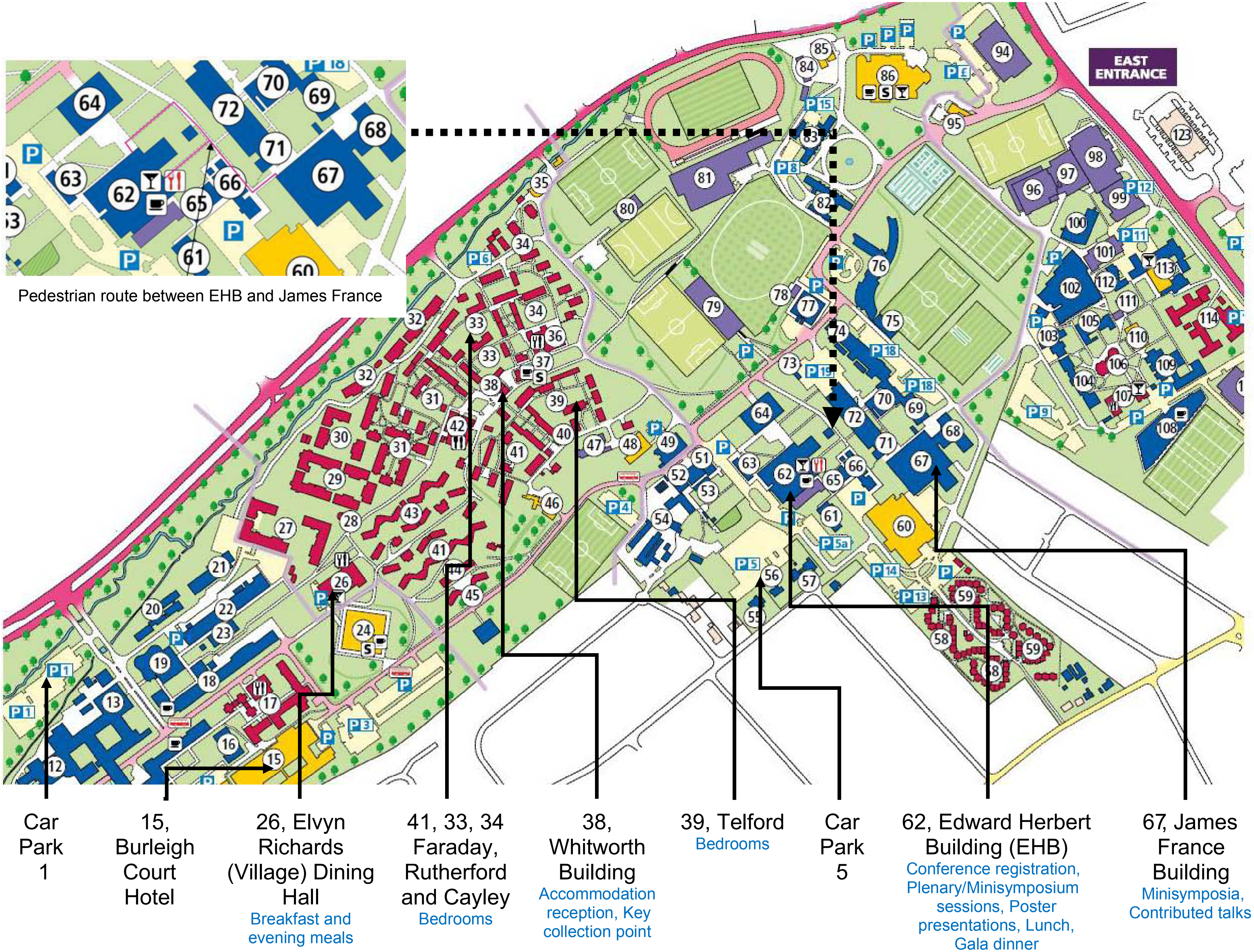
Equadiff 2011

Loughborough, UK
1-5 August 2011


EAST ENTRANCE
Pedestrian route between EHB and James France
Car Park 1
15, Burleigh Court Hotel
26, Elvyn Richards (Village) Dining Hall
Breakfast and evening meals
41, 33, 34 Faraday, Rutherford and Cayley
Bedrooms
38, Whitworth Building
Accommodation reception, Key collection point
39, Telford
Bedrooms
Car Park 5
62, Edward Herbert Building (EHB)
Conference registration, Plenary/Minisymposium sessions, Poster presentations, Lunch, Gala dinner
67, James France Building
Minisymposia, Contributed talks

Equadiff 2011

International Conference on Differential Equations
Loughborough, 1–5 August 2011

Welcome

Welcome to *Equadiff 2011*, the latest in a series of biennial European conferences on theoretical aspects of differential equations held in rotation in Eastern and Western Europe.

Organising committee

Jackie Baseley (Loughborough University conference organiser)

Mark Groves, Loughborough/Saarbrücken (Co-Chair)
Bjorn Sandstede, Brown (Co-Chair)

John Ball (Oxford)
Jack Carr (Heriot-Watt)
Alan Champneys (Bristol)
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Equadiff 2011
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Equadiff 2011

Contents

Conference venue

Conference site

The conference will take place in the Edward Herbert Building (EHB) and the nearby James France Building. The EHB and James France Buildings can be found on the campus map as buildings 62 and 67 in the Central Park area of Loughborough University campus.

Oral presentations will take place in the following rooms.

Plenary talks and parallel session 1 in J.1.10 (EHB)
Parallel session 2 in J.0.02 (EHB)
Parallel session 3 in J.0.01 (EHB)
Parallel session 4 in CC.00.11 (James France Building)
Parallel session 5 in CC.00.12 (James France Building)
Parallel session 6 in CC.00.13 (James France Building)
Parallel session 7 in CC.00.29a (James France Building)
Parallel session 8 in CC.00.14 (James France Building)
Parallel session 9 in CC.1.09 (James France Building)
Parallel session 10 in CC.1.10 (James France Building)
Parallel session 11 in Woodhouse Room (EHB)

Registration

The registration desk is located in the EHB Atrium. You will be issued with a badge at registration. Please wear your badge at all times.

The registration desk will be open at the following times.

