies

Wed 10 Jul
09:15
MS23
KO-8

Antoine Remond-Tiedrez (Carnegie Mellon University)

Co-authors: Ian Tice (Carnegie Mellon University)

The viscous surface wave problem consists of the study of a three-dimensional incompressible fluid in a horizontally periodic domain with finite depth whose boundary is the graph of a function. The fluid is subject to gravity and generalized forces arising from a surface energy. The surface energy incorporates both bending and surface tension effects, which give rise to a fourth order quasilinear operator acting on the free surface function. It can be proven that for initial conditions sufficiently close to equilibrium the problem is globally well-posed and solutions decay to equilibrium exponentially fast, in an appropriate norm. In this talk I will discuss how the proof is centered around a nonlinear energy method that is coupled to careful estimates of the fully nonlinear surface energy.

Formal classification of parabolic Dulac maps

Tue 09 Jul
16:10
CT12
KO-3

Maja Resman (University of Zagreb, Faculty of Science, Department of Mathematics)

Co-authors: Pavao Mardešić (Université de Bourgogne), Jean-Philippe Rolin (Université de Bourgogne), Vesna Županović (University of Zagreb)

The Dulac germs are germs analytic on (0,d), extendable to a standard quadratic domain and admitting power-logarithmic asymptotic expansion. They appear as first return maps of hyperbolic polycycles in planar vector fields. We discuss the formal normal form and formal embedding in a flow for such maps. This is a joint work with P. MardeÅąiÄĞ, J.P.Rolin and V. Å¡upanoviÄĞ.

Space-time trace FEM for PDEs on evolving surfaces

Mon 08 Jul
17:30
MS3
KO-5

Arnold Reusken (RWTH Aachen)

We present a particular class of finite element methods for the solution of partial differential equations on evolving surfaces. The evolving hypersurface in $\mathbb{R}^d$ defines a d-dimensional space-time manifold in the space-time continuum $\mathbb{R}^{d+1}$. We derive and analyze well-posedness of a variational formulation for a class of diffusion problems on such a space-time manifold. Based on this formulation a discrete in time variational formulation is introduced that is very suitable as a starting point for a discontinuous Galerkin (DG) space-time finite element discretization. For the approximation of the evolving manifold a level set method is used. The FEM employs discontinuous piecewise linear in time – continuous piecewise linear in space finite elements. Trial and test surface finite element spaces consist of traces of standard volumetric elements on the space-time manifold. This DG space-time method is explained and results of a discretization error analysis are discussed. Results of numerical experiments, with applications in two-phase flow simulations, are presented that illustrate properties of this space-time FEM.

Stochastic Solutions to Hamilton-Jacobi Equations

Tue 09 Jul
17:00
MS34
KO-11

Fraydoun Rezakhanlou (Professor)

In this talk we give an overview of stochastic solutions to Hamilton-Jacobi PDE with deterministic or random Hamiltonian function. Specifically we analyze the evolution of solutions that are either Markovian or possess Markovian derivative derivatives.

Fundamental solutions of the time-fractional telegraph equation with Laplace or Dirac operators

Thu 11 Jul
09:45
CT16
KO-1

M. Manuela Rodrigues (CIDMA & University of Aveiro)

Co-authors: Nelson Vieira (CIDMA - Center for Research and Development in Mathematics and Applications, Department of Mathematics, University of Aveiro), Milton Ferreira (School of Technology and Management, Polytechnic Institute of Leiria & CIDMA - Center for Research and Development in Mathematics and Applications)

In this work we obtain the first and second fundamental solutions (FS) of the multidimensional time-fractional equation with Laplace or Dirac operators, where the two time-fractional derivatives of orders $\alpha \in]0,1]$ and $\beta \in]1,2]$ are in the Caputo sense. We obtain representations of the FS in terms of Hankel transform, double Mellin-Barnes integrals, and H-functions of two variables. As an application, the FS are used to solve Cauchy problems of Laplace and Dirac type.

Stability of traveling waves in balance laws

Tue 09 Jul
09:45
MS9
KO-8

Luis Miguel Rodrigues (Univ Rennes & IUF)

Co-authors: Vincent Duchêne (Univ Rennes & CNRS)

The derivation from spectral stability of the asymptotic stability (in the sense of Lyapunov, i.e. in large time) of traveling waves of hyperbolic systems is an important question, that is still open to a large extent. Among difficulties to overcome stand three facts:

1. the systems under consideration are in general quasi-linear whereas the dynamics does not exhibit strong regularization effects;
2. wave profiles contain in general characteristic points where, even in dimension 1, the underlying operators lose ellipticity;
3. wave profiles may be discontinuous so that the perturbed evolution problem becomes of mixed initial/boundary value type with free surfaces of discontinuity.

In the present talk, based on recent contributions with Vincent DuchÃłne (CNRS, Rennes), we shall see how those difficulties may be bypassed relatively easily for waves of scalar balance laws in dimension 1.

Hyperparametric Random Fields, Deformations and Heavy-tailed Distributions with Applications in Bayesian Inversion

Thu 11 Jul
08:45
MS28
KO-12

Lassi Roininen (Lappeenranta-Lahti University of Technology)

Co-authors: Sari Lasanen (Lappeenranta-Lahti University of Technology), Sara Wade (University of Edinburgh), Karla Monterrubio-Gómez (University of Warwick)

Gaussian processes are often used for modelling priors for continuous-parameter inverse problems. They are analytically appealing, and easy to use in various applications. Typical assumptions include stationarity and light tails, which might be unrealistic. We propose to overcome some constrains via studying hierarchical Gaussian Markov random fields via their stochastic partial differential equation (SPDE) presentations, and length-scale deformations. The deformations guarantee homogeneity of the variance âĂŞ a property which is usually lost. If we replace the Gaussian noise in the SPDE formulation with symmetric alpha-stable distributions, we obtain heavy-tailed SPDE-random field priors. They are appealing in modelling material interfaces e.g. in subsurface imaging or medical tomography.

Variational and viscosity solutions of the evolutionary Hamilton-Jacobi equation

Tue 09 Jul
16:30
MS34
KO-11

Valentine Roos (ENS de Lyon)

The classical solution of the evolutionary Hamilton-Jacobi equation is given by the action of the characteristics as long as they don't cross. Two types of weak solutions were defined even after the characteristics cross, namely viscosity and variational solutions. For Tonelli Hamiltonians, they are both given by the Lax-Oleinik semigroup, and we will discuss in which cases they coincide or not. One can approach the viscosity solution by iterating the variational operator on a subdivision of the time interval. This result suggests an original nondiffusive numerical scheme that we implemented with H. Hivert, valid in 1D for integrable (nonconvex!) Hamiltonians and semiconcave data. I will present an explicit example where viscosity and variational solutions differ to underline the precision of the scheme.

Periodically forced Nonlinear Lattices-Applications in Metamaterials and Acoustic Vacuum

Thu 11 Jul
09:15
MS11
KO-6

Vassilios Rothos (Professor)

In this talk, we present some resent results on travelling waves in periodically forced nonlinear lattices. We analyse the existence of travelling wave solution for dissipative nonlocal lattices using homoclinic birfurcation and Melnikov theory. We apply the theoretical results in two nonlinear lattices with applications in metamaterials and acoustic vacuum. We study the in-plane oscillations of a finite lattice of particles coupled by 1 linear springs under distributed harmonic excitation.

Patterns and coherence resonance in the stochastic Swift-Hohenberg equation with Pyragas control

Mon 08 Jul
16:30
MS10
KO-8

Vivi Rottschäfer (Mathematical Institute, Leiden University)

Co-authors: Rachel Kuske (Georgia Tech), Chia Lee (AIR Worldwide, Boston)

In this talk, I provide a multiple time scales analysis for the SwiftâĂŞHohenberg equation with delayed feedback via Pyragas control, with and without additive noise. An analysis of the pattern formation near onset indicates both the possibility of either standing waves (rolls) or traveling waves via Turing or Turing-Hopf bifurcations, respectively. Thereafter, the focus will lie on Turing bifurcations, where the delay can drive the appearance of an additional time scale, intermediate to the usual slow and fast time scales observed in the modulation of rolls without delay. In the deterministic case, a GinzburgâĂŞLandau-type modulation equation is derived that inherits Pyragas control terms from the original equation. The Eckhaus stability criteria is obtained for the rolls, with the intermediate time scale observed in the transients. In the stochastic context, slow modulation equations are derived for the amplitudes of the primary modes that are coupled to a fast OrnsteinâĂŞUhlenbeck-type equation with delay for the zero mode driven by the additive noise. Approximations for the spectral densities of the primary and zero modes show that oscillations on the intermediate times scale are sustained through the phenomenon of coherence resonance. These dynamics on the intermediate time scale are sustained through the interaction of noise and delay, in contrast to the deterministic context where dynamics on the intermediate times scale are transient.

Inviscid limit in the presence of dispersion

Tue 09 Jul
17:00
MS21
KO-12

Frederic Rousset (Université Paris-Sud)

Co-authors: Changzhen Sun (Université Paris-Sud)

We will study the stability of global small irrotational solutions in dispersive fluid models with respect to perturbation by viscosity.Our main example will be the Euler/Navier-Stokes Poisson systemfrom plasma physics.

Criteria of Global Attraction in Systems of Delay Differential Equations with Mixed Monotonicity

Tue 09 Jul
15:30
MS17
KO-10

Alfonso Ruiz-Herrera (University of Oviedo)

In this talk we derive criteria of global attraction in systems of the form

$$x_i'(t) = -\alpha_i x_i(t) + F_i(X(t-\sigma), X(t-\tau))$$

for $i = 1, ..., n$ where $\alpha_i > 0$, $\sigma, \tau \geq 0$ and $F_i : [0,\infty)^{2n} \longrightarrow [0,\infty)$ is a smooth map with mixed monotonicity. Our methodology is reminiscent to the classical approach of "descomposing+embedding". Our results have two strengths: (i) We derive sharp delay-dependent conditions of global attraction and (ii) we drop some common monotonicity conditions. We present several applications in classical models of Mathematical Biology. This is a joint work with H. A. EL-Morshedy.

The spectrum of linear delay differential equations with multiple hierarchical large delays

Thu 11 Jul
17:50
CT21
KO-3

Stefan Ruschel (University of Auckland)

Co-authors: Serhiy Yanchuk (Technische Universität Berlin)

It is shown that the spectrum of the linear delay differential equation $x'(t) = A_0 x(t) + A_1 x(t-\tau_1) + \ldots + A_n x(t-\tau_n)$ with multiple hierarchical large delays $1 \ll \tau_1 \ll \tau_2 \ll \ldots \ll \tau_n$ splits into two distinct parts: the strong spectrum and the pseudo-continuous spectrum. As the delays tend to infinity, the strong spectrum converges to specific eigenvalues of A_0, the so-called asymptotic strong spectrum. Eigenvalues in the pseudo-continuous spectrum however, converge to the imaginary axis. We show that after rescaling, the pseudo-continuous spectrum exhibits a hierarchical structure corresponding to the time-scales $\tau_1, \tau_2, \ldots, \tau_n$. Each level of this hierarchy is approximated by spectral manifolds that can be easily computed. The set of spectral manifolds comprises the so-called asymptotic continuous spectrum. It is shown that the position of the asymptotic strong spectrum and asymptotic continuous spectrum with respect to the imaginary axis completely determines stability. In particular, a generic destabilization is mediated by the crossing of an n-dimensional spectral manifold corresponding to the timescale τ_n.

A semigroup approach for solving the space-fractional diffusion equations

Thu 11 Jul
10:05
CT16
KO-1

Katarzyna Ryszewska (Warsaw University of Technology)

In this talk we will consider a fractional diffusion equation in the divergence, i.e. conservative form. The flux is given as the fractional Caputo derivative of the concentration. The motivation for studying such a problem originates from modelling the diffusion in heterogeneous media. A typical example of such phenomenon is a sub-surface water motion. We will present the results concerning the well posedness of the problem

$$\begin{cases} u_t - \frac{\partial}{\partial x} D^\alpha u = f & \text{in } (0,1) \times (0,T), \\ u_x(0,t) = 0, \quad u(1,t) = 0 & \text{for } t \in (0,T), \\ u(x,0) = u_0(x) & \text{in } (0,1), \end{cases}$$

where by D^α we denote the fractional Caputo derivative. We will obtain this result by means of the analytic semigroup theory. Namely, we will describe the domain of $\frac{\partial}{\partial x} D^\alpha$ in terms of fractional Sobolev spaces and as a final result, we will show that $\frac{\partial}{\partial x} D^\alpha$ is a generator of analytic semigroup.

VLASOV-POISSON-POISSON EQUATIONS, CRITICAL MASS AND KORDYLEWSKI CLOUDS

Tue 09 Jul
16:10
CT11
KO-2

Tatiana Salnikova (Lomonosov Moscow State University)

Co-authors: Sergey Stepanov (Dorodnicyn Computing Center, FRC CSC RAS and Lomonosov Moscow State University), Victor Vedenyapin (Keldysh Institute of Applied Mathematics (Russian Academy of Sciences) and RUDN University)

We study the time evolution of an ensemble of charged dust particles. They evolve according to the Vlasov-Poisson equations. The problem we have to solve here consists in adding to the electric field produced by the charged particles the gravitational forces and the forces of inertia. This setting emerges from the problem of elusive Kordylewski clouds - dust particles in vicinity of the Lagrange libration points of the Earth-Moon system. The mathematical approach is based on the reduction of the stationary Vlasov equation by means of energy substitution, and following analysis of the system of non-linear elliptic equations.

Axisymmetric flows of convection in rotating fluid spheres

Thu 11 Jul
09:45
MS2
KO-5

Juan Sánchez Umbría (Universitat Politècnica de Catalunya)

Co-authors: Marta Net (Universitat Politècnica de Catalunya)

A numerical study of the torsional solutions of convection in rotating, internally heated, self-gravitating fluid spheres will be presented. Their dependence on the Rayleigh number has been found for two pairs of Ekman (E) and small Prandtl numbers in the region of parameters where the linear stability of the conduction state predicts that they can be preferred at the onset of convection.