Sunday 31 July from 17.00 to 19.00
Monday 1 August from 9.00 to 16.00
Tuesday 2 August from 9.00 to 14.00
Wednesday 3 August from 9.00 to 14.00
Thursday 4 August from 9.00 to 14.00
Friday 5 August from 9.00 to 14.00

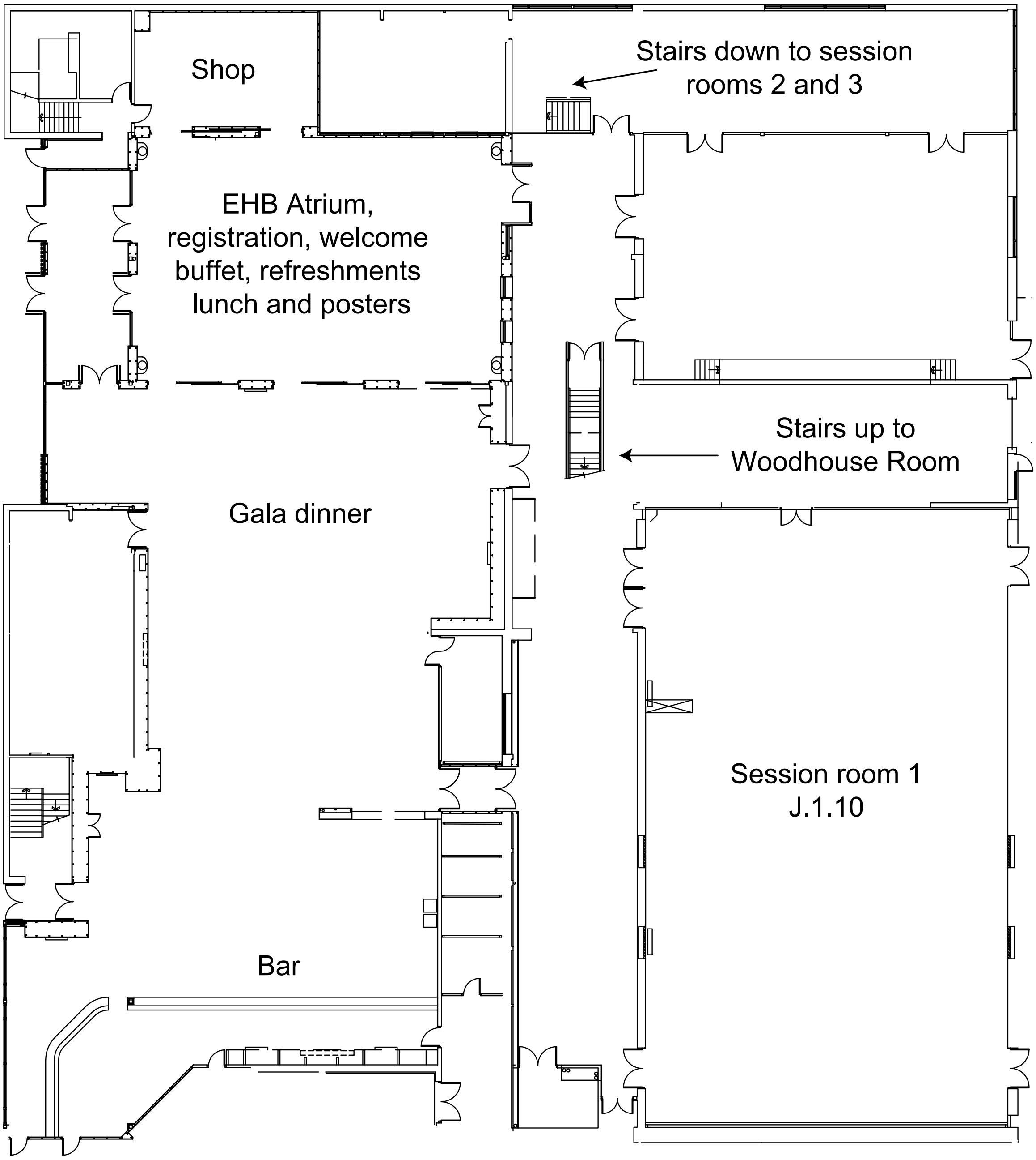
Meals and refreshments

For all delegates:

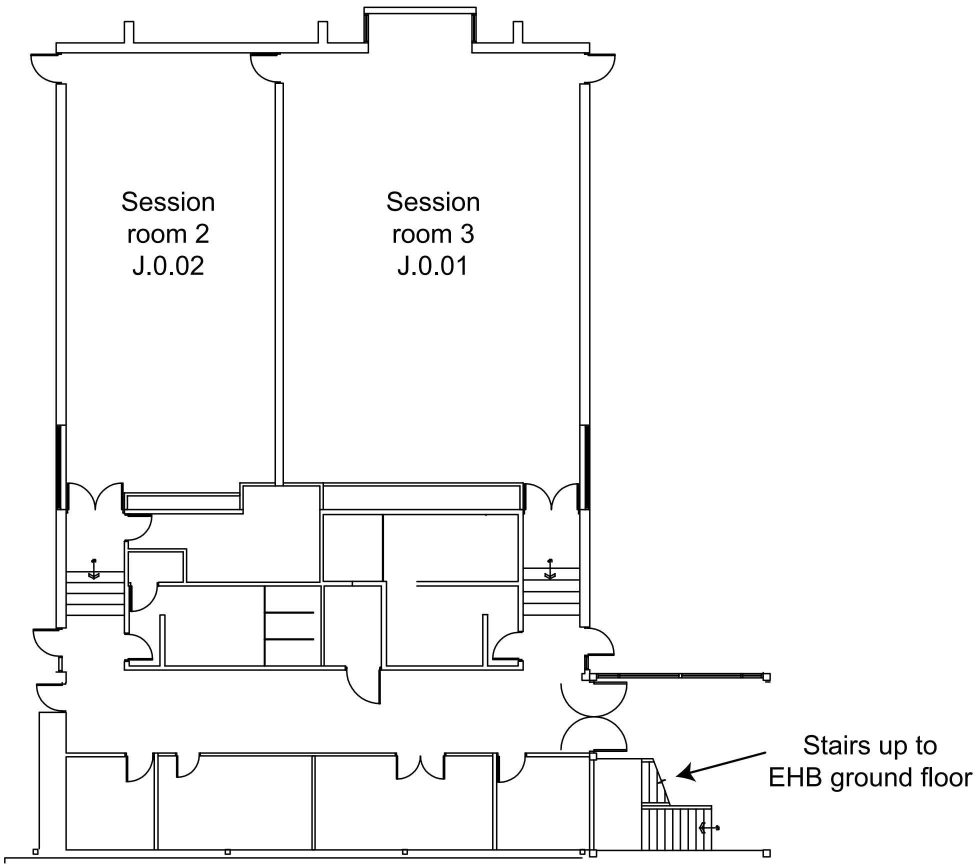
A welcome buffet will be served in the EHB at 18.00 on Sunday 31 July.
Refreshments will be served each morning in the EHB Atrium and each afternoon in the EHB Atrium and James France exhibition area.
Lunch will be served in the EHB Atrium and lounge.
The gala dinner takes place on Tuesday at 19.00 in the EHB Atrium and lounge.

For residential delegates only:

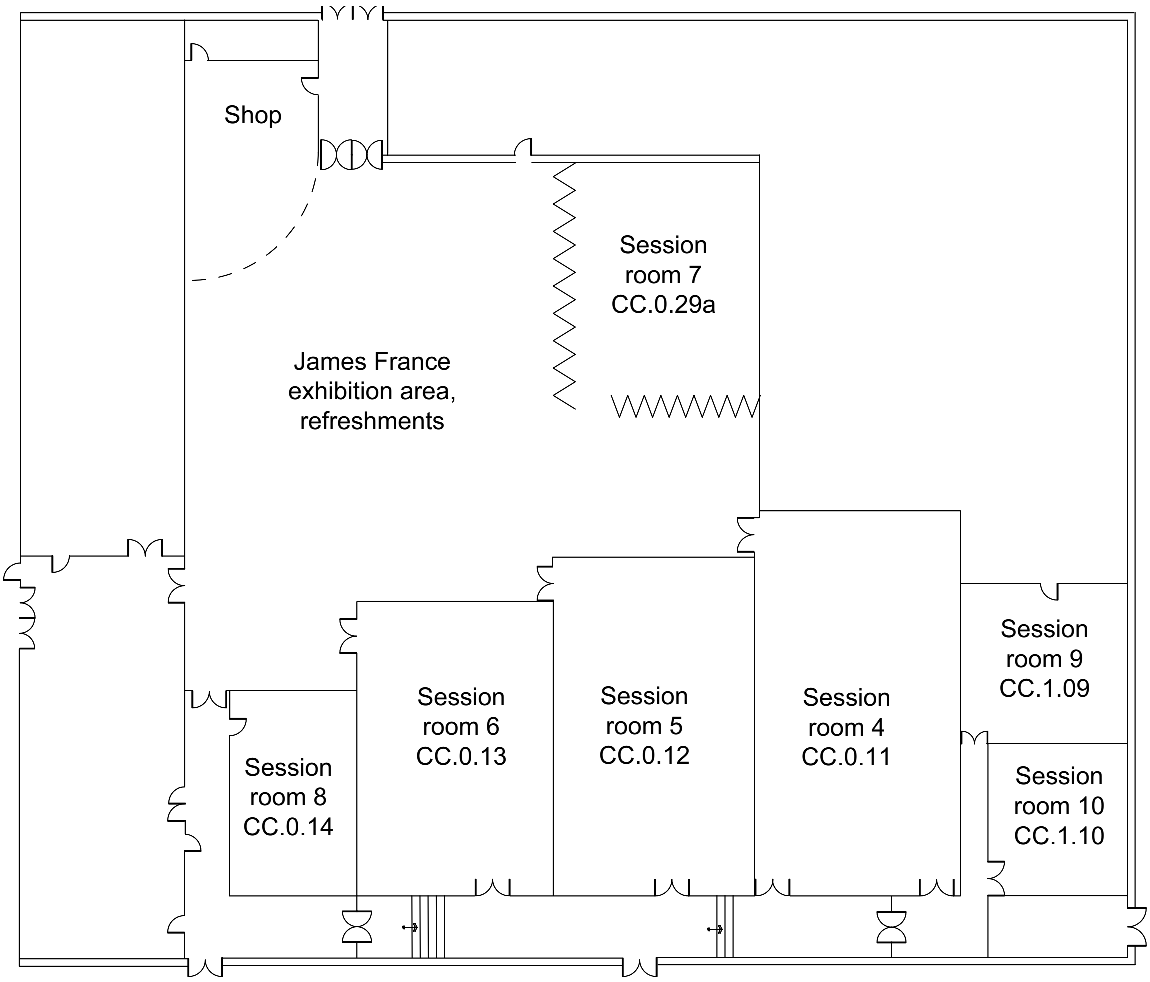
Breakfast and dinner will be served in the Elvyn Richards Dining Room (building 26 in the Village Park area of Loughborough University campus).



Edward Herbert Building ground floor



Edward Herbert Building lower ground floor



James France Building

Information for delegates

Loughborough University campus map

You may find it helpful to view the campus map to familiarise yourself with the Loughborough University campus. You can download a PDF version of the campus map from

http://www.lboro.ac.uk/about/map/downloads/campus-map-2011.pdf

Printed copies are available from the registration desk.

Village Park accommodation

The single ensuite accommodation will be in the Village Park area of the Loughborough University campus in Faraday, Rutherford, Cayley and Telford Halls.

Keys should be collected on your arrival from the village accommodation 24 hour reception in the Whitworth Building (building 38 in Village Park). The reception is open 24 hours a day.

All bedrooms are supplied with towels and basic toiletries, and tea/coffee making facilities are provided. Delegates are advised to bring adapters if required as not all rooms have shaving points.

Bedrooms must be vacated by 9.30 on the day of departure.

Oral presentations

All minisymposium and contributed talks are 25 minutes plus 5 minutes for discussion.

Every room is equipped with overhead and data projectors. Please bring your own computer if you wish to use a data projector.

Poster presentations

Poster boards are 1.8m x 0.8m. They are Velcro covered and either Velcro or drawing pins should be used to secure posters. Velcro will be available at the registration desk to fix your posters. Pease set up your poster in the EHB Atrium between 14.00 and 17.30 on Monday 1 August and attend your poster to take questions during the Poster Session Wine Reception between 18.30 and 19.30 on Monday evening. Allocation of position in the exhibition room will be on a first come first served basis. Please remove your poster at the end of the poster session on Monday evening. Any posters not collected will be destroyed.

Social events

Various social events are planned for delegates. All social events are included in the registration fee and all delegates are welcome.

Sunday 31 July: Welcome buffet at 18.00 in the EHB.

Monday 1 August: Poster session and wine reception at 18.30 in the EHB Atrium and lounge.

Tuesday 2 August: Gala dinner at 19.00 in the EHB Atrium and lounge.

Wednesday 3 August: Excursion to Chatsworth House and Gardens.