The periodic torsional solutions are axisymmetric and not rotating waves, unlike the non-axisymmetric case. Therefore they have been computed by using continuation methods for periodic orbits. Their stability with respect to axisymmetric perturbations and physical characteristics have been analyzed. It was found that the time and space averaged equatorially antisymmetric part of the kinetic energy of the stable orbits splits into equal poloidal and toroidal parts, while the symmetric part is much smaller. Direct numerical simulations for $E = 10^{-4}$, at higher Rayleigh numbers, show that this trend is also valid for the non-periodic flows.

The oscillations bifurcated from the quasi-periodic torsional solutions reach a high amplitude compared with that of the periodic, increasing slowly and decaying very fast. This repeated behavior is interpreted as trajectories near heteroclinic connections of unstable periodic solutions. We have seen that these complex solutions are able to generate magnetic fields by dynamo effect.

Wave propagation in microtubule networks

Mon 08 Jul
16:30
MS35
KO-12

Björn Sandstede (Brown University)

Co-authors: Veronica Ciocanel (MBI, Ohio State University), Samantha Jeschonek (Brown University), Kimberly Mowry (Brown University)

Active transport of proteins and other cargo plays an important role in the functioning of living cells. Cargo will bind and unbind to molecular motors which move along microtubules or actin filament networks in the cell. In this talk, I will discuss ways to quantify the effective speeds and diffusion constants for transport in heterogeneous microtubule networks. Our results suggest in particular that randomness of the underlying network structure increases effective transport speeds. I will discuss an application to active transport of mRNA to the vegetal cortex during oogenesis of the frog Xenopus laevis.

Data-Driven Forward Surrogates for Bayesian Inversion

Wed 10 Jul
08:45
MS28
KO-12

Daniel Sanz-Alonso (University of Chicago)

A common computational bottleneck of the Bayesian approach to inverse problems and data assimilation is that standard methodology requires repeated evaluation of the forward model. In many applications the forward model arises from a differential equation that needs to be solved numerically, and a natural question is how to build numerical schemes with the end-goal of resolving the inverse problem rather than the forward one. The aim of this talk is to introduce a simple data-driven methodology to build forward surrogates for Bayesian inversion.

Calcium in the egg is traveling, but is it a traveling wave?

Tue 09 Jul
19:00
Poster
KO

Benoit Sarels (Sorbonne Université)

Calcium is one of a few ions that play a crucial role in the different functions of a cell such as homeostasy and signalling. Due to the existence of organelles for sequestration, the concentration of calcium in the cytoplasm is allowed to quickly change over time.

Here we are concerned with calcium oscillations in eggs. After fertilization, the ovocyte is going through a series of rapid events that allow its transformation from a quiescent cell to a fully awake one, ready to enter the development cycle. Notably, the ovocyte undergoes an increase of free calcium in the cytoplasm, starting at the sprem entry point and then propagating in the cell.

These waves have been studied by developmental biologists who demonstrated their versatility and therefore developed a terminology to describe them: type I and type II waves, tsunami and tidal waves; furthermore they show a wide range of speeds and frequencies.

Here we establish a model, close to minimal but still retaining the variety of behaviors. It is composed of two partial differential equations and few parameters. We show that this model admits traveling waves solutions and discuss the existence of other type of propagating solutions that merely a classical definition of traveling wave is not sufficient to describe.

Consistent manifold learning from data

Tue 09 Jul
08:45
MS29
KO-6

Timothy Sauer (George Mason University)

Characterizing attracting sets of dynamical systems is a key concern for data-driven algorithms. We take a geometric approach by assuming the data points lie on a Riemannian manifold, and reconstruct the Laplace-Beltrami operator. In particular, we show how build a graph Laplacian that converges, pointwise and spectrally, to the continuous operator in the large data limit. If this can be achieved, geometric and topological information about the manifold can be inferred from a single graph. Since real data is typically sampled irregularly, it is necessary to introduce a criterion called Continuous k-Nearest Neighbors (CkNN) for the graph construction that implies convergence for arbitrary sampling.

Smooth uniform attractors for measure driven quintic damped wave equations on 3D torus

Mon 08 Jul
17:30
CT4
KO-1

Anton Savostianov (Durham University)

Co-authors: Sergey Zelik (University of Surrey)

In this talk we discuss the existence of uniform attractors for nonautonomous damped wave equations with nonlinearities of quintic growth. We show that Strichartz estimates, which are necessary for global well-posedness of such equations, remain valid when the forcing term is a vector-valued measure with bounded total variation. This leads to new classes of admissible external forces, which guarantee existence of smooth uniform attractors for our problems.

Synchrony: From Franklin Bells to Brain Dynamics

Tue 09 Jul
19:00
Poster
KO

Mustafa Sayli (University of Nottingham)

Co-authors: Yi Ming Lai (University of Nottingham), Rüdiger Thul (University of Nottingham), Stephen Coombes (University of Nottingham)

What do Franklin bells and neural dynamics have in common? Both can be described by non-smooth dynamical systems. Here we explore networks of self-excited electromechanical impact oscillators that model Franklin bells and Wilson-Cowan neural mass models with piecewise linear and Heaviside firing rate functions. In particular, we study the linear stability of synchronous solutions of these networks. For a single Franklin Bell, we first construct the discontinuous periodic solution and determine its linear stability using saltation matrices and Floquet theory. We then propose a smoothing technique for the discontinuous system and demonstrate that by taking an appropriate limit the smooth system converges towards the discontinuous system. At the network level we employ the master stability function approach to determine the linear stability of the synchronous state. We show that linear stability depends on the network topology, and that the network eigenvectors serve as good predictors of the network patterns that emerges once synchrony is unstable. Direct numerical simulations are in excellent agreement with our theory. For a network of Wilson Cowan nodes, we show that taking the steep limit of the piecewise linear firing rate function does not recover the network dynamics for the Heaviside case. For this special case we show that the order that perturbations cross switching manifolds must be determined to treat stability properly.

Parameter identification in a structured population model

Fri 12 Jul
09:45
MS33
KO-4

Matthias Schlottbom (University of Twente)

Co-authors: Alexander Lorz (Sorbonne Universite), Jan-Frederik Pietschmann (University of Chemnitz)

We study parameter identification problems in a structured population model without mutations. Given measurements of the total population size or critical points of the population, we aim to recover its growth rate, death rate or initial distribution. We present uniqueness results under suitable assumptions and present counterexamples when these assumptions are violated. Our results a supplemented by numerical studies, either based on Tikhonov regularization or the use of explicit reconstruction formulas.

Large deviations in two-scale systems characterized by principal eigenvalues

Mon 08 Jul
15:30
MS34
KO-11

Mikola Schlottke (Eindhoven University of Technology)

Co-authors: Mark A. Peletier (Eindhoven University of Technology), Richard C. Kraaij (Delft University of Technology)

In this talk we consider examples in which diffusion and jump processes are coupled to a process that runs on a much faster time scale. We show that under suitable ergodicity assumptions on the fast process and continuity assumptions on the coupling, the diffusion and jump processes satisfy path-wise large-deviation principles with rate functions given in action-integral form. The Hamiltonians characterizing the rate functions are derived from principal-eigenvalue problems associated to the generator of the fast process.The examples illustrate how exactly a coupling to a fast process affects the large-deviation behaviour, and how Hamilton-Jacobi theory can be applied to study two-scale systems. This talk is based on joint works with Mark A. Peletier (TU Eindhoven, The Netherlands) and Richard C. Kraaij (TU Delft, The Netherlands).

Travelling waves in discrete FitzHugh-Nagumo type systems

Wed 10 Jul
09:45
MS5
KO-4

Willem Schouten-Straatman (Leiden University)

We establish the existence and nonlinear stability of traveling pulse solutions for the discrete FitzHugh-Nagumo equation in different settings: we consider infinite-range interactions, periodic lattices and fully discrete systems. For the verification of the spectral properties, we need to study a functional differential equation of mixed type (MFDE), possibly with unbounded shifts. We avoid the use of exponential dichotomies and phase spaces, by building on a technique developed by Bates, Chen and Chmaj for the discrete Nagumo equation. This allows us to transfer several crucial Fredholm properties from the PDE setting to our discrete setting.

Scaling limit of metastable diffusion processes

Fri 12 Jul
09:45
MS19
KO-8

Insuk Seo (Seoul National University)

In this presentation, we explain a new methodology for the analysis of metastable processes. For continuous processes exhibiting metastable behavior, the martingale approach developed by Beltran and Landim is hard to be applied. Our new methodology is based on the analysis of Poisson equations related to the generator of the corresponding metastable process. This presentation is based on the joint works with Claudio Landim, and with Fraydoun Rezakhanlou.

Strictly positive solutions for non-potential and non-radial Dirichlet systems with Minkowski operator

Thu 11 Jul
17:50
CT22
KO-5

Calin Serban (West University of Timisoara)

Using topological degree type arguments we develop a lower and upper solution method for a (λ_1, λ_2)-parameterized Dirichlet system having the form

$$\begin{cases} -\mathcal{M}(u) = \lambda_1 f_1(u,v), & \text{in } \Omega, \\ -\mathcal{M}(v) = \lambda_2 f_2(u,v), & \text{in } \Omega, \\ u|_{\partial\Omega} = 0 = v|_{\partial\Omega}, \end{cases}$$

where $\mathcal{M}$ stands for the mean curvature operator in Minkowski space

$$\mathcal{M}(u) = \operatorname{div}\left(\frac{\nabla u}{\sqrt{1-|\nabla u|^2}}\right),$$

Ω is a general bounded domain in $\mathbb{R}^N$ and the continuous functions f_1, f_2 satisfy some growth, sign and quasi-monotonicity conditions. Among others, these type of nonlinearities, include the Lane-Emden ones. For such system we show the existence of a hyperbola like curve which separates the first quadrant in two disjoint sets, an open one $\mathcal{O}$ and a closed one $\mathcal{F}$, such that the system has zero or at least one strictly positive solution, according to $(\lambda_1, \lambda_2) \in \mathcal{O}$ or $(\lambda_1, \lambda_2) \in \mathcal{F}$. Moreover, we show that inside of $\mathcal{F}$ there exists an infinite rectangle in which the parameters being, the system has at least two strictly positive solutions. The talk is based on joint work with D. Gurban and P. Jebelean. This work was supported by CNCS-UEFISCDI grant PN-III-P1-1.1-PD-2016-0040 - "Multiple solutions for systems with singular ϕ-Laplacian operator".

Optimal potentials for quantum graphs

Tue 09 Jul
10:15
MS6
KO-4

Andrea Serio (Department of Mathematics, Stockholm University)
Co-authors: Pavel Kurasov (Stockholm University)

SchrÃűdinger operators on metric graphs with delta couplings at the vertices are studied. We discuss which potential and which distribution of delta couplings on a given graph maximise the ground state energy, provided the integral of the potential and the sum of strengths of the delta couplings are fixed. It appears that the optimal potential if it exists is a constant function on its support formed by a set of intervals separated from the vertices. In the case where the optimal configuration does not exist explicit optimising sequences are presented.

Existence of solutions for the nonlinear Schrödinger equation on metric graphs in supercritical case

Tue 09 Jul
16:30
MS6
KO-4

Junping Shi (College of William and Mary)
Co-authors: Jun Wang (Jiangsu University), Xiaoli Zhu (Shanxi University)

The existence of solutions for the nonlinear Schrödinger equation on metric graphs is shown in the L^2-supercritical case. The variational methods are used and the dependence of the solution set on the topology of the graph is explored.

Mathematical models of rhythm-generating circuits

Wed 10 Jul
09:45
MS26
KO-10

andrey shilnikov (Georgia State University)

Biological systems are in dynamic equilibrium. They maintain stability by self-adjusting to a variable environment through feedback. The systems maintain stability even as the animal itself changes during growth and aging. We have found that some neural circuits themÂŋselves can exhibit a resilience that is independent of sensory feedback. Understanding the matheÂŋmatical basis for such resilience has general applications for any network of interacting units. it is imperative to devise and showcase experimental systems that are can be reliably replicated and engineered in computational models, analyzed in detail and verified. Using dynamical system and stability theory we develop a new computational apparatus to elucidate stability, resilience, and adaptability of neural circuits to evaluate and quantify the existence range of emergent network-bursting in mathematical circuits against various short-term and graduate perturbations. Models are based on electrophysiological recordings made from neurons in the swim central pattern generators of sea slugs: Melibe and Dendronotus. The goal here is to transform the assimilated detailed knowledge about complex nonlinear interactions of coupled neurons and synapses into causal, predictive relationships between the properties of mathematical and biological circuits.

Uniqueness of a positive solution of a second-order ordinary differential equation and its application to elliptic problems

Tue 09 Jul
16:30
CT12
KO-3

Naoki Shioji (Yokohama National University)
Co-authors: Satoshi Tanaka (Okayama University of Science), Kohtaro Watanabe (National Defense Academy)

We study the uniqueness of a positive solution of

$$u_{ss}(s) = g(s, u(s)), \quad u(\alpha) = u(\beta) = 0,$$

where $g \in C^1([\alpha, \beta] \times (0, \infty))$, and we give an improvement of Ni-Nussbaum's uniqueness theorem in CPAM 38 (1985). As an application, we study an elliptic problem

$$\Delta u(x) + f(u(x)) = 0 \text{ in } A_{a,b}, \quad u(x) = 0 \text{ on } \partial A_{a,b},$$

where $n \geq 3$, $A_{a,b} = \{x \in \mathbf{R}^3 : a < |x| < b\}$, and $f \in C^1([0, \infty))$ satisfying $uf'(u) > f(u) > 0$. With an assumption $p \geq uf'(u)/f(u)$ with some $p > 1$, we improve Korman's uniqueness condition $(b/a)^{n-2} \leq 2n - 3$ in Math. Nachr. 229 (2001). We also show some other uniqueness results.