Chatsworth House, the seat of the Cavendish Family, lies at the heart of the Peak District National Park and is the magnificent home of the 12th Duke and Duchess of Devonshire. It is generally regarded as the finest palatial home in England; it is one of the country's greatest treasure-houses with a vast collection of art treasures and ancient artefacts from all over the world. The beautiful Chatsworth Gardens are home to rare specimen trees, temples, sculptures, streams and fountains. A tour of the house is included in your registration fee and will take 75 minutes. You will be free to walk at your own pace around the magnificent rooms, which contain a fascinating and varied collection of art, furnishings and curiosities from around Europe and beyond, and include the Sculpture Gallery, recently seen in the recent film of Pride and Prejudice. Coaches leave from outside the EHB at 13.00 and from Chatsworth House for the return journey to Loughborough at 18.00. The journey takes between 60 and 75 minutes.

Car parking

There is ample car parking on the Loughborough University campus. You should enter and exit the site from the Epinal Way entrance (East entrance on the campus map). A Security Officer will issue you with a windscreen identification tag. At the Epinal Way entrance please use the lane marked visitors. All visitors must conform to the Highway Code and to the speed restriction of 15mph. Always park in a proper bay as improperly parked vehicles will be clamped.

Please use Car Park 1 if you are a resedential delegate.

Fire procedures

All visiting delegates must make themselves aware of the fire procedure notices, which are located throughout the Loughborough University campus. These notices contain information as to the action to be taken in the event of discovering a fire, hearing the fire alarm sounders and with regards to the designated areas of assembly after evacuating a building.

Insurance

The University has insurance cover, including fire insurance, which extends to cover loss, damage, or injury suffered by conference visitors in the event of legal liability being attributed to the University or its employees. These insurances are held with Royal & Sun Alliance Insurance Group. There is no cover to protect visitors' property other than as outlined above. Delegates are advised to carry their own insurance.

Liability

Loughborough University - Imago is unable to accept liability for loss or damage occurring to any property or motor vehicle left, deposited, or parked on campus.

Local facilities

On campus you will find banks, bars, shops, an optician and a dentist at the Student Union. A chapel and the Medical Centre are located in the immediate vicinity of the EHB. The EHB shop and the Union Shop sell a variety of food, snacks, drinks, stationery, magazines and newspapers. Loughborough town centre, which has many more facilities, is within walking distance. There is also a shuttle bus service, which picks up from several stops on site.

Lost property

Any enquiries regarding lost property should be made with the Imago Sales Office (Imago is Loughborough University's conference service provider), who will endeavour to locate the property in question. Telephone 08450 364624 or email info@welcometoimago.com. Prepayment for postage must first be received in order for any items to be returned.

Health Centre

Loughborough NHS Walk-in Centre situated in Loughborough's town centre, is open 24 hours a day. It is situated in Loughborough Health Centre, Pinfold Gate, Loughborough, Leicestershire, LE11 1BE. Telephone 01509 553998.

The nearest accident and emergency centre is located approximately 10 miles away at the Leicester Royal Infirmary. Address: Leicester Royal Infirmary, Infirmary Square, Leicester LE1 5WW. Telephone 0300 303 1573.

Smoking

Smoking is prohibited within all Loughborough University facilities.

Sports facilities

Loughborough University has extensive on-campus sport and leisure facilities which can be booked for individual conference delegates.

Delegates can swim in the 50m Olympic swimming pool for a small charge payable on the door.

A fitness centre with first class techno gym equipment is available for a small charge. For details contact the Sports Reception, telephone: 01509 226250 or email sdc@lboro.ac.uk.

Burleigh Springs Leisure Complex, located in the Burleigh Court Hotel comprises a 15m swimming pool, sauna, whirlpool spa, steam room, fully equipped gymnasium and beauty treatment rooms. Opening times: Monday to Friday 7.00am - 9.00pm, Saturday 7.00am - 8.00pm, Sunday 7.00am - 6.00pm. Delegates and their partners can pay to use this facility on a per day basis. For more information, contact Burleigh Springs, telephone 01509 633016 or email info@welcometoimago.com.

Local travel information

University shuttle bus service

Kinchbus Sprint travels between the University, Loughborough town centre and the railway station every ten minutes (less frequently in the evenings and at weekends).. A timetable can be found at

http://www.kinchbus.co.uk/timetables/sprint.aspx

Taxis

Ashley David Taxis, Loughborough University. Tel: 01509 260000
ABC Taxis. Tel: 01509 218585
AAA Taxis. Tel: 01509 504488
ACE Taxis. Tel: 01509 215656

Computer use

All conference delegates may connect personal computing devices (laptops, mobile phones, iPads, etc.) to the network using wireless LAN. The conference venue (EHB and James France Building) and most delegate bedrooms are covered by an externsive wireless network. Residential delegates may also connect a personal computer by cable to the campus network in their bedrooms to gain access to the internet.

Alternatively, if you do not wish to bring your computer to the conference, you can log in from open access computers in the University Library on campus.

Delegates MUST read Loughborough Universitys acceptable use policies concerning computer use before using any computing facilities on campus. The policies may be found at

http://www.lboro.ac.uk/it/policies/loughborough-aup.html

and a printed copy is available from the conference organiser. All computers connected to the network MUST be running an up-to-date virus checker program and their operating systems MUST be patched against security vulnerabilities.

Using the Wireless LAN

Loughborough University is a member of the *eduroam* federation which permits guests from other *eduroam* member institutions to access the internet without having to obtain local usernames and passwords. Further details about *eduroam* can be obtained from

http://www.ja.net/roaming

or

http://www.eduroam.org

Please contact your local IT support for details of how to configure and access *eduroam* prior to attending the conference. At Loughborough simply enable wireless on your device and join the *eduroam* wireless network to connect to the internet without further intervention. If you have any problems please contact your home institution in the first instance.

Delegates unable to access *eduroam* may also use the *imago* wireless network. For this purpose you will need to obtain a username and password from the conference registration desk or Whitworth reception and follow these instructions:

(i) Enable wireless on your device.

(ii) Join the *imago* wireless network.

(iii) Open a browser and attempt to visit a website (for example your home page).

(iv) You will be directed to a login page. Enter your login id and password to gain access to the internet.

(v) You may freely browse the internet after logging in. You may occasionally need to re-authenticate using the above procedure.

Please note that *imago* is an open wireless network.

Wired network access

Although most halls of residence have wireless network access, residential delegates can also make use of wired network facilities in the bedrooms. A username and password will be needed, which can be obtained from the conference registration desk or Whitworth reception. This is the same system used by the *imago* wireless network described above, so if you have obtained one for that purpose you do not need to obtain another. Once you have a username and password follow these instructions:

(i) Connect your device to network socket on the wall in your bedroom. If there are two sockets, then only one will be active (normally marked with a sticker).

(ii) Open a browser and go to

http://hallnet.info/register

Enter your login id and password, and click on 'Sign In'.

(iii) Close your browser and disconnect and re-connect the network cable or restart your device.

(iv) Open a browser and attempt to visit a website (for example your home page).

(v) You will be directed to a login page. Enter your login id and password to gain access to the internet.

(vi) You may freely browse the internet after logging in. You may occasionally need to re-authenticate using the above procedure.

Browsing from open access computers

Delegates may also log into the campus network and browse the internet from the open access computers in the Pilkington Library (open from 9.00 to 17.30). Please see

http://www.lboro.ac.uk/library/labhelp.html

for further details. Your login id and password are required to log in to these computers and access the internet.

Plenary talks

Recent progress on the Yamabe problem

Simon Brendle
Stanford University, USA

We give a survey of various compactness and non-compactness results for the Yamabe equation. We also discuss the gradient flow for the Yamabe functional, and its asymptotic behavior.

How can we modify the least action principle for conservative dynamical systems, in order to handle dissipative phenomena?

Yann Brenier
Université de Nice, France

We consider dynamical systems in a Hilbert space H for which the potential energy is minus the square distance to a given bounded subset S of H. This class contains interesting systems of interacting particles (in some gravitational or matrix models). The subset N of points in H for which there are several distinct closest points in S is singular for such a potential. Typical solutions of the dynamical system hit N after a finite time and there is not a unique way to extend them. From the classical least action principle we only get solutions that conserve the total energy. In the lecture, we show how the action can be modified, in a somewhat canonical way, to input dissipation of energy, which matters for several concrete applications. (From the very elementary case of sticky particles moving along the real, to the more challenging problem, in cosmology, of reconstructing the early universe, -following Zeldovich, Peebles, and, more recently, Frisch *et al*, through the classical inviscid Burgers equation.)

Delay induced behaviour

Sue Ann Campbell
University of Waterloo, Canada

Models involving delay differential equations can exhibit a variety of interesting behaviour when the delay is varied as a parameter. Examples include oscillator death, attractor switching, multistability and delay induced canards. I will present models exhibiting these phenomena and show how the behaviour can often be predicted and understood using bifurcation analysis involving two or more parameters.

The Hofstadter butterfly, uniform hyperbolicity, and gap labeling

David Damanik
Rice Unversity, USA

We describe how the Hofstadter butterfly, a fractal in the plane, arises numerically through the study of the eigenvalues of a parametrized family of finite matrices and discuss known results and open problems. In particular, we explain a recent approach, developed jointly with Artur Avila and Jairo Bochi, towards a description of the wings of this butterfly and those of a colored version due to Yosi Avron and Daniel Osadchy. This approach is based on a characterization of the wings of the butterfly in terms of uniform hyperbolicity of the associated $\mathrm{SL}(2,\mathbb{R})$-cocycles. Our main results show that under suitable assumptions, uniform hyperbolicity is dense in the continuous category and all gaps allowed by the gap labeling theorem are generically open.

Interaction of vortices in viscous planar flows

Thierry Gallay
Université de Grenoble, France

It is a well established fact that vortex interactions play a crucial role in the time evolution of viscous planar flows. In particular, numerical simulations of two-dimensional freely decaying turbulence reveal a fascinating coarsening dynamics, which is related to the inverse energy cascade and appears to be essentially driven by vortex mergers. Although strongly nonlinear couplings such as vortex mergers are extremely hard to investigate mathematically, it is possible to obtain a rigorous description of vortex interactions in the perturbative regime where the size of the vortex cores is much smaller than the distance between the vortex centers. This is the case, for instance, if the initial flow is a superposition of point vortices, and if the Navier-Stokes evolution is considered in the vanishing viscosity limit. In this way, we obtain a simple and rigorous derivation of the Helmholtz-Kirchhoff point vortex system, together with an accurate description of the deformations of the vortex profiles due to mutual interactions. In the particular case of a single vortex pair, we conjecture that the slightly viscous solution can be nicely approximated by a particular solution of Euler's equation which is stationary in a uniformly translating or rotating frame.

Dynamics of slow-fast Hamiltonian systems

Vassili Gelfreich
University of Warwick, UK

In this talk, I will give an overview of recent results in the theory of slow-fast Hamiltonian systems. I will briefly review classical results on averaging methods and explain the role played by adiabatic invariants. I will discuss the long time evolution of energy in a non-autonomous system with a slowly changing Hamiltonian assuming that each frozen Hamiltonian system has a chaotic invariant subset. I will illustrate the theory by an application to Fermi acceleration. Then I will explain how the theory can be extended onto systems with several fast and several slow degrees of freedom. I will explain that the slow dynamics has features similar to a random dynamical systems and describe a situation when the slow component of the dynamic is similar to a random walk. In particular, under certain assumptions, any continuous curve can be shadowed by the slow component of a trajectory.

Stirring tails of evolution

Raymond Goldstein
University of Cambridge, UK

One of the most fundamental issues in biology is the nature of evolutionary transitions from single cell organisms to multicellular ones. Not surprisingly for microscopic life in a fluid environment, many of the processes involved are related to transport and locomotion, for efficient exchange of chemical species with the environment is one of the most basic features of life. This is particularly so in the case of flagellated eukaryotes such as green algae, whose members serve as model organisms for the study of transitions to multicellularity. In this talk I will focus on recent experimental and theoretical studies of the stochastic nonlinear dynamics of these flagella, whose coordinated beating leads to graceful locomotion but also to fluid flows that can out-compete diffusion. A synthesis of high-speed imaging, micromanipulation, and three-dimensional tracking has quantified the underlying stochastic dynamics of flagellar beating, allowed for tests of the hydrodynamic origins of flagellar synchronization, and revealed a eukaryotic equivalent of the run-and-tumble locomotion of peritrichously flagellated bacteria. Challenging problems in applied mathematics, fluid dynamics, and biological physics that arise from these findings will be highlighted.