Non-smooth saddle-node bifurcation in a non-autonomous delay differential equation

Mon 08 Jul
15:20
CT1
KO-1

Jan Sieber (University of Exeter)
Co-authors: Courtney Quinn (CSIRO)

Typical models for the Earth' Climate during Ice Ages combine dynamics due to Earth's internal mechanisms (ice, carbon dioxide, ocean circulation) and quasi-periodic forcing from the Sun. A curious feature of the models and data records is a transition from smaller-amplitude high-frequency ice ages to large-amplitude relaxation oscillation type ice ages about 800,000 years ago.The talk will present numerical evidence for a simple delay differential equation with forcing provided by data that the underlying mechanism for this transition is a so-called non-smooth saddle-node bifurcation, based on the theory developed by Jaeger et al. for quasi-periodically forced scalar maps. I will show numerical observations in the model, outline the theory for quasiperiodically forced maps and show the connection between theory and observations.

Pattern selection in advective reaction-diffusion systems

Fri 12 Jul
09:15
MS2
KO-5

Eric Siero (University of Oldenburg)

Reaction-advection-diffusion systems in two space dimensions have been proposed to model vegetation patterns in arid regions. These patterns have been observed on satellite images of arid ecosystems all around the world. Different patterns include gaps, stripes and spots. The formation of patterns has been linked to increased aridity (decreased rainfall).

If advection is present (on sloped terrain), stripes along contours are the first to bifurcate from a spatially homogeneous steady state. As a parameter changes (climatic conditions deteriorate), which subsequent patterns can be observed? Is the response gradual or does the norm (biomass) suddenly collapse? In this talk I present overviews of stable patterns (Busse balloons) obtained by numerical continuation.

Non-dissipative system as limit of a dissipative one

Thu 11 Jul
10:05
CT17
KO-2

Ricardo Silva (University of Brasilia)

Let $\Omega \subset \mathbb{R}^n$ be a bounded smooth domain in $\mathbb{R}^n$. Given $u_0 \in L^2(\Omega)$, $g \in L^\infty(\Omega)$ and $\lambda \in \mathbb{R}$, consider the family of problems parametrised by $p \searrow 2$,

$$\begin{cases} \dfrac{\partial u}{\partial t} - \Delta_p u &= \lambda u + g, & \text{on} & (0,\infty) \times \Omega, \\ u &= 0, & \text{in} & (0,\infty) \times \partial\Omega, \\ u(0,\cdot) &= u_0, & \text{on} & \Omega, \end{cases}$$

where $\Delta_p u := \operatorname{div}\big(|\nabla \mathrm{u}|^{\mathrm{p}-2}\nabla \mathrm{u}\big)$ denotes the p-laplacian operator.Our aim in this work is to describe the asymptotic behavior of this family of problems comparing compact attractors in the dissipative case $p > 2$, with non-compact attractors in the non-dissipative limiting case $p = 2$ with respect to the Hausdorff semi-distance between then.

Properties of eigenvalues and some regularities on fractional p-Laplacian with singular weights

Thu 11 Jul
17:30
CT21
KO-3

Inbo Sim (University of Ulsan)

Co-authors: Ky Ho (Duy Tan University)

We provide standard properties of the first eigenpair of the eigenvalue problem fractional p-Laplacian problems with singular weights which require the help of Hardy type inequality and also show that the second eigenvalue is well-defined. We obtain a-priori bounds of solutions to problems with such singular weights and the continuity of solutions to problems with weaker singular weights. Moreover, applying the above results, we show a global bifurcation which is emenating from the first eigenvalue and get the existence of infinitely many solutions for some nonlinear problems.

Singular Sturmian theory for linear Hamiltonian systems

Mon 08 Jul
18:30
MS16
KO-9

Roman Simon Hilscher (Masaryk University)

Co-authors: Peter Sepitka (Masaryk University)

We discuss new singular Sturmian separation and comparison theorems for conjoined bases of nonoscillatory linear Hamiltonian systems on unbounded intervals. We present a theory, which includes the multiplicities of focal points at infinity (new notion) and at the same time avoids the traditional controllability assumption. The results are based on the comparative index (J. Elyseeva 2009 & 2016), on the inqualities for solutions of Riccati differential equations for uncontrollable systems (P. Sepitka 2019), and on new transformation formulas for multiplicities of focal points. Our theory generalizes and extends the previous result for controllable systems on unbounded interval (Dosly & Kratz 2013), as well as the previous result in the uncontrollable case on compact interval (J. Elyseeva 2016).

Modeling Glucose-Insulin Regulation System in Humans

Mon 08 Jul
15:20
CT3
KO-3

Melike Sirlanci (California Institute of Technology)

Co-authors: Andrew Stuart (Caltech), Matthew Levine (Caltech), David Albers (University of Colorado Denver)

Research has shown that keeping blood glucose levels of intensive care unit patients has a positive effect on these patients in a certain range has a significant effect on their recovery process and in general, in the reduction of mortality rate. To achieve this goal, first, we model the glucose-insulin regulation system in humans icy using Ornstein Uhlenbeck process. Then, estimating model parameters based on the data that is collected from patients induces an inverse problem. We use different methods such as MAP estimator and MCMC techniques and a combination of these methods to solve this problem in the most efficient way for our purposes. By estimating the joint distribution of the unknown model parameters, besides parameter estimates, we can also assess the accuracy of our estimation.

One component regularity for the Navier-Stokes equations

Mon 08 Jul
15:20
CT2
KO-2

Zdenek Skalak (Institute of Hydrodynamics of the Czech Academy of Sciences)

We study the conditional regularity for the incompressible Navier-Stokes equations in the whole three dimensional space in terms of one component of the velocity field $u = (u_1, u_2, u_3)$. We show that if $u_3 \in L^p(0, T; L^\infty_v \dot{H}^{2/p}_h)$, where $p \in [2, \infty)$, then u is regular on $(0, T]$. This criterion generalizes several recent criteria from the literature. We also show a regularity criterion which is optimal but, unlike other such criteria from the literature, does not require any information on the derivative of u_3.

Mathematical modelling of human sleep/wake patterns: the interaction of light, sleep, circadian and social rhythms

Fri 12 Jul
10:15
MS25
KO-11

Anne Skeldon (University of Surrey)

For healthy human function, daily biological rhythms need to operate in a carefully coordinated manner. Disruption to this system is correlated with many physical and mental health problems, including increased risk of cardiovascular disease, type II diabetes, obesity and cognitive decline. Sleep is a critical component of this complex oscillatory system. Sleep/wake regulation is often described as the interaction of two primary oscillators: a self-excited oscillator with a period of approximately 24 hours mimicking the approximately 24 hour (circadian) natural rhythm of our body clock, and a relaxation oscillator known as the sleep homeostat. Historically, this coupled oscillator system was entrained to 24 hours by our interaction with the natural light-dark cycle. However, artificial light has given us an un-precedented ability to manipulate this entraining signal. In this talk, I will discuss coupled oscillator system models of the sleep-wake cycle and the essential features of entrainment. I will describe how we have used models to suggest plausible, robust, physiological mechanisms to explain changes in sleep timing and duration across the age span and explored societal questions such as whether to move school start time for adolescents. Our results also have implications for the recent European Union debate on whether or not we should continue changing the clocks in the autumn and the spring and more generally for understanding circadian disruption.

Lotka-Volterra competition model on graphs

Antonín Slavík (Charles University, Prague)

Mon 08 Jul
17:30
MS16
KO-9

The classical Lotka-Volterra model describing two competing species has the form

$$u'(t) = \rho_1 u(t)(1 - u(t) - \alpha v(t)),$$
$$v'(t) = \rho_2 v(t)(1 - \beta u(t) - v(t)),$$

where $\rho_1, \rho_2, \alpha, \beta > 0$. Depending on the values of α and β, the two species can either coexist, or one of them dies out.

More realistic models are usually formulated in terms of reaction-diffusion partial differential equations. We consider a model where the spatial domain consists of a finite number of discrete patches inhabited by both species, which can move between selected pairs of patches. Thus, the spatial domain can be described by a finite graph $G = (V, E)$, where $V = \{1, \dots, n\}$ is the set of patches, and an edge $(i, j) \in E$ means that the species can move between patches i and j. The model has the form

$$u_i'(t) = d_1 \sum_{j \in \mathcal{N}(i)} (u_j(t) - u_i(t)) + \rho_1 u_i(t)(1 - u_i(t) - \alpha v_i(t)),$$
$$v_i'(t) = d_2 \sum_{j \in \mathcal{N}(i)} (v_j(t) - v_i(t)) + \rho_2 v_i(t)(1 - \beta u_i(t) - v_i(t)),$$

for all $i \in V$, where d_1, d_2 are diffusion constants, and $\mathcal{N}(i)$ denotes the set of all neighbors of vertex i.

The goal of this talk is to provide information about solutions of the above-mentioned system. We focus on homogeneous and heterogeneous stationary solutions and their stability, and discuss the asymptotic behavior of solutions.

Time-parallel iterative solvers for parabolic evolution equations

Iain Smears (University College London)

Co-authors: Martin Neumuller (Johannes Kepler University Linz)

Mon 08 Jul
15:00
MS3
KO-5

Time-parallel solvers are iterative methods for the discrete systems originating from evolution problems, and they can provide effective alternatives to the sequential time-stepping approach on parallel computers. Although time-parallel methods can applied to classical time-discretisation schemes, they are based on a global space-time formulation of the problem that is similar to the approach adopted in recent space-time discretisation methods. We present how the inf-sup stability of space-time formulations of continuous and discretized parabolic problems provides an effective approach to the construction and rigorous analysis of parallel-in-time solvers. Considering the implicit Euler discretization of a general linear parabolic evolution equation with time-dependent self-adjoint spatial operators, we use the inf-sup stability of the problem to show that the standard nonsymmetric time-global system can be equivalently reformulated as an original symmetric saddle-point system that remains inf-sup stable in the same norms. We then propose and analyse an inexact Uzawa method for the saddle-point reformulation based on an efficient parallel-in-time preconditioner. The preconditioner is non-intrusive and easy to implement in practice, and we prove robust spectral bounds, leading to convergence rates that are independent of the number of time-steps, final time, or spatial mesh sizes. Large scale parallel numerical experiments demonstrate the efficiency of the method.

Stabilization by boundary noise: a Chafee-Infante equation with dynamical boundary conditions

Stefanie Sonner (Radboud University)

Co-authors: Klemens Fellner (University of Graz), Bao Quoc Tang (University of Graz), Do Duc Thuan (Hanoi University of Science and Technology)

Fri 12 Jul
10:25
CT25
KO-3

The stabilization of parabolic PDEs by ItÃť noise has been widely studied over the past decades. Despite of the extensive literature, the stabilization by a noise acting only on the boundary of a domain has not been addressed so far.As a first step in this direction we analyze whether a multiplicative ItÃť noise on the boundary can have a stabilizing effect on the Chafee-Infante equation with dynamical boundary conditions. In particular, we show that there exists a finite range of noise intensities that imply the exponential stability of the trivial steady state. Our results differ essentially from previous works on stabilization, where the noise acts inside the domain, and stabilization typically occurs for an infinite range of noise intensities.

Exact solutions to classical diffraction problems with an application to General Relativity

Fri 12 Jul
08:45
MS31
KO-12

John Stalker (Trinity College Dublin)

Diffraction problems have been around as long as optics, so it's somewhat surprising to find previously unknown exact diffraction solutions to the Maxwell equations. Although these are solutions in flat Minkowski space, their investigation was motivated by recent work of Tahviladar-Zadeh on the zero-gravity limit of the KerrâĂŞNewman spacetimes and their electromagnetic fields, and is connected to much older work of Zipoy on singular spacetimes. The method employed is an old idea of Sommerfeld, transported from the elliptic case to the hyperbolic by a somewhat delicate analytic continuation argument.

Uniform L^2 bounds for semigroups generated by Hamiltonian linearizations

Tue 09 Jul
17:00
MS9
KO-8

Milena Stanislavova (University of Kansas)

We consider abstract Hamiltonian linearized operators in the form $\mathcal{JL}$, where $\mathcal{J}^* = -\mathcal{J}$ and $\mathcal{L}^* = \mathcal{L}$. We prove that $\mathcal{JL}$ generates a semigroup on L^2 and moreover, $\|e^{t\mathcal{JL}}\|_{L^2 \to L^2}$ grows at most polynomially in time. We apply this to the linearized NLS problem on periodic domain.

Global bifurcation index of critical orbit of strongly indefinite functional

Tue 09 Jul
16:50
CT10
KO-1

Piotr Stefaniak (West Pomeranian University of Technology in Szczecin)
Co-authors: Anna Gołębiewska (Faculty of Mathematics and Computer Science, Nicolaus Copernicus University)

The main aim of the talk is to investigate critical points of some functionals, associated with differential equations with symmetries. The symmetries imply that the critical points do not have to be isolated. That is why we study an index of a critical orbit, defined in terms of the degree for invariant strongly indefinite functionals. We apply techniques of the equivariant analysis to establish a relationship of the index of the critical orbit with the index of a critical point of the map restricted to the space normal to the orbit. The second aim of the talk is to apply the abstract results to nonlinear elliptic systems of the form

$$\left\{ \begin{array}{rcll} A\triangle u & = & \nabla_u F(u,\lambda) & \text{in} \quad U \\ \frac{\partial u}{\partial \nu} & = & 0 & \text{on} \quad \partial U, \end{array} \right.$$

for U being an open, bounded and $SO(N)$-invariant set, $A = diag(\pm 1, \ldots, \pm 1)$ and F satisfying some additional assumptions. We consider the problem with Γ-symmetric potential F, where Γ is a compact Lie group. For this system we prove the global bifurcation of nontrivial solutions from the set of trivial ones. Since the problem is symmetric, the trivial solutions do not have to be isolated. That is why we consider bifurcations from an orbit. Applying our abstract results, we formulate sufficient conditions for global bifurcations in terms of the right-hand side of the system and eigenvalues of the Laplace operator.

Mutlichromatic Travelling Waves for Lattice Nagumo Reaction Diffusion Equation

Mon 08 Jul
14:30
MS16
KO-9

Petr Stehlik (University of West Bohemia)
Co-authors: Hermen Jan Hupkes (Universiteit Leiden), Leonardo Morelli (Universiteit Leiden), Vladimir Svigler (University of West Bohemia)

In this talk we discuss multichromatic front solutions to the bistable Nagumo lattice differential equation. Such fronts connect the stable spatially homogeneous equilibria with spatially heterogeneous n-periodic equilibria and hence are not monotonic like the standard monochromatic fronts. These multichromatic fronts can disappear and reappear as the diffusion coefficient is increased. In addition, these multichromatic waves can travel in parameter regimes where the monochromatic fronts are also free to travel. This leads to intricate collision processes where an incoming multichromatic wave can reverse its direction and turn into a monochromatic wave.