Damped-driven Hamiltonian PDE

Sergei Kuksin
École Polytechnique, France

I will discuss the following class of nonlinear PDE:

$$\langle \text{Hamiltonian PDE} \rangle = \varepsilon \cdot \langle \text{damping} \rangle + \varkappa_\varepsilon \cdot \langle \text{force} \rangle. \qquad (\star)$$

The equations are considered in finite volume, $\varepsilon > 0$ is a small parameter and the scaling constant $\varkappa_\varepsilon$ is chosen in such a way that the solutions stay of order one when time is large and ε is small. Equations $(*)$ describe turbulence in various physical media. I will discuss three groups of them:

(i) Navier-Stokes equations;

(ii) 1D Burgers equation;

(iii) Equations $(\star)$, where the Hamiltonian PDE is a non-linear Schrödinger equation (NLS).

Navier-Stokes equations with small viscosity ε describe water turbulence in dimensions 2 and 3. If $(\star)$ is the 3D Navier-Stokes equations, we know about solutions with small ε almost nothing (e.g., the right scaling constant $\varkappa_\varepsilon$ is unknown). In the 2D case we know about the limit some nontrivial results. In particular, now for the case of random forces $\varkappa_\varepsilon = \sqrt{\varepsilon}$, the set of stationary measures μ_ε for equations $(\star)$ is tight and all limiting measures $\lim_{\varepsilon_j \to 0} \mu_{\varepsilon_j}$ are invariant measures for the 2d Euler equation and are genuinely infinite-dimensional.

1D Burgers equation with small ε describes the "burgulence" – a popular model for the real turbulence above. Now $\varkappa_\varepsilon = 1$ and various results are available for equation $(\star)$ with small ε and for its limit as $\varepsilon \to 0$. Those for $(\star)$ with $\varepsilon > 0$ may be interpreted in terms of the intermittency in burgulence.

Equations from the third group with random force, among other things, describe the optical turbulence. Now again $\varkappa_\varepsilon = \sqrt{\varepsilon}$. Interesting results are available when the Hamiltonian equation is the integrable 1D NLS, or when it is a linear Schrödinger equation with a generic potential, while the damping is nonlinear. In these cases the limiting dynamics is described by a well-posed infinite system of dissipative stochastic equations. I will discuss these results in details.

Improved Moser-Trudinger inequalities and Liouville equations on compact surfaces

Andrea Malchiodi
SISSA, Italy

We consider a class of equations with exponential nonlinearities and possibly singular sources motivated from the study of abelian Chern Simons models or from the curvature prescription problem in conformal geometry. Using improvements of the classical Moser-Trudinger inequality and, combined with Morse theory, we derive some general existence results.

A menagerie of stochastic stabilization

Jonathan Mattingly
Duke University, USA

The qualitative understanding of stochastic differential equations is not at the same level of completeness as its deterministic counterpart. It is not a simple case of "porting" the techniques to the stochastic setting since the questions can be quite different. A basic problem for a stochastic system is to show that it possesses a unique steady state which dictates the long term statistics of the system. Sometimes the existence of such a measure is the difficult part. One needs control of the excursions away from the systems typical scale. As in deterministic system, one popular method is the construction of a Lyapunov function. In the stochastic setting there lack of systematic methods to construct a Lyapunov function when the interplay between the deterministic dynamics and stochastic dynamics are important for stabilization. I will give some modest steps in this direction which apply to a number of cases. In particular I will show a system where an explosive deterministic system is stabilized by the addition of noise and examples of physical systems where it is not clear how the deterministic system absorbs the stochastic excitation with out blowing up.

Self-similarity in Smoluchowski's coagulation equations

Barbara Niethammer
University of Oxford, UK

Smoluchowskis coagulation equations are a mean-field model to describe coagulation of homogeneously distributed particles. Of particular interest is the question of dynamic scaling, that is whether solutions converge to a self-similar profile. However, for general rate kernels not much is known even only about the existence of self-similar solutions. We will review what is known about these aspects for a class of solvable kernels and will discuss some recent results for non-solvable kernels.

Large deviation problems for partial differential equations and applications to uncertainty quantification

George Papanicolaou
Stanford University, USA

Uncertainty quantification is a relatively new research area that seeks to model, analyze and quantify the origin and propagation of errors in complex systems. It is a response to the increasing complexity of scientific computations which produce results that are difficult to assess, even if they can be reproduced. Roughly speaking, we want to calculate error bars, or confidence intervals, about all solutions that we compute. This increases enormously the complexity of already complex computations that are to be carried out. Differential equations based models need to account for probabilistic fluctuations in coefficients and data, as well as for deeper uncertainties regarding the very equations themselves. How do these uncertainties influence the solutions? It is out of the question to generate samples of solutions by simply repeating a basic computation, not only because of computational cost but because some fluctuations have little effect while others can have big effects and this is not so clear in direct numerical simulations. I will discuss some recent work on mean field models and conservation laws with random forcing that address such issues with tools from probability and differential equations that have the potential to bring down computational costs substantially.

Numerical mathematics and the method of averaging

Jesus Maria Sanz-Serna
Universidad de Valladolid, Spain

We shall explain how to perform averaging analytically through the combinatorial techniques now used to study the properties of numerical integrators. The novel approach has a wider scope than conventional averaging methods. Furthermore it systemizes greatly the derivation of high-order averaged systems. We shall also discuss how to perform averaging by purely numerical means.

Numerical mathematics and the method of averaging

Mary Silber
Northwestern University, USA

We extend the methods of Pyragas time-delayed feedback control of unstable periodic orbits to the situation where the unstable periodic orbits arise in a symmetry breaking Hopf bifurcation. We consider traveling wave patterns with spatio-temporal symmetries, as well as oscillator patterns for equivariant Hopf bifurcation problems.

Singularities of water waves with vorticity

Georg Weiss
Universität Dusseldorf, Germany

We extend our proof of the Stokes conjecture concerning the shape of extreme two-dimensional water waves to water waves with vorticity. Here we consider the case where the vorticity function has linear growth in the normalised stream function variable. We recover most of the results obtained in the zero vorticity case, including isolatedness of singularities and a characterisation of non-degenerate and degenerate singularities. Our analysis is completely local. (Joint work with Eugen Varvaruca, University of Reading)

Equadiff 2011

Minisymposia

CELESTIAL MECHANICS

Organisers: Alain Albouy (IMCCE, France), Eldar Straume (NTNU, Norway)

Two approaches to Smale's sixth problem

Alain Albouy
IMCCE, France

Recently with Vadim Kaloshin we proved the finiteness of the number of relative equilibria in the 5-body problem, for most of the choices of masses. Other arguments were previously developed by Hampton, Moeckel and Jensen, including BKK theory and Tropical Geometry. Both approaches have strong similarities in their concluding arguments. These arguments could complete each other, thus improving the results.

Topology and stability of integrable Hamiltonian systems

Alexey Bolsionv
Loughborough University, UK

A general topological approach is proposed for the study of stability of periodic solutions of integrable dynamical systems with two degrees of freedom. The methods developed are illustrated by examples of several integrable problems, in particular, in the dynamics of gaseous expanding ellipsoids. These topological methods also enable one to find non-degenerate periodic solutions of integrable systems, which is especially topical in those cases where no general solution (for example, by separation of variables) is known.

Higher variational equation integrability conditions and applications to the n body problem

Jean-Baptiste Caillau
Université de Bourgogne, France

The controlled planar circular restricted three-body problem is considered. The third body (e. g. a spacecraft in the Earth-Moon system) is assumed to have a thrust, so a control term is added linearly to the second order CR3BP dynamics. The resulting dynamical system has two parameters, the bound on the control (the thrust is limited) and the ratio of the primary masses.

Given two points in the four-dimensional phase space, the first issue is the existence of measurable controls that generate trajectories connecting these points. Existence of minimum time trajectories among those is then discussed. Both matters involve a comparison with the Jacobian constant of Lagrange points, as well as taking care of collision trajectories. Minimizing arcs must be projections of curves of a generalized Hamiltonian system on the (eight-dimensional) cotangent bundle of the phase space. This provides some insight into the structure of these optimal arcs and sets the ground for numerical computations. Such computations eventually rely on a continuation with respect to the ratio of masses which allows to connect the two-body control problem (setting one of the primary masses to zero) to the three-body one.

This work is in collaboration with Bilel Daoud (Bourgogne) and Joseph Gergaud (Toulouse).

Higher variational equation integrability conditions and applications to the n body problem

Thierry Combot
IMCCE, France

We present a general criterion of integrability at order 2 for homogeneous potentials of degree -1, which strengths the integrability conditions of Morales Ramis. We apply this criterion and a restricted integrability criterion of order 3 for resistant cases to prove the non integrability of the Newtonian 3 and 4 body problem on a line with positive masses. We then present some possible generalizations for the non integrability of n body problem with n higher than 4, especially in the planar case.

Platonic polyhedra, topological constraints and periodic solutions of the N-body problem

Giovanni Gronchi
Universita' di Pisa, Italy

We prove the existence of a number of smooth periodic motions u_* of the classical Newtonian N-body problem which, up to a relabeling of the N particles, are invariant under the rotation group G of one of the five Platonic polyhedra. The number N coincides with the order of G and the particles have all the same mass. Our approach is variational and u_* is a minimizer of the Lagrangian action A on a suitable subset K of T-periodic maps u in the Sobolev space $H^1(\mathbb{R}, \mathbb{R}^{3N})$. The set K is a cone and is determined by imposing to u both topological and symmetry constraints which are defined in terms of the rotation group G. There exist infinitely many such cones K, all with the property that the action A, restricted to K, is coercive. For a certain number of them, using level estimates and local deformations, we show that minimizers are free of collisions and therefore classical solutions of the N-body problem with a rich geometric-kinematic structure.

Complexity of collisions in newtonian 3-body problems

Jean-Pierre Marco
Université Paris VI, France

We will analyze the complexity of collisions in 3-body problems by means of a topological method generalizing the Souriau regularization. A byproduct of our method is that it yields a precise definition for the "regularizability" of singular systems. We will prove that in general the 3-body problem is not regularizable according to this definition.

Non-integrability of N-body problems via variational equations

Juan Morales-Ruiz
Technical University of Madrid, Spain

This talk will be devoted to gives a survey about several non-integrability results of N-body problems by means of the structure of the Galois groups of the variational equations aroud a particular integral curve.

Generic Nekhoroshev theory without small divisors and applications

Laurent Niederman
Université Paris Sud and IMCCE, France

We present a new approach of Nekhoroshev's theory for generic analytic quasi-integrable Hamiltonian systems which completely avoids small divisors problems. The proof is an extension of a method introduced by P. Lochak, it combines averaging along periodic orbits with simultaneous Diophantine approximation and uses geometric arguments designed by the first author to handle generic integrable Hamiltonians.

This method reduces the analytic part of the proof to its minimum and this feature allowed Abed Bounemoura to obtain applications in two settings :

- He has proved generic results of super-exponential stability around linearly stable invariant tori in an analytic Hamiltonian system.
- He has obtained generic results of stability for differentiable or Gevrey quasi-integrable Hamiltonian systems.

We will discuss possible applications to the N-body planetary problem.

Cyclic central configurations in the four-body problem

Gareth Roberts
College of the Holy Cross, USA

We classify the set of central configurations lying on a common circle in the Newtonian four-body problem. Such a configuration will be referred to as a cyclic central configuration. Using mutual distances as coordinates, we show that the set of cyclic central configurations with positive masses is a two-dimensional surface, a graph over two of the exterior side-lengths. Two symmetric families, the kite and isosceles trapezoid, are investigated extensively. We prove a specific ordering of the masses is required for a cyclic central configuration and find explicit bounds on the mutual distances. In contrast to the general four-body case, we show that if any two masses of a cyclic central configuration are equal, then the configuration has a line of symmetry. In addition to utilizing many analytic arguments, our techniques also invoke classical geometry (e.g., the Cayley-Menger determinant and Ptolemy's Theorem) as well as modern computational algebra (e.g., Groebner bases and Sturm's Theorem.)

Higher-order variational equations and their application to problems in celestial mechanics

Sergi Simon
University of Portsmouth, UK

The linearized higher variational equations of a given dynamical system are an important step in the study of its integrability. So far, this importance has been made more or less explicit, for the case in which the dynamical system is Hamiltonian, in the recent result by Morales, Ramis and Simo. Our aim is to now push the boundaries of this theoretical framework a bit further by giving a systematic description of the form taken by these equations and the matrix groups linked to them, and by giving some account, in the form of examples derived from celestial mechanics, of why said framework is such a powerful tool.

Constant inclination solutions of the three-body problem

Eldar Straume
NTNU, Norway

A constant inclination solution of the three-body problem is a solution where the plane spanned by the bodies makes a constant inclination angle with the invariable plane. Thus, planary motions have zero inclination, and in general the angle lies between zero and $\pi/2$. The solutions with constant inclination angle $\pi/2$ have been described by H.E.Cabral (1990). A.Wintner (1941) conjectured that there are no solution with a constant inclination angle stictly between zero and $\pi/2$,and we shall give a proof of this conjecture.