Coercive space-time finite element methods

Mon 08 Jul
14:00
MS3
KO-5

Olaf Steinbach (TU Graz)
Co-authors: Marco Zank (TU Graz)

We propose and analyze new space-time Galerkin-Bubnov type finite element formulations of parabolic and hyperbolic second order partial differential equations in finite time intervals. This approach is based, using Hilbert type transformations, on elliptic reformulations of first and second order time derivatives, for which the Galerkin finite element discretization results in positive definite and symmetric matrices. For the variational formulation of the heat and of the wave equation we prove related stability conditions in appropriate norms, and we discuss the stability of related finite element discretizations. Numerical results are given which confirm the theoretical results.

Analysis of Some Non-Smooth Bifurcations with Applications to Ship Maneuvering

Tue 09 Jul
16:10
CT10
KO-1

Miriam Steinherr Zazo (University of Bremen)
Co-authors: Jens Rademacher (University of Bremen), Ivan Ovsyannikov (University of Hamburg)

The super/subcriticality of a Hopf bifurcation in a generic smooth 2D system can be readily determined by the sign of the first Lyapunov coefficient. However, for a system of continuous but non-smooth equations this cannot be applied in general. We show new results for autonomous systems of arbitrary finite dimension with focus on non-smooth nonlinearities of the form $|u_i|u_j$. This is motivated mainly by models for ship maneuvering and its control. We present the unfolding of Hopf-type bifurcations for such systems and discuss generalizations to bifurcations at switching points for continuous piecewise smooth systems.

Extreme value laws and mean squared error growth in dynamical systems

Wed 10 Jul
09:15
MS15
KO-9

Alef Sterk (University of Groningen)
Co-authors: Mark Holland (University of Exeter)

Extreme value theory for chaotic deterministic dynamical systems is a rapidly expanding area of research. Given a system and a scalar observable defined on its state space, extreme value theory studies the asymptotic probability distributions of large values attained by the observable along evolutions of the system. The aim of this talk is to explain the relationship between the statistics and predictability of extremes. Predictability is measured by the mean squared error (MSE), which is estimated from the difference of pairs of forecasts conditional on one of the forecasts exceeding a threshold. Under the assumption that pairs of forecast variables satisfy a linear regression model, we show that the MSE can be decomposed into the sum of three terms: a threshold-independent constant, a mean term that always increases with threshold, and a variance term that can either increase, decrease, or stay constant with threshold. Using the generalised Pareto distribution to model excesses over a threshold, we show that the MSE always increases with threshold at sufficiently high threshold. However, when the forecasts have a negative tail index the MSE can be a decreasing function of threshold at lower thresholds.

Stability of Galerkin discretizations of parabolic evolution equations

Mon 08 Jul
15:30
MS3
KO-5

Rob Stevenson (University of Amsterdam)
Co-authors: Jan Westerdiep (University of Amsterdam)

We analyze Galerkin discretizations of a new well-posed mixed space-time variational formulation of parabolic PDEs. For suitable pairs of finite element trial spaces, the resulting Galerkin operators are shown to be uniformly stable. The method is compared to two related space-time discretization methods introduced in [IMA J. Numer. Anal., 33(1) (2013), pp. 242-260] by R. Andreev and in [Comput. Methods Appl. Math., 15(4) (2015), pp. 551-566] by O. Steinbach.

The inverse problem of transient states MRI: Analysis of MR fingerprinting

Thu 11 Jul
17:00
MS33
KO-4

Chris Stolk (University of Amsterdam)
Co-authors: Alessandro Sbrizzi (University Medical Center Utrecht)

In this talk we discuss an inverse problem in MRI that currently attracts a lot of attention, namely the processing of transient states data for multiparameter MRI. In conventional MRI, the object is brought into a time-periodic state, which becomes a steady state after restricting to a short time interval in the period. The data is given by samples of the spatial Fourier transform of this steady state. This data can easily be processed using the Fourier transform. Transient states data require different algorithms. In this talk we will analyze the imaging errors of the so called MR Fingerprinting (MRF) method. We obtain a new model for the spatially dependent imaging errors as a function of the experimental parameters. The model explains why certain choices of experimental parameters work well (experimental design). Full nonlinear inversion, a more costly alternative to MRF, will be briefly discussed.

Periodic solutions of symmetric Hamiltonian systems

Tue 09 Jul
19:00
Poster
KO

Daniel Strzelecki (Nicolaus Copernicus University in Toruń)

The talk is devoted to present a theorem which provides the existence of periodic solutions of Hamiltonian system $\dot{z}(t) = JH'(z(t))$ with symmetries in a nearby of the stationary solutions z_0. When Hamiltonian H is invariant under symplectic symmetries then its critical points form an orbit of this symmetry action and, as a consequence, they are not isolated in general. Therefore it is hard to apply classical tools to study the existence of new non-stationary solutions in a neighbourhood of the stationary ones.

We prove that under some assumptions expressed in terms of Brouwer degree of $H'(z_0)$ and Morse index of the Hessian $H''(z_0)$ there exists a connected family of non-stationary periodic solutions of the system $\dot{z}(t) = JH'(z(t))$ emanating from the stationary solution z_0. Moreover, we are able to estimate the minimal periods of this new solutions. The result presented in this talk is a generalization of the famous result of Liapunov.

The abstract result will be applied to the study of quasi-periodic motions near the geostationary orbit of the oblate spheroid.

Characterization of FilippovâĂŹs definition of the sliding vector field

Tue 09 Jul
19:00
Poster
KO

Tomoharu Suda (Kyoto University)

While studying piecewise-continuous vector fields, it is important to consider how a vector field can be introduced on a discontinuity set. Although several methods have been proposed for the said purpose, FilippovâĂŹs definition of the sliding vector field is widely incorporated in various applications. However, characterization of FilippovâĂŹs definition, which is essential for understanding its naturalness, has not been comprehensively studied. In this study, FilippovâĂŹs definition of the sliding vector field is characterized in terms of geometric and dynamical properties. The obtained results provide an insight into the meaning and possible refinement of FilippovâĂŹs definition of the sliding vector field.

Localised waves in inhomogeneous sine-Gordon equations

Mon 08 Jul
17:00
MS35
KO-12

Hadi Susanto (University of Essex)

The talk is on inhomogeneous sine-Gordon equations that model Josephson junctions with phase-shifts. We will present some results on the bifurcations and dynamics of localised waves that are admitted by the models, including experimental results on wave orderings and breather interactions with the vertex in the models on a star graph domain. Open problems, such as a rigorous justification of breather splittings, will also be discussed.

Three-dimensional steady water waves with vorticity

Mon 08 Jul
17:30
CT5
KO-2

Douglas Svensson Seth (Lund University)

Co-authors: Evgeniy Lokharu (Lund University), Erik Wahlén (Lund Univesity)

We will consider the nonlinear problem of steady gravity-driven waves on the free surface of a three-dimensional flow of an incompressible fluid. In the talk we will discuss a recent progress on three-dimensional waves with vorticity, which is a relatively new subject. The rotational nature of the flow is modeled by an assumption on the velocity field, that it is proportional to its curl. Such vector fields are known in magnetohydrodynamics as Beltrami fields. We plan to provide a necessary background on the topic and prove the existence of three-dimensional doubly periodic waves with vorticity.

Periodic solutions and and switching behavior in a model of bipolar disorder

Tue 09 Jul
09:15
MS8
KO-7

Peter Szmolyan (Technische Universität Wien)

Co-authors: Ilona Kosiuk (Technische Universität Wien), Ekatarina Kutafina (University Hospital RWTH Aachen)

We analyze a 4-dimensional system of ODEs which models the cyclic behavior observed in bipolar disorder. The phenomenological model is based on mutual inhibition and cross activation of two states related to mania and depression. The model appears to be a standard slow-fast system with two slow and two fast components depending on a small parameter ε. However, it turns out that the slow-fast structure is more complicated and several rescalings must be used to capture the global dynamics. An interesting feature of the problem is that some of the rescaled versions of the system are non-smooth in the limit $\varepsilon \to 0$. This complication is caused by the occurrence of powers of ε in Michaelis-Menten and Hill terms which model the interactions in the system. We show that repeated blow-ups are a convenient tool to overcome these difficulties and to prove the existence of a complicated relaxation oscillation.

An approximation solvability method for semilinear equations in Banach spaces

Mon 08 Jul
17:00
MS16
KO-9

Valentina Taddei (University of Modena and Reggio Emilia)

Co-authors: Irene Benedetti (University of Perugia), Nguyen Van Loi (PetroVietNam University), Luisa Malaguti (University of Modena and Reggio Emilia), Stefania Perrotta (University of Modena and Reggio Emilia)

A new approximation solvability method is developed for the study of semilinear differential equations in Banach spaces without any compactness on the semigroup nor on the nonlinearity. The method is based on the Yosida approximations of the generator of the semigroup, on a continuation principle, and on the weak topology. The solutions are limits of functions with values in finitely dimensional spaces. An existence result is obtained for a wide class of nonlocal boundary value problems, including periodic, anti-periodic, weighted mean value and multipoint conditions. By means of linear control terms, the controllability problem is also investigated. The final configuration is always achieved with a control with minimum norm. Applications to diffusion models are given.

Rigorous numerics for nonlinear heat equations in the complex plane of time

Mon 08 Jul
15:30
MS1
KO-4

Akitoshi Takayasu (University of Tsukuba)

Co-authors: Jean-Philippe Lessard (McGill University), Hisashi Okamoto (Gakushuin University)

In this talk, we consider a numerical method for proving the existence of solutions for nonlinear heat equations in the complex t-plane. Extending the time variable of nonlinear heat equations into the complex plane, there seem to be no singularity other than the blow-up point, which exists on the real line. Our aim of this study is to turn out the dynamics of such a solution with computer assistance. As a first step of this study, we provide a rigorous integrator of the complex-valued nonlinear heat equations (a kind of complex Ginzburg-Landau equation) using Chebyshev-Fourier spectral methods.

Perturbed finite-state Markov systems with holes and Perron complements of Ruelle operators

Tue 09 Jul
19:00
Poster
KO

Haruyoshi Tanaka (Wakayama Medical University)

We consider a perturbed system $(\Sigma_A^+, \varphi(\epsilon, \cdot))$ with topologically transitive subshift of finite type Σ_A^+ and Hölder continuous functions $\varphi(\epsilon, \cdot)$ defined on Σ_A^+ endowed with small parameter $\epsilon > 0$. Through our choice of $\varphi(\epsilon, \cdot)$, we realize the situation that the perturbed system has a unique Gibbs measure μ_ϵ of the potential $\varphi(\epsilon, \cdot)$ for each $\epsilon > 0$ and on the other hand the unperturbed system possesses several Gibbs measures $\mu_1, \mu_2, \ldots, \mu_m$ of the limit potential at $\epsilon = 0$. In this talk, we give a necessary and sufficient condition for convergence of the measure μ_ϵ using the notion of Perron complements of Ruelle operators. Our results can be applied also to the problems of convergence of stationary distributions of perturbed Markov chains with holes.

Perturbations of half-linear differential systems and its application to quasilinear elliptic equations

Tue 09 Jul
16:50
CT12
KO-3

Satoshi Tanaka (Okayama University of Science)

This is a joint work with Kenta Itakura and Masakazu Onitsuka (Okayama University of Science). The differential system

$$x' = ax + b|y|^{p^*-2}y + k(t,x,y), \quad y' = c|x|^{p-2}x + dy + l(t,x,y)$$

is considered, where a, b, c and d are real constants with $b^2 + c^2 > 0$, p and p^* are positive numbers with $1/p + 1/p^* = 1$, and k and l are continuous for $t \geq t_0$ and small $x^2 + y^2$. When $p = 2$ or $b^2 + c^2 = 0$, this system is reduced to the linear system. We show that the behavior of solutions near the origin $(0,0)$ is very similar to the behavior of solutions to the unperturbed system near $(0,0)$, provided k and l are small in some sense. We emphasize that we can not linearize this system at $(0,0)$ when $p \neq 2$, because the Jacobian matrix can not be defined at $(0,0)$. We also apply our result to radial solutions of the quasilinear elliptic equation

$$(r^\alpha |u'|^{\beta-1}u')' + r^{r-1}|u|^{p-1}u = 0,$$

which includes m-Laplacian and k-Hessian.

Localized solutions in a three-component FitzHugh-Nagumo model

Mon 08 Jul
15:30
MS35
KO-12

Takashi Teramoto (Asahikawa Medical University)

We combine geometrical singular perturbation techniques and an action functional to study the existence and stability of stationary localized structures in a singularly perturbed three-component FitzHughâĂŞ-Nagumo model. We apply this action functional approach to analyze pinned pulse solutions with a small jump- and bump-type heterogeneity. We derive explicit conditions for the existence and stability of the pinned solutions by computing the pinning distance of a localized solution to the defect. This is a joint work with Peter van Heijster, Chao-Nien Chen, and Yasumasa Nishiura.

Discrete Aubry-Mather theory in a quasi-periodic environnement

Tue 09 Jul
10:15
MS34
KO-11

Philippe Thieullen (Université de Bordeaux)

Discrete Aubry-Mather theory may be seen as a tool to study the ground state of a chain of atoms in mutual interaction and in interaction with a substrate. It may be also be seen as a time-discretization method to solve time-periodic Hamilton-Jacobi equations. We consider in this talk a non-autonomous quasi-periodic Hamiltonian in the continous setting or more precisely a quasi-periodic discrete Aubry-Mather problem. The quasi-periodic environnement is described by impurities aranged on a line according to a Fibonacci sequence, or a sequence with low complexity. We show the existence of a discrete weak KAM solution, that is a kind of effective potential that quantify the variation of energy along the chain of atoms.

The stability of contact lines in fluids

Wed 10 Jul
10:15
MS23
KO-8

Ian Tice (Carnegie Mellon University)

The contact line problem in interfacial fluid mechanics concerns the triple-junction between a fluid, a solid, and a vapor phase. Although the equilibrium configurations of contact lines have been well-understood since the work of Young, Laplace, and Gauss, the understanding of contact line dynamics remains incomplete and is a source of work in experimentation, modeling, and mathematical analysis. In this talk we consider a 2D model of contact point (the 2D analog of a contact line) dynamics for an incompressible, viscous, Stokes fluid evolving in an open-top vessel in a gravitational field. The model allows for fully dynamic contact angles and points. We show that small perturbations of the equilibrium configuration give rise to global-in-time solutions that decay to equilibrium exponentially fast. This is joint work with Yan Guo.

Analysis of Oceanic and Tropical Atmospheric Models with Moisture: Global Regularity, Finite-time Blowup and Singular Limit Behavior

Tue 09 Jul
11:30
Plenary
HK

Edriss Titi (Texas A&M University)

In this talk I will present some recent results concerning global regularity of certain geophysical models. This will include the three-dimensional primitive equations with various anisotropic viscosity and turbulence mixing diffusion, and certain tropical atmospheric models with moisture. Moreover, I will show that in the non-viscous (inviscid) case there is a one-parameter family of initial data for which the corresponding smooth solutions of the primitive equations develop finite-time singularities (blowup).Capitalizing on the above results, I will also provide rigorous justification of the derivation of the Primitive Equations of planetary scale oceanic dynamics from the three-dimensional Navier-Stokes equations as the vanishing limit of the small aspect ratio of the depth to horizontal width. Specifically, I will show that the Navier-Stokes equations, after being scaled appropriately by the small aspect ratio parameter of the physical domain, converge strongly to the primitive equations, globally and uniformly in time, and the convergence rate is of the same order as the aspect ratio parameter. Furthermore, I will also consider the singular limit behavior of a tropical atmospheric model with moisture, as $\varepsilon \to 0$, where $\varepsilon > 0$ is a moisture phase transition small convective adjustment relaxation time parameter.

Pattern formation in non-local analogues of the Fisher-KPP equation

Thu 11 Jul
09:45
MS5
KO-4

Pavlo Tkachov (Gran Sasso Science Institute)
Co-authors: Christian Kuehn (Technical University of Munich)

We present results on the existence, bifurcations, and stability of stationary solutions for an analogue of the Fisher-KPP equation with non-local reaction and diffusion parts. We prove that under suitable conditions on the parameters a bifurcation from the non-trivial homogeneous state can occur and periodic stationary patterns are generated. Then we prove that these patterns are locally asymptotically stable. We also compare our results to previous work on the non-local Fisher-KPP equation containing a local diffusion term and a non-local reaction term. If the diffusion is approximated by a non-local kernel, we show that our results are consistent and reduce to the local ones in the local singular diffusion limit. Furthermore, we prove that there are parameter regimes, where no bifurcations can occur. The results demonstrate that intricate different parameter regimes are possible.

Stability region analysis of a linear delay system with two parameters

Tue 09 Jul
19:00
Poster
KO

Petr Tomasek (Brno University of Technology)

Stability analysis of linear delay differential equations plays an important role in the control theory. Results dealing with linear systems are employed in stability analysis of nonlinear systems, too. In the contribution we focus to stability and instability regions of the system

$$\dot{x}(t) = Ax(t) + Bx(t - \tau),$$

where $A, B \in \mathbb{R}^{2\times 2}$, and $\tau > 0$ is a constant delay. Various cases of matrices A and B depending on a pair of two real parameters (a, b) are considered and asymptotic stability regions are discussed with respect to the delay. The boundary locus technique is used to construct the stability and instability regions in the parameter plane (a, b). The stability regions are visualized and they are also compared with several known sufficient conditions.

Open discussion

Mon 08 Jul
18:00
MS29
KO-6

Chad Topaz (Williams College)

TBA

The effect of threshold energy obstructions on the $L^1 \to L^\infty$ dispersive estimates for some Schrodinger type equations

Fri 12 Jul
09:15
MS31
KO-12

Ebru Toprak (Rutgers University)

In this talk, I will discuss the differential equation $iu_t = Hu$, $H := H_0+V$, where V is a decaying potential and H_0 is a Laplacian related operator. In particular, I will focus on whenH_0 is Laplacian, Bilaplacian and Dirac operators. I will discuss how the threshold energy obstructions, eigenvalues and resonances, effect the $L^1 \to L^\infty$ behavior of $e^{itH}Pac(H)$. The threshold obstructions are known as the distributional solutions of $H = 0$ in certain dimension dependent spaces. Due to its unwanted effects on the dispersive estimates, its absence has been assumed in many works. I will mention our previous results on Dirac operator and recent results on Bilaplacian operator under different assumptions on threshold energy obstructions.

Global Well-Posedness and Higher Sobolev Bounds for Non-Focusing NLS Equations on Mixed Domains

Mon 08 Jul
15:00
MS10
KO-8

Nathan Totz (University of Miami)

We consider the long time well-posedness of the Cauchy problem with large initial data for a class of nonlinear Schrodinger equations (NLS) on mixed flat/periodic domains of spatial dimension $d \geq 2$, and with power nonlinearities of arbitrary odd degree. This class of equations includes a family of energy supercritical defocusing NLS equations, as well as NLS equations of mixed spatial signature; global existence for such equations by standard dispersive PDE methods is an open problem. We argue by contradiction that, if certain scaling-subcritical Sobolev norms of a solution increase faster than a certain threshold of growth, we can directly construct arbitrarily close perturbations of this solution that grow slower than this growth rate, violating classical stability results. The perturbed NLS solution at the core of the argument is constructed as a modulational limit of a carefully constructed artificial evolution equation.

On the turnpike property

Thu 11 Jul
14:45
Plenary
HK

Emmanuel Trélat (Sorbonne Université)

The turnpike property was discovered in the 50's by the Nobel prize Samuelson in econometry. It stipulates that the optimal trajectory of an optimal control problem in large time remains essentially close to a steady state, itself being the optimal solution of an associated static optimal control problem.We have established the turnpike property for general nonlinear finite and infinite dimensional optimal control problems, showing that the optimal trajectory is, except at the beginning and the end of the time interval, exponentially close to some (optimal) stationary state, and that this property holds as well for the optimal control and for the adjoint vector coming from the Pontryagin maximum principle. We prove that the exponential turnpike property is due to an hyperbolicity phenomenon which is intrinsic to the symplectic feature of the extremal equations. We infer a simple and efficient numerical method to compute optimal trajectories in that framework, in particular an appropriate variant of the shooting method.The turnpike property turns out to be ubiquitous and the turnpike set may be more general than a single steady-state, like for instance a periodic trajectory. We also show the property of shape turnpike for PDE models in which a subdomain evolves in time according to some optimization criterion.These works are in collaboration with Gontran Lance, Can Zhang and Enrique Zuazua.

OPTIMAL FEEDBACK CONTROL PROBLEM FOR MODIFIED KELVIN-VOIGT FLUID MODEL

Wed 10 Jul
09:45
CT14
KO-2

Mikhail Turbin (Voronezh State University)

Co-authors: Anastasiia Ustiuzhaninova (Voronezh State University)

The problem of optimal control of fluid motion by external forces often arises in practical applications. Usually, in such problems, the control is chosen from some given (finite) set. However, in papers of V.G. Zvyagin, V.V. Obukhovskii, M.V. Turbin it were considered problems with external forces (control), depending on the velocity of the fluid (such problems are called problems with feedback). This approach allows to select the control more precisely, since in this case the control is chosen not from the finite set of available controls, but belongs to the image of some multivalued map (naturally, this map satisfies to some conditions). The solution to the consudered problem is the pair (v, f), where v is the velocity of the fluid, and f is the control. Moreover, f belongs to the image of some multivalued map depending on the velocity v of the fluid. In connection with the fact that there can be many such pairs, it naturally arises the concept of an optimal solution (it gives a minimum to a given quality functional). In this talk, we consider the feedback control problem for the modified Kelvin-Voigt model. First, it is shown that there exists a solution to the control problem with feedback. Then it is proved that among the solutions of the considered problem there exists a solution giving a minimum to a given quality functional. Acknowledgments This research was supported by the Ministry of Science and Higher Education of the Russian Federation (grant 14.Z50.31.0037).

Dynamics and topological entropy of 1D-Greenberg-Hastings cellular automata

Tue 09 Jul
19:00
Poster
KO

Dennis Ulbrich (Universität Bremen)

Co-authors: Jens Rademacher (Universität Bremen), Marc Kesseböhmer (Universität Bremen)

Greenberg-Hastings cellular automata (GHCA) are paradigmatic models of excitable media and capture many of the basic features. We analyse the non-wandering set of 1D-GHCA models for excitable media with $e \geqslant 1$ excited and $r \geqslant 1$ refractory states. We determine its (strictly positive) topological entropy and show that it results from a Devaney-chaotic closed invariant subset of the non-wandering set that consists of colliding and annihilating travelling waves. We reveal its inherent dynamical structure by providing a semi-conjugacy to a skew-product dynamical system consisting of coupled shift-dynamics. Moreover, we determine the remaining part of the non-wandering set explicitly as a Markov system with strictly less topological entropy that also scales differently for large e, r.

On spectral properties of a class of differential operators

Thu 11 Jul
16:50
CT21
KO-3

Elena Ulianova (Voronezh State Technical University)
Co-authors: Maria Glazkova (Voronezh State Technical University)

Some spectral properties of second order differential operators with homogeneous and periodic boundary value conditions are described. Asymptotic formulas for eigenvalues, estimates of projectors and conditions for equi-convergence of spectral resolutions are discussed. The results are obtained by the method of similar operators.

Existence of a loop of positive solutions for concave-convex problems with indefinite weights

Thu 11 Jul
18:10
CT22
KO-5

Kenichiro Umezu (Ibaraki University)
Co-authors: Uriel Kaufmann (Universidad Nacional de Córdoba), Humberto Ramos Quoirin (Universidad de Santiago de Chile)

We establish the existence of a loop type subcontinuum of nonnegative solutions for a class of concave-convex type elliptic equations with indefinite weights, under Dirichlet and Neumann boundary conditions. Our approach depends on local and global bifurcation analysis from the zero solution in a non-regular setting, since the nonlinearities considered are not differentiable at zero, so that the standard bifurcation theory does not apply. To overcome this difficulty, we combine a regularization scheme with a priori bounds, and Whyburn's topological method.

On traveling wave solution for a diffusive simple epidemic model with a free boundary

Tue 09 Jul
19:00
Poster
KO

Takeo Ushijima (Tokyo University of Science)
Co-authors: Yoichi Enatsu (Tokyo University of Science), Emiko Ishiwata (Tokyo University of Science)

In this poster, we will show the following results on a diffusive simple epidemic model with a free boundary. We proved existence and nonexistence of traveling wave solution for the model in the case where the diffusion coefficient d of susceptible population is zero and the basic reproduction number is greater than 1. We obtain a curve in the parameter plane which is the boundary between the regions where existence and nonexistence of traveling wave. We numerically observe that in the region where the traveling wave exists the disease successfully propagate like a traveling wave but in the region of no traveling wave disease stops to invade. We also numerically observe that as d increases the speed of propagation slows down and the parameter region of propagation narrows down.

Solutions of impulsive BVPs via a generalized PoincarÃľ-Miranda theorem

Fri 12 Jul
08:45
CT24
KO-2

José Uzal (Universidade de Santiago de Compostela)

In this talk we will study several linear boundary value problems of first and second order with impulses at fixed times. Using a generalization of the well-known PoincarÃľ-Miranda theorem to multivalued maps we will prove some existence results.

Quasiperiodic solutions of elliptic equations on the entire space

Tue 09 Jul
16:00
MS12
KO-9

Dario Valdebenito (McMaster University)
Co-authors: Peter Polacik (University of Minnesota)

In this talk I discuss the construction of solutions of solutions of semilinear elliptic equations which are quasiperiodic in one variable and decay in the remaining variables. These solutions are constructed using spatial dynamics, a center manifold reduction, and results from the KAM theory. I will explain how these results apply to "many" nonhomogeneous equations, and the difficulties of trying to apply these results to homogeneous equations.

Computer-assisted theorems in dynamics

Fri 12 Jul
13:45
Plenary
HK

Jan Bouwe van den Berg (VU Amsterdam)

When studying nonlinear differential equations, we often simulate theirdynamics on a computer. It would be great if we can be sure that what we see onthe computer screen genuinely represents a solution of the problem, so that wecan use these objects as ingredients of a mathematical theory. This leads tothe question: how can one turn such numerical simulations into theorems? Inthis talk I will highlight an approach based on a Newton-Kantorovich typeargument in a suitable neighborhood of a numerically computed candidate. Thismethod has been applied successfully for various problems in ordinarydifferential equations, delay differential equations as well as partialdifferential equations. By putting the problem into a functional analyticframework, one can combine mathematical analysis with computer calculations torigorously validate numerical computations. Such a computer-assisted approachmakes it possible to prove theorems about solutions which are out of reach ofpen and paper analysis alone. The appearance of spontaneous periodic orbits inthe Navier-Stokes flow will serve as a concrete illustration of these generalideas.

Dynamical distribution networks

Mon 08 Jul
14:00
MS4
KO-6

Arjan van der Schaft (University of Groningen)

Distribution networks arise abundantly, in the natural as well as in the engineering sciences. In many cases they are inherently dynamical, e.g., due to internal storage. On the other hand, they differ from standard dynamical systems in at least two aspects: 1) distribution networks are typically open systems with non-zero inflows and outflows, 2) their complexity is primarily caused by their large-scale nature; similar to network flow theory in optimization. In this talk we aim at a general geometric framework for the modeling, analysis and control of dynamical distribution networks, based on port-Hamiltonian systems theory. We will primarily discuss two main examples: power networks as underlying the electricity grid, and chemical reaction networks as appearing in systems biology. One specific question to be addressed concerns the stability of dynamical distribution networks for constant, but non-zero, in-out flows, corresponding to steady states that are not anymore minima of the storage functions (Hamiltonians). Furthermore, in the context of power networks we will address the stability of the physical dynamics coupled to market dynamics, as arising from the adjustment of the generated and consumed power towards optimal steady state values set by static optimization.

Pulse dynamics in reaction-diffusion equations with strong spatially localised impurities

Tue 09 Jul
15:30
MS9
KO-8

Petrus van Heijster (Queensland University of Technology (QUT))
Co-authors: Arjen Doelman (Leiden University), Jianhe Shen (Fujian Normal University)

I will discuss a general geometric singular perturbation framework to study the impact of strong, spatially localized, nonlinear impurities on the existence, stability and bifurcations of localized structures in systems of linear reactionâĂŞdiffusion equations. By taking advantage of the multiple-scale nature of the problem, I derive algebraic conditions determining the existence and stability of pinned single- and multi-pulse solutions. These methods enable me to explicitly control the spectrum associated with a (multi-)pulse solution. In the scalar case, I show how eigenvalues may move in and out of the essential spectrum and that Hopf bifurcations cannot occur. By contrast, even a pinned 1-pulse solution can undergo a Hopf bifurcation in a two-component system of linear reactionâĂŞdiffusion equations with (only) one impurity.

A kernel method for joint parameter and state estimation

Thu 11 Jul
18:00
MS33
KO-4

tristan van leeuwen (Utrecht University)

Many inverse problems can be cast as a PDE-constrained optimisation problems, where the goal is to estimate the coefficients from partial measurements of the state. Such problems are classically solved using a reduced-space method which eliminates the PDE-constraints. It has been shown to be advantageous to relax the constraints and solve a joint parameter-state estimation problem instead. The challenge here is to device an algorithm that avoids having to store and update the full state. In this talk I discuss a formulation of this problem in a Reproducing Kernel Hilbert Space, where the Representer Theorem can be used to yield a finite-dimensional optimisation problem whose dimension is dictated by the size of the data, which is typically much smaller than the size of the discretised state.

On some discrete elliptic boundary value problems

Tue 09 Jul
19:00
Poster
KO

Vladimir Vasilyev (Belgorod National Research University)
Co-authors: Oksana Tarasova (Belgorod National Research University)

We study discrete approximations for the following boundary value problem

$$(Au)(x) = 0, \quad x \in \mathbb{R}^m_+, \qquad (1)$$

$$\frac{\partial u}{\partial x_m}|_{x_m=0} = g(x'), \quad x' \in \mathbb{R}^{m-1}, \qquad (2)$$

where A is an elliptic pseudo-differential operator with the symbol $A(\xi)$ satisfying the condition

$$c_1(1+|\xi|)^\alpha \le |A(\xi)| \le c_2(1+|\xi|)^\alpha, \quad \alpha \in \mathbb{R},$$

with positive constants c_1, c_2.

It is well known the problem (1), (2) has a unique solution in the Sobolev–Slobodetskii space $H^s(\mathbb{R}^m_+)$ for arbitrary right-hand side $g \in H^{s-\frac{3}{2}}(\mathbb{R}^{m-1})$ [1] under some restrictions on factorization index κ of the symbol $A(\xi)$, namely $\kappa - s = 1 + \delta, |\delta| < 1/2$..

For approximate solution of the problem (1), (2) we construct digital pseudo-differential operator A_d acting in spaces $H^s(h\mathbb{Z}^m_+)$ of discrete variables and formulate corresponding discrete boundary value problem. For the latter problem its unique solvability is studied by methods [2].

References.

[1] G. Eskin, Boundary value problems for elliptic pseudodifferential equations. AMS, Providence, RI, 1981. [2] A.V. Vasilyev, V.B. Vasilyev, Pseudo-differential operators and equations in a discrete half-space. Math. Model. Anal. 2018. V. 23, No 3. P. 492–506.

On some operator calculus and its applications

Thu 11 Jul
17:10
CT19
KO-1

Vladimir Vasilyev (Belgorod National Research University)

We study classes of special operator families which can be treated as symbols of some elliptic operators [1]. Such abstract constructions can be applied to studying of Fredholm properties for elliptic pseudo-differential equations on a manifold with non-smooth boundary. It was shown that every such operator can be represented as a sum of certain operators related to non-smooth components of a boundary. These operators and equations arise in various problems of mathematical physics. Using the local principle we consider a local situation for each point of a manifold, and add some boundary conditions if it is necessary. Such boundary conditions appear if an index of special symbol factorization is not vanishing. For the latter case we consider simplest non-smooth domain like a multidimensional cone and describe some boundary conditions for which we can construct the solution of the boundary value problem in Sobolev–Slobodetskii spaces [2,3]. References.[1] V.B. Vasilyev, Operator symbols, ArXiv: FA/1901.06630. [2] V.B. Vasilyev, Pseudo-differential equations, wave factorization, and related problems. Math. Meth. Appl. Sci. 2018. V. 41, Issue 18. P. 9252–9263. [3] V.B.Vasilyev, Pseudo-differential equations and conical potentials: 2-dimensional case. Opusc. Math. 2019. V.39, No 1. P. 109–124.

The foliation on the Lens space as Liouville foliation of the integrable billiards.

Tue 09 Jul
19:00
Poster
KO

Viktoria Vedyushkina (Lomonosov Moscow State University)

Consider an integrable billiard in a planar domain bounded by arcs of confocal ellipses and hyperbolas. Let us consider a domain bounded by arcs of the focal line, an ellipse and two hyperbolas. Glue n copies of such billiard along two convex boundary arcs and the segment of the focal line. Let us define the motion as follows: when hitting a boundary arc, the billard ball will change the domain by some permutation. Then there exist permutations that, being attributed to the convex arcs and the segment of the focal straight line, make it possible to obtain a foliation in the neighborhood of an unstable trajectory of any non-degenerate saddle bifurcation of Liouville tori. If one of this permutation is cyclic permutation and the permutation on the adjacent arc is the some degree k of the given cyclic permutation then the isoenergy 3-manifold is homeomorphic to the lens space L(n,k). This lens space is stratified into levels of the additional first integral which is the parameter of the confocal quadric (called caustic) tangent to all straight lines containing the links of the billiard path. As in the planar case, the motion along convex boundary arcs is stable, and the motion along the focal line segment is unstable. This work was supported by the Russian Science Foundation (project No.17-11-01303).

Towards stochastic modeling of turbulence in the stably stratified atmospheric boundary layer

Tue 09 Jul
17:00
MS30
KO-7

Nikki Vercauteren (Freie Universität Berlin)

Co-authors: Vyacheslav Boyko (Freie Universität Berlin), Danijel Belušić (SMHI), Davide Faranda (LSCE-IPSL, CEA, CNRS)

Numerical weather prediction or climate models represent mixing in the atmospheric boundary layer (ABL) through a turbulence closure model or ABL parametrization. The order of the turbulence closure and the use of local or nonlocal mixing approaches are two main choices for an ABL parametrization scheme. Representing turbulent mixing within a thermally stable stratification is particularly challenging due to buoyantly suppressed turbulence and the presence of myriads of processes on multiple spatiotemporal scales that modulate the turbulence. Stochastic modelling could complement classical turbulence parameterization approaches to effectively represent unsteady and intermittent mixing rates in such contexts.

In this presentation I will approach the question of intermittency of turbulence and its partial modulation by non-turbulent motions based on multiscale data analysis and statistical clustering methods. A statistical indicator that quantifies the dynamical (in)stability of timeseries provides evidence that weak wind flow regimes under the influence of non-turbulent small-scale motions are dynamically unstable and require higher order closure models to reflect non-local scale interactions. I will suggest a data-driven approach to include stochastic inflow structures in a turbulence resolving simulation tool. This approach could help study and derive new types of stochastic parameterisations for weather and climate models.

Mathematical models for simulation of skin behavior after burn injuries

Wed 10 Jul
09:15
MS24
KO-6

Fred Vermolen (Delft Institute of Applied Mathematics, Delft University of Technology)

In this presentation, we will consider both agent-based models and continuum-scale for the time evolution of skin after serious burn trauma. The models contain aspects from wound contraction and scar development. Plastic deformations are dealt with using morpho-elasticity. Since many of the parameters are not known well, uncertainty quantification is touched as well.

Time-fractional diffusion-wave and parabolic Dirac operators and their fundamental solutions

Thu 11 Jul
10:25
CT16
KO-1

Nelson Vieira (CIDMA - University of Aveiro)

In this talk, we study the multidimensional time-fractional diffusion-wave equation where the time fractional derivative is in the Caputo sense with order $\beta \in]0,2]$. Applying operational techniques via Fourier and Mellin transforms we obtain an integral representation of the fundamental solution (FS) of the time fractional diffusion-wave operator. Series representations of the FS are explicitly obtained for any dimension. From these, we derive the FS for the time fractional parabolic Dirac operator in the form of integral and series representation. Fractional moments of arbitrary order $\gamma > 0$ are also presented. To illustrate our results we present and discuss some plots of the FS for some particular values of the dimension and of the fractional parameter. The results presented in the talk can be found in [1]. This presentation is based on joint work with M. Ferreira (IPL & CIDMA).

[1] M. Ferreira and N. Vieira. Fundamental solutions of the time fractional diffusion-wave and parabolic Dirac operators. J. Math. Anal. Appl., 447(1), (2017), 329-353.

Delayed Bifurcation Phenomena in Multi-Timescale Reaction-Diffusion Equations

Mon 08 Jul
18:00
MS8
KO-7

Theodore Vo (Monash University)

Co-authors: Tasso Kaper (Boston University), Richard Bertram (Florida State University)

Spiking and bursting rhythms in space-clamped (i.e., ODE) models are typically driven by either canard dynamics or slow passage through Hopf bifurcations. In both cases, solutions which are attracted to quasi-stationary states (QSS) sufficiently before a fold or Hopf bifurcation remain near the QSS for long times after the states have become repelling, resulting in a significant delay in the loss of stability and hence in the onset of oscillations. In this work, we present the spatio-temporal analogues of these delayed bifurcation phenomena in multi-timescale reaction-diffusion equations. We show the existence of canard-induced bursting rhythms in a spatially extended model of the electrical activity in pituitary cells. We then derive asymptotic formulas for the space-time boundaries that act as buffers beyond which solutions cannot remain near the repelling QSS (and hence at which the delayed onset of oscillations must occur) for slow passage through Hopf bifurcations in reaction-diffusion equations.

Uncertainty quantification of climate sensitivity: State-dependence, extreme values and the probability of tipping

Tue 09 Jul
16:30
MS30
KO-7

Anna von der Heydt (Utrecht University)

Co-authors: Peter Ashwin (University of Exeter)

The Equilibrium Climate Sensitivity (ECS) remains not very well constrained, either by climate models, observational, historical or palaeoclimate data. Next to the classical (measurement) uncertainty, the spread in ECS values is due to dynamical aspects: (i) The climate system has strong internal variability on many timescales such that the âĂŸequilibriumâĂŹ will only be relative to fixing slow processes. This implies the assumption that time scale separation exists and ECS values from palaeoclimate time series can be compared to short model simulations. Palaeoclimate records often determine the Earth System Sensitivity, which includes the integrated effect of slow processes and boundary conditions (e.g. geography, vegetation and land ice). (ii) The background state dependence of fast feedback processes: Information from the late Pleistocene ice age cycles indicates that ECS varies considerably between regime because of fast feedback processes changing their relative strength over one cycle. (iii) Tipping elements in the climate system: Extreme values of palaeo-derived ECS suggest that the climate response is in a region where the assumption of linear response to perturbations breaks down. Here we show for climate system models with more than one regime and occasional switches between these regimes, we can empirically determine probability of change in regime and confirm that extremes of climate sensitivity are associated with very high probabilities of tipping.

Jordan-Kronecker invariants of semidirect sums of semisimple Lie algebras with a commutative ideal

Tue 09 Jul
19:00
Poster
KO

Konstantin Vorushilov (Lomonosov Moscow State University)

Hamiltonian systems defined by Euler equations on Lie algebras arise in various problems in mathematical physics. A.S. Mischenko and A.T. Fomenko presented a so-called argument shift method, which can be used to construct a family of polynomials in involution w.r.t. a Lie-Poisson bracket on a Lie algebra; these polynomials are the integrals of such Hamiltonian system. It turns out that these polynomials commute w.r.t. another Poisson bracket on a Lie algebra. It is natural to ask whether there exists a complete family of polynomials in involution w.r.t. both Poisson brackets.Jordan-Kronecker invariants of a Lie algebra were first introduced by A.V. Bolsinov and P. Zhang in 2011. These invariants describe the canonical block-diagonal decomposition of a pair of skew-symmetric forms defined by the generic pair of elements of dual Lie algebra with blocks of Jordan and Kronecker types. A pair of forms corresponds to a pair of Poisson brackets mentioned earlier. It was proved by Bolsinov that the completeness of commutative family of shifts for a Lie algebra is equivalent to the fact that the canonical decomposition of two forms contains only Kronecker blocks.The poster will cover one of the interesting nontrivial cases of Lie algebras for which Jordan-Kronecker invariants were unknown until recently, namely the case of semidirect sums of semisimple Lie algebras with a commutative ideal.This work was supported by the Russian Science Foundation (project 17-11-01303).

A Space-Time Approach to Two-Phase Stokes Flow

Mon 08 Jul
14:30
MS3
KO-5

Igor Voulis (Johannes Gutenberg-Universität Mainz)

We consider a time dependent Stokes problem with a prescribed, sharp, moving interface. This model problem has discontinuous density and viscosity coefficients, a pressure solution that is discontinuous across an evolving interface and an interfacial force (surface tension). This strongly simplified model problem is used to develop and analyse of space-time finite element discretization methods for two-phase flow problems.

For this Stokes problem a dynamic spatial mesh is considered because it is a useful tool to limit the computational cost for two-phase flow problems where a fine mesh is only necessary near the moving interface. We discuss the influence of the changing spatial mesh on the global error bounds. This is done for the velocity and for the pressure Lagrange multiplier. We also consider the influence of a (discrete) temporal derivative with a discontinuous time-dependent coefficient.

Mathematical analysis of Barenblatt's non-equilibrium model for two-phase flow in porous media

Tue 09 Jul
16:30
CT11
KO-2

Anja Vrbaski (University of Zagreb)

It has been known that in some problems of multiphase flow and transport in porous media, particularly in mechanisms of secondary oil recovery such as the forced water-oil displacement and spontaneous countercurrent imbibition, the assumption of local phase equilibrium is not appropriate since the characteristic time of the process is comparable with the time of redistribution of flow paths between the two phases (for instance oil and water). Therefore the non-equilibrium effects should be taken into account. We study the Barenblatt's non-equilibrium model of two-phase immiscible flow, where the relative phase permeabilities and the capillary pressure depend on the so-called effective saturation rather than on the actual saturation. We prove the existence of the weak solutions to this problem.

Double Hopf bifurcations at normal-normal resonance

Tue 09 Jul
09:45
MS12
KO-9

Florian Wagener (Universiteit van Amsterdam)

Co-authors: Henk Broer (Rijksuniversiteit Groningen), Heinz Hanßmann (Universiteit Utrecht)

We consider families vector fields X_μ on the phase space $\mathbb{T}^n \times \mathbb{R}^4$ that leave invariant a family of tori $T_\mu = \mathbb{T}^n \times \{0\}$. Such a family goes through a double Hopf bifurcation at normal-normal resonance if the torus T_0 carries quasi-periodic dynamics and has two imaginary Floquet exponents in $\ell_1 : \ell_2$ resonance. The bifurcation is analysed with approximating truncated normal forms. These are expressed in terms of invariants rather than polar coordinates. Persistence of the results of the approximating analysis is established using standard techniques from quasi-periodic bifurcation theory developed by the authors.

Combinatorial Topological Dynamics

Mon 08 Jul
17:00
MS29
KO-6

Thomas Wanner (George Mason University)

Forman's combinatorial vector fields on simplicial complexes are a discrete analogue of classical flows generated by dynamical systems, and they have found numerous applications in the context of homology computations and data analysis. Over the last decade, many notions from dynamical systems theory have found interpretations in this combinatorial setting, such as for example discrete gradient flows and Forman's discrete Morse theory. In this talk, we survey recent results which aim to establish a formal tie between combinatorial and classical dynamics. After outlining a Conley-Morse theory in the combinatorial setting, we show that every combinatorial dynamical system in the sense of Forman defined on a finite simplicial complex gives rise to both a discrete-time multivalued dynamical system on its geometric realization, as well as a continuous-time semiflow. The constructed dynamical systems can be chosen in such a way that the isolated invariant sets, Conley indices, Morse decompositions, and Conley-Morse graphs of the two systems are in one-to-one correspondence.

Collision dynamics of traveling spots against axisymmetric heterogeneity

Mon 08 Jul
14:30
MS35
KO-12

Takeshi Watanabe (Faculty of Engineering)
Co-authors: Yasumasa Nishiura (AIMR, MathAM-OIL, AIST, Tohoku University)

Collision of traveling spot against an axisymmetric heterogeneity in 2D is investigated. This work is placed on the series of works of collision dynamics of spatially localized traveling structures. In previous works, collision of traveling pulse against a bump in 1D has been investigated. In the 2D axisymmetric problem, collision phenomena is one-parameter family if the shape of the bump is fixed because the angle of collision to the bump can be changed and therefore the asymptotic state must be much more complicated than 1D case. However it is expected that the collision dynamics can be understood by investigating the global bifurcation structure of heterogeneity induced ordered pattern (HIOP) because in 1D problem, it is strongly suggested that the solution set of all HIOP branches emanated from trivial solution contains all asymptotic states after collision against bump. The main aim of 2D work is to investigate whether this conjecture also holds for 2D problem. Another point is "sharksucker" structure of two branches. In this structure, both stationary and moving pulse/spot, which has almost the same shape, bifurcates from symmetric branch in a close proximity and go alongside each other. In 1D problem, this structure appears in so called snakes-and-ladders structure as "double snaky" branch, however it does not appear in HIOP solution branches. On the other hand, in 2D problem, this structure appears in HIOP solution branches.

Traveling wave solutions for parabolic-hyperbolic conservation laws

Mon 08 Jul
18:10
CT6
KO-3

Hiroshi Watanabe (Oita University)

We consider the one-dimensional Cauchy problem (CP) for parabolic-hyperbolic conservation laws. The equation is regarded as a linear combination of the hyperbolic conservation laws and the porous medium type equations. Thus, this equation has both properties of hyperbolic equations and those of parabolic equations. Accordingly, it is difficult to investigate the behavior of solutions to (CP). In this talk, we focus our attention on traveling wave solutions to (CP). More precisely, we construct concrete discontinuous traveling wave solutions and discuss the speed of discontinuities. Moreover, we show the qualitative properties for entropy solutions to this problem using the constructed traveling wave solutions.

Hybrid Inverse Problems for Nonlinear Elasticity

Thu 11 Jul
17:30
MS33
KO-4

Alden Waters (University of Groningen)
Co-authors: Hugo Carrillo (UChile, University of Groningen)

We consider the Saint-Venant model in 2 dimensions for nonlinear elasticity. Under the hypothesis the fluid is incompressible, we recover the displaced field and the Lame parameter μ from power density measurements. A stability estimate is shown to hold for small displacement fields, under some natural hypotheses on the direction of the displacement.The techniques introduced show the difficulties of using hybrid imaging techniques for non-linear inverse problems.

Extended integrable lattices and their asymptotic behaviour

Tue 09 Jul
17:00
MS11
KO-6

Jonathan Wattis (University of Nottingham)

Co-authors: Pilar Gordoa (Universidad Rey Juan Carlos), Andrew Pickering (Universidad Rey Juan Carlos)

Recently, some integrable lattice systems have been generalised using algebraic approaches which give rise to hierarchies of extended systems. In this talk we use asymptotic techniques to show how solutions of these extended systems relate to more familiar systems. For example, we derive connections between the extended Toda lattice and generalised KdV equations. If time permits, we will also discuss the Volterra equation, modified Volterra, and a new (yet to be named) equation, which is of interest in both its classical scalar form as well as its matrix version.

Asymptotic Stability of the Toda m-soliton

Fri 12 Jul
10:15
MS2
KO-5

C. Eugene Wayne (Boston University)

Co-authors: Nick Benes (Office of Naval Research), Aaron Hoffman (Olin College)

We prove that multi-soliton solutions of the Toda lattice are both linearly and nonlinearly stable. Our proof uses neither the inverse spectral method nor the Lax pair of the model but instead studies the linearization of the BÃď cklund transformation which links the $(m-1)$-soliton solution to the m-soliton solution. We use this to construct a conjugation between the Toda flow linearized about an m-solition solution and the Toda flow linearized about the zero solution, whose stability properties can be determined by explicit calculation. This is joint work with Nick Benes and Aaron Hoffman.

Two-stroke relaxation oscillators – not all is van der Pol

Tue 09 Jul
13:45
Plenary
HK

Martin Wechselberger (The University of Sydney)

'Two-stroke' relaxation oscillations consist of two distinct phases per cycle – one slow and one fast – which distinguishes them from the well-known van der Pol-type 'four-stroke' relaxation oscillations. These type of oscillations can be found in singular perturbation problems in non-standard form where the slow-fast timescale splitting is not necessarily reflected in a slow-fast variable splitting.Based on Fenichel's seminal work, I will discuss a framework for the application of geometric singular perturbation theory to problems of this kind. The analysis of such two-stroke oscillations is motivated by applications which arise in the dynamics of electronic circuits, models for mechanical oscillators with friction and biochemical oscillators.

How mathematical modelling can help to improve our understanding of topical and transdermal drug delivery

Thu 11 Jul
17:30
MS25
KO-11

Jane White (University of Bath)

Co-authors: Begona Delgado-Charro (University of Bath)

The main purpose of our largest organ, the skin, is to provide a barrier function, protecting the body from harmful external substances whilst preventing excessive water loss from it. So when it comes to thinking about delivering or monitoring drugs across the skin, it is clearly challenging to understand how that might be possible. However, since the skin is large and accessible, there is a real interest in exploring the potential to exploit it for pharmaceutical purposes. Currently, there is a wide range of products readily available, such as nicotine patches and anti-inflammatory creams, that are designed to deliver drugs across or into the skin barrier. However, they are often inefficient, delivering only a small fraction of the available drug to the target site. It seems that there is a need to understand better how drugs penetrate the skin in order to make more effective dermal drug treatments. In this talk, I will present a selection of projects that I have worked on that use mathematical modelling to elucidate possible mechanisms that facilitate drug penetration into the skin layers as a function of the physico-chemical properties of the drug components. I will highlight how the models have been used both to understand empirical data and to provide hypotheses which inform new empirical studies. And I will discuss the potential for mathematical modelling to impact on future developments in pharmaceutical science.

Modelling cooperativity and the effects of the dimerisation of receptors on ligand binding

Thu 11 Jul
17:00
MS25
KO-11

Carla White (Swansea University)

It is now widely accepted that consideration of binding and signalling dynamics is an important factor in the drug discovery process. Furthermore, there is widespread acknowledgement that many receptors, such as G protein-coupled receptors (GPCRs), may exist as dimers, whilst others dimerize in response to ligand binding. As classical receptor theory is built around monomeric receptor assumptions, extending this to include dimers is necessary in order to classify, quantify and simulate ligand-receptor interactions and their signalling outcomes. A key factor in developing theoretical models of dimer signalling is cooperativity, whereby the binding of a ligand to one receptor affects the binding of another receptor. We present and analyse two models for ligand binding dynamics as an essential building block in the development of dimerised receptor theory. Our first model, a linear model for dimerised GPCRs, assumes that all receptors are pre-dimerised, where each of these are able to bind a single drug molecule. Our second model focuses on a vascular endothelial growth factor (VEGF) system. These receptors exist as monomers, and dimerisation is triggered upon ligand binding. Once a ligand molecule is bound to a receptor the ligand reversibly binds a second ligand, instantaneously dimerising the two receptors. The resulting ODE system for this model is nonlinear so we use both numerical and perturbation methods to analyse the intricacies of the time-course dynamics.

Temporal dissipative solitons in a DDE model of a ring laser with optical injection

Tue 09 Jul
16:50
CT11
KO-2

Matthias Wolfrum (Weierstrass Institute, Berlin)

Temporal dissipative solitons can be observed in DDEs with large delay as periodic solutions with a period close to the delay time, that stay close to a stable equilibrium during a large part of the period and show periodically a localized deviation from the equilibrium. We investigate a DDE model of a ring laser with optical injection showing showing so called phase solitons. Applying recent theoretical results on the Floquet spectra of temporal dissipative solitons in the limit of large delay, we study the stability of the phase solitons together with the stability of the background state. In particular, we show the effects of a delocalization of the soliton and of an oscillatory instability of the background state.

Stochastic model reduction for slow-fast systems with moderate time-scale separation

Wed 10 Jul
09:45
MS30
KO-7

Jeroen Wouters (University of Reading)
Co-authors: Georg A. Gottwald (University of Sydney)

We propose a stochastic model reduction strategy for deterministic and stochastic slow-fast systems with a moderate time-scale separation. The stochastic model reduction strategy improves the approximation of systems with finite time-scale separation, when compared to classical homogenization theory, by incorporating deviations from the infinite time-scale limit considered in homogenization, as described by an Edgeworth expansion in the time-scale separation parameter.To approximate these deviations from the limiting homogenized system in the reduced model, a surrogate system is constructed the parameters of which are matched to produce the same Edgeworth expansion as in the original multi-scale system, up to any desired order. We corroborate our analytical findings by numerical examples, showing significant improvements to classical homogenized model reduction.

Scaling limits and surface tension for gradient field models

Thu 11 Jul
18:00
MS20
KO-9

Wei Wu (University of Warwick)
Co-authors: Scott Armstrong (New York University)

Joint work with Scott Armstrong

A Cauchy Problem for Some Nonlinear Nonlocal integro-partial differential equation

Thu 11 Jul
17:50
CT20
KO-2

Hailu Bikila Yadeta (Sabanci University)

Co-authors: Albert Erkip (Sabanci University)

We study the local well-posedness as well finite time blow-up and global existence of the initial value problem for integro-partial differential equations of the form $u_{tt}(x,t) = \int_\Omega \alpha(x-y)g(u(y,t))dy$, with kernel α, and nonlinear function g where $\Omega \subset \mathbb{R}^n$ is a bounded domain.The improved Boussinesq equation is an example of equations that can be reduced to a convolution type integral equation on $\mathbb{R}$ as was studied in [1]. General convolution type integral equations on $\mathbb{R}$ arising in theory of elasticity were studied in [2].What makes the current work different is the restriction to the domain Ω which changes the properties of the convolution.References: 1. Constantin, Adrian; Molinet, Luc. The initial value problem for a generalized Boussinesq equation. Differential Integral Equations 15 (2002), no. 9, 1061–1072. `https://projecteuclid.org/euclid.die/13560607632`. N Duruk, H A Erbay and A Erkip Global existence and blow-up for a class of nonlocal nonlinear Cauchy problems arising in elasticity, Nonlinearity, 23,107

Bifurcations of homoclinic orbits in reversible systems

Tue 09 Jul
16:30
MS11
KO-6

Kazuyuki Yagasaki (Kyoto University)

We consider a class of reversible systems and study bifurcations of homoclinic orbits to hyperbolic saddle equilibria. Here we concentrate on the case in which homoclinic orbits are symmetric, so that only one control parameter is enough to treat their bifurcations, as in Hamiltonian systems. First, we apply an argument given in Part I to show that if such bifurcations occur in four-dimensional systems, then variational equations around the homoclinic orbits are integrable. We next extend the Melnikov method to reversible systems and obtain theorems on saddle-node, transcritical and pitchfork bifurcations of symmetric homoclinic orbits. We illustrate our theory for a four-dimensional system, and demonstrate the theoretical results by numerical ones.

Singular optimal control problems for quasi-variational evolution equations

Wed 10 Jul
10:05
CT14
KO-2

Noriaki Yamazaki (Kanagawa University)

Co-authors: Nobuyuki Kenmochi (Chiba University), Ken Shirakawa (Chiba University)

We consider singular optimal control problems for the following quasi-variational evolution equations (QP) governed by double time-dependent subdifferentials:

$$\partial_*\psi^t(u'(t)) + \partial_*\varphi^t(u; u(t)) + g(t, u(t)) \ni f(t) \text{ in } V^* \text{ for a.e. } t \in (0,T),$$

with initial data $u(0) = u_0$ in V, where V is a uniformly convex Banach space such that V is dense in a real Hilbert space H and the injection from V into H is compact. We also suppose that the dual space V^* of V is uniformly convex, and $H = H^*$. In addition, $0 < T < \infty$, $u' = du/dt$ in V, $\psi^t : V \to \mathbb{R} \cup \{\infty\}$ is a time-dependent proper, l.s.c., convex function on V for each $t \in [0,T]$, $\partial_*\psi^t$ is its subdifferentials from V into V^*, $g(t,\cdot)$ is a single-valued operator from V into V^*, f is a given V^*-valued function and $u_0 \in V$ is a given initial datum. Furthermore, $\varphi^t(v; z)$ is a time-dependent, non-negative, continuous convex function in $z \in V$, and $(t, v) \in [0,T] \times L^2(0,T;V)$ is a parameter that determines the convex function $\varphi^t(v;\cdot)$ on V. Moreover, the subdifferential $\partial_*\varphi^t(v;z)$ of $\varphi^t(v;z)$ is single-valued, linear, and bounded with respect to z from V into V^*.In this talk, we propose a general class of singular optimal control problems that are set up for non-well-posed state systems (QP).

Pitchfork bifurcations and linear stability of solitary waves in coupled nonlinear SchrÃűdinger equations

Tue 09 Jul
16:00
MS11
KO-6

Shotaro Yamazoe (Kyoto University)
Co-authors: Kazuyuki Yagasaki (Kyoto University)

We study pitchfork bifurcations and linear stability of solitary waves in coupled nonlinear SchrÃűdinger equations on the line. Here the coupled equations are assumed to possess a solitary wave of which one component is zero. We call the solution a fundamental solitary wave. It was previously shown that pitchfork bifurcations of the fundamental solitary wave occur at infinitely many values of the control parameter. In this talk, we present our results on linear stability of the fundamental and bifurcated solitary waves. We use the Evans function approach to determine their linear stability. Numerical evidence for our theoretical results is also given.

Temporal dissipative solitons in delay feedback systems

Tue 09 Jul
16:00
MS17
KO-10

Serhiy Yanchuk (Technical University of Berlin)
Co-authors: Stefan Ruschel (Technical University of Berlin), Jan Sieber (University of Exeter), Matthias Wolfrum (Weierstrass Institute)

We outline a theory for temporal dissipative solitons (TDS) in systems with time-delayed feedback. While this phenomenon was thoroughly studied in spatially extended systems, temporally localized states are gaining attention only recently, driven primarily by applications from fiber and semiconductor lasers. TDS is a special class of stable slowly oscillating solutions. First, we provide a definition and criteria for their emergence. In particular, we derive a system with an advanced argument, which determines the profile of the TDS. We also provide a complete classification of the spectrum of TDS into interface and pseudo-continuous spectrum. The theory is illustrated with two examples: a generic delayed phase oscillator, which is a reduced model for an injected laser with feedback, and the FitzHugh-Nagumo neuron with delayed feedback. Finally, we discuss possible destabilization mechanisms of TDS.

Turing instability and energy estimates for reaction-subdiffusion equations

Tue 09 Jul
19:00
Poster
KO

Jichen Yang (University of Bremen)
Co-authors: Jens Rademacher (University of Bremen)

The modelling of linear and nonlinear reaction-subdiffusion processes is much more subtle than normal diffusion and causes different phenomena. The resulting equations feature a time fractional derivative and spatial Laplacian, which yield a memory kernel that grows indefinitely. We present the model derivation and obtain some analytical results on spectral stability as well as numerical computations of spectra for the linear equations. This corroborates the heuristically expected stabilising effect of subdiffusion compared to normal diffusion. Moreover, we consider the linearisation of a nonlinear reaction-subdiffusion equation about non-zero homogeneous steady state. Here the spectrum cannot be analysed directly by Fourier-Laplace transform, and we provide some energy estimates.

Long-time Behavior of the Semi-linear Beam Equation with Localized Viscosity

Tue 09 Jul
09:45
CT8
KO-2

Sema Yayla (Hacettepe University)

This study is devoted to the initial boundary value problem for the semi-linear beam equation including localized viscosity. We prove the existence of the compact global attractor. Additionally, we establish the regularity of this attractor.

Global existence and finite-time blow-up in a quasilinear degenerate chemotaxis system with flux limitation

Mon 08 Jul
17:50
CT4
KO-1

Tomomi Yokota (Tokyo University of Science)

We consider the quasilinear degenerate chemotaxis system with flux limitation

$$\begin{cases} u_t = \nabla \cdot \left(\dfrac{u^p \nabla u}{\sqrt{u^2 + |\nabla u|^2}} \right) - \chi \nabla \cdot \left(\dfrac{u^q \nabla v}{\sqrt{1 + |\nabla v|^2}} \right), & x \in \Omega,\ t > 0, \\ 0 = \Delta v - \mu + u, & x \in \Omega,\ t > 0, \end{cases}$$

where $\Omega := B_R(0) \subset \mathbb{R}^n$ ($n \in \mathbb{N}$, $R > 0$) is a ball with $R > 0$, $p, q \geq 1$, $\chi > 0$ and μ is the mean value of the initial data u_0 of u: $\mu = \frac{1}{|\Omega|} \int_\Omega u_0$. In particular, if $p = q = 1$, then global existence and finite-time blow-up of solutions to the above system were proved by Bellomo and Winkler (Comm. Partial Differential Equations 42 (2017), 436-473, Trans. Amer. Math. Soc. Ser. B 4 (2017), 31-67). However, thier methods cannot be applied directly to the case that $p, q > 1$. We modify them by using new comparison functions. As a consequence, we establish results for global existence and finite-time blow-up in the above system. This work is partially based on joint works with Yuka Chiyoda, Masaaki Mizukami, Tatsuhiko Ono.

Topological methods analyzing incompressible fluids on multi-connected domains and their implementations

Wed 10 Jul
09:45
CT15
KO-3

Tomoo Yokoyama (Kyoto University of Education)

In this talk, we introduce topological fluid data analysis methods, called a partially cyclically ordered rooted tree (COT) representation. The COT representation is a complete invariant for generic incompressible flows on multi-connected domains. In other words, the topological equivalent classes of such flows correspond with the isomorphic classes of labelled rooted trees uniquely. Therefore a generic incompressible fluid on a multi-connected domain can be converted uniquely by a walk in a graph, called a transition graph, in the topological point of view. For instance, generic solutions of Euler equations on multi-connected domains can be described uniquely as walks in the transition graph. Applying the topological method to a plate in a time-dependent vortex flow under mild conditions, we can estimate when the lift-to-drag ratios of the plate are maximal and can determine the intermediate topologies of the vortex flow. Moreover, we explain that COT representations can be implemented using persistent homology. Finally, we demonstrate an implementation of COT representations of generic incompressible flows on multi-connected domains.

Deep Learning for Ocean Data Inference and Turbulence Parameterisation

Wed 10 Jul
08:45
MS30
KO-7

Laure Zanna (University of Oxford)
Co-authors: Thomas Bolton (University of Oxford)

Data from observations and ocean models lack information at small and fast scales. Here we use machine learning to leverage observations and model data by predicting unresolved turbulent processes and subsurface flow fields. We train convolutional neural networks on degraded data from a highâĂŘresolution quasiâĂŘgeostrophic ocean model. We demonstrate that convolutional neural networks successfully replicate the spatiotemporal variability of the subgrid eddy momentum forcing, are capable of generalizing to a range of dynamical behaviors, and can be forced to respect global momentum conservation. We also show that the subsurface flow field can be predicted using only information at the surface (e.g., using only satellite altimetry data). Our results indicate that dataâĂŘdriven approaches can be exploited to predict both subgrid and largeâĂŘscale processes while respecting physical principles, even when data are limited to a particular region or external forcing.

Linear inviscid damping for shear flows via the vector field method

Tue 09 Jul
09:45
MS21
KO-12

Zhifei Zhang (Peking University)

In this talk, I will present a new proof of linear inviscid damping for monotone shear flows via the limiting absorption principle and vector field method in the sprit of wave equation.

Analysis of a finite element method for measure-valued optimal control problems governed by the 1D wave equation

Tue 09 Jul
19:00
Poster
KO

Alexander Zlotnik (NRU Higher School of Economics, Moscow)

This work is a joint study together with B. Vexler (Munich) and P. Trautmann (Graz). It deals with the optimal control problems governed by a 1D wave equation (with variable coefficients) and the broad control spaces $\mathcal{M}_T$ of either measure-valued functions $L^2_{w^*}(I, \mathcal{M}(\Omega))$ or vector measures $\mathcal{M}(\Omega, L^2(I))$. The cost functional involves the standard quadratic tracking terms and the regularization term $\alpha\|u\|_{\mathcal{M}_T}$, $\alpha > 0$. We construct and study three-level in time bilinear finite element approximations for such problems. The main results are stability bounds for approximate solutions as well as error estimates for the optimal state variable and the error in the cost functional. The latter issue is a delicate matter due to a very low weak regularity of solutions. The analysis is essentially based on some previous results of the authors. In the short form the results are presented in [1].

1. B. Vexler, A. Zlotnik, P. Trautmann. On a finite element method for measure-valued optimal control problems governed by the 1D generalized wave equation // Compt. Rend. Math., 356 (5) (2018), 523-531.

On the strong continuity on data in weaker norms of global weak solutions to 1D viscous compressible Navier-Stokes equations and an error of their two-scale homogenization

Mon 08 Jul
15:40
CT2
KO-2

Alexander Zlotnik (NRU Higher School of Economics, Moscow)

The well-posedness theory of global in time weak solutions to IBVPs for the 1D compressible Navier-Stokes equations with large initial data from the Lebesgue spaces is described in the recent review [1]. It contains theorems on the Lipschitz continuous dependence of the solution (η, u, θ) (the specific volume, velocity and absolute temperature) on its initial data (η^0, u^0, θ^0) in the $L^\infty(\Omega) \times L^2(\Omega) \times L^q(\Omega)$ norms. Here $q = 1, 2$ and $Q = \Omega \times (0, T)$.In this report, by another technique we prove the alternative Lipschitz continuous dependence of the solution in the $L^{2,\infty}(Q) \times L^2(Q) \times L^2(Q)$ norm on (η^0, u^0, e^0) in the much weaker $L^2(\Omega) \times H^{-1}(\Omega) \times H^{-1}(\Omega)$ norm and the free terms in the mass, momentum and internal energy equations in some dual norms; here e^0 is the initial total energy.Moreover, we consider the case of the rapidly oscillating initial data and apply the above result to derive an estimate of order $O(\varepsilon)$ for their two-scale Bakhvalov-Eglit-type homogenization [2] thus solving a long-time standing problem.1. A. Zlotnik, Well-posedness of the IBVPs for the 1D viscous gas equations, In: Handbook of Math. Anal. in Mech. of Viscous Fluids, Y. Giga and A. Novotny, eds. Cham, Springer, 2017. P. 1-73.2. A.A. Amosov, A.A. Zlotnik, Comp. Math. Math. Phys. 38 (7) 1152-1167 (1998).

Alpha model for viscoelastic fluid with memory

Wed 10 Jul
10:05
CT15
KO-3

Andrey Zvyagin (Voronezh State University)

We consider the existence of weak solutions to one alpha-model for fractional Voigt type model of viscoelastic fluid. This model takes into account a memory along the motion trajectories. The investigation is based on the theory of regular Lagrangean flows, approximation of the problem under consideration by a sequence of regularized Navier-Stokes systems and the following passage to the limit.

Weak solvability and attractors for model of viscoelastic fluid with memory motion

Wed 10 Jul
10:25
CT15
KO-3

Victor Zvyagin (Voronezh State University)

In the report the existence of weak solutions to the initial-boundary value problem for one viscoelastic model of OldroydâĂŹs type fluid with memory along trajectories of the velocity field on finite interval is obtained. The proof uses the theory of regular Lagrange flows and a topological approximation method. For this method we reformulate the problem into the operator form, consider the ϵ-regularization of this operator equation in smoother spaces, obtain a priori estimates and use a topological degree for the proof of the solvability of this ϵ-regularized equations and, finally, we passage to the limit as $\epsilon \to 0$. Also the existence theorems for trajectory and global attractors for the system under consideration in the autonomous and non-autonomous cases are obtained. For this we use the attractors theory for non-invariant trajectory spaces, which is constructed in the monograph V.G. Zvyagin, D.A. Vorotnikov Topological Approximation Methods for Evolutionary Problems of Nonlinear Hydrodynamics // De Gruyter Series in Nonlinear Analysis and Applications (12), Walter de Gruyter, Berlin-New York, 2008, 230 p. Also, the existence of weak solutions for a motion model of viscoelastic fluid with memory along trajectories of the velocity field on an infinite interval is proved.

Explicit stabilised Runge-Kutta methods and their application to Bayesian inverse problems

Wed 10 Jul
09:45
MS28
KO-12

Konstantinos Zygalakis (University of Edinburgh)

The concept of Bayesian inverse problems provides a coherent mathematical and algorithmic framework that enables researchers to combine mathematical models with data. The ability to solve such inverse problems depends crucially on the efficient calculation of quantities relating to the posterior distribution, giving rise to computationally challenging high dimensional optimization and sampling problems. In this talk, we will connect the corresponding optimization and sampling problems to the large time behaviour of solutions to differential equations. Establishing such a connection allows utilising existing knowledge from the field of numerical analysis of differential equations. In particular, we will show that numerical stability is key for a good performing algorithm, and hence we will explore the applicability of explicit stabilised Runge-Kutta methods for optimization and sampling problems. These methods are optimal in terms of their stability properties within the class of explicit integrators and we will show that when used as optimization methods they match the optimal convergence rate of the conjugate gradient method for quadratic optimization problems, with the behaviour remaining the same for nonlinear problems. In the case of sampling, we will investigate their applicability to Bayesian inverse problems arising in computational imaging and show that explicit stabilised methods deliver much better MCMC samples than the current state of the art algorithms.