Euler equations of many body systems

Lars Sydnes
NTNU, Norway

We generalize the Euler equations from rigid body kinematics to the kinematics of many body systems and deformable bodies, and give an application to coplanar analytic many body motions: If the plane spanned by the bodies is perpendicular to the total angular momentum at one instance of time, then it is always perpendicular to the total angular momentum.

CONSERVATION LAWS

Organisers: Peter Szmolyan (TU Wien, Austria),
Kevin Zumbrun (Indiana University Bloomington, USA)

Vanishing viscosity for nonlinear systems of conservation laws

Gui-Qiang Chen
University of Oxford, UK

The vanishing viscosity limit is one of the most classical, longstanding fundamental issues in the theory of nonlinear conservation laws. In this talk, we will discuss some of old and recent developments on this issue. These especially include the inviscid limit of the Navier-Stokes equations to the Euler equations for compressible flow, convergence of the viscosity method for the Euler equations with spherical symmetry, random force terms, among others. This talk is based on joint work with Mikhail Perepelitsa and Qian Ding, respectively.

Kinetic shock profiles for nonlinear hyperbolic conservation laws

Carlota Cuesta
ICMAT, Spain

A unified framework for studying the existence and stability of kinetic shock profiles will presented. This includes small amplitude waves for the situation when the macroscopic model is a hyperbolic system of conservation laws with genuine nonlinearity. For the case of scalar conservation laws, also large amplitude waves can be understood. Applications range from BGK-models for general scalar conservation laws and for gas dynamics, to an equation for fermions in a scattering background under the action of an electric field.

Algebraic vortex spirals and non-uniqueness of inviscid flow

Volker Elling
University of Michigan, USA

In fluid dynamics, vortex sheets – curves across which the tangential flow velocity jumps, while pressure, density and normal velocity are continuous – occur naturally in many important problems, for example from the trailing edge of wings in accelerating aircraft, when several interacting shock waves meet in some types of Mach reflection, or in buoyant plumes. A particularly important case discovered by Pullin relates to non-uniqueness of Euler flow.

Vortex sheets have a tendency to roll up into spirals, whose asymptotic (and sometimes exact) behaviour has an x/t^m self-similar scaling. While logarithmic spiral solutions of the corresponding Birkhoff-Rott equation have been known since the 1920s, no existence proof was previously known for the more relevant algebraic spirals. I will discuss a proof in the case of sufficiently many symmetric branches and outline ongoing generalization to single-branched spirals.

Asymptotic stability of boundary layers to the Euler-Poisson equation in plasma physics

Shinya Nishibata
Tokyo Institute of Technology, Japan

The main concern of the present talk is mathematical analyses on a boundary layer around a surface of a material with which plasma contacts. The layer, called a sheath in plasma physics, has a larger density of positive ions than that of electrons. The Bohm criterion for formation of the sheath requires that ion velocity should be hyper-sonic. This physical phenomena is studied in the Euler-Poisson equations describing behavior of ionized gas. We show that the sheath is regarded as a planar stationary solution in multi-dimensional half space. Precisely, under the Bohm sheath criterion, we show the existence of the stationary solution, which is time asymptotically stable. Moreover we obtain a convergence rate of the solution towards the stationary solution.

Modulation and large time asymptotic profiles near periodic traveling waves

Miguel Rodrigues
Université Claude Bernard Lyon 1, France

We emphasize the special role of modulation as the main large-time behavior of perturbed periodic traveling waves. Spectrally stable traveling waves, after undergoing a localized perturbation, returns in the large-time to a non uniform shift of themselves. We prove that this occurs through modulation in parameters and describe precisely the evolution of these parameters, as a byproduct validating Whitham averaged equations.

A priori estimates for 3D incompressible current-vortex sheets

Paolo Secchi
University of Brescia, Italy

In this lecture we present a recent result about the free boundary problem for current-vortex sheets in ideal incompressible magneto-hydrody-namics. It is known that current-vortex sheets may be at most weakly (neutrally) stable due to the existence of surface waves solutions to the linearized equations. The existence of such waves may yield a loss of derivatives in the energy estimate of the solution with respect to the source terms. However, under a suitable stability condition satisfied at each point of the initial discontinuity and a flatness condition on the initial front, we prove an a priori estimate in Sobolev spaces for smooth solutions with no loss of derivatives. Our result gives some hope for proving the local existence of smooth current-vortex sheets without resorting to a Nash-Moser iteration. Such result would be a rigorous confirmation of the stabilizing effect of the magnetic field on Kelvin-Helmholtz instabilities, which is well known in astrophysics.

Ill-posedness issues for first-order quasi-linear systems

Benjamin Texier
Université Paris-Diderot, France

Metivier proved in 2005 that hyperbolicity, meaning reality of the spectrum of the principal symbol, is a necessary condition for the well-posedness of the initial-value problem associated with first-order quasi-linear operators. Following recent work by Lerner, Morimoto, and Xu, we show that instabilities persist in the limiting case in which hyperbolicity holds initially, but is instantaneously lost. Examples in nonlinear optics (Klein-Gordon-Zakharov) and gas dynamics (Van der Waals, Burgers) illustrate the results.

Existence and stability of relativistic plasma-vacuum interfaces

Yuri Trakhinin
Sobolev Institute of Mathematics, Russia

We study the plasma-vacuum interface problem in relativistic magnetohydrodynamics for the case when the plasma density does not go to zero continuously, but jumps. Unlike the nonrelativistic version of this problem, due to the presence of a non-zero displacement current in vacuum, the planar interface can be violently unstable. By using a suitable secondary symmetrization of the Maxwell equations in vacuum, we find a sufficient condition that precludes violent instabilities. We prove the local-in-time existence and uniqueness of smooth solutions of the original nonlinear free boundary problem provided that this neutral stability condition is satisfied at each point of the initial interface.

DELAY DIFFERENTIAL EQUATIONS

Organisers: Jan Sieber (University of Portsmouth, UK),
Hans-Otto Walther (Universität Giessen, Germany)

Existence and estimation of solutions of a class of time-delay dynamical systems

Lotfi Boudjenah
University of Oran, Algeria

In the time-delay dynamical systems analysis the states space variables dynamics depends on the history values of states spaces and control variables. Their evolution is described by differential equations which include information on the past history. The present state of a time-delay system is determined in some way by its past history. The reaction of real world systems to exogenous signals is never instantaneously and it needs some delay. In general, a time-delay system arises as a result of inherent delays in the transmission of information between different parts of the system and/or as a deliberate introduction of time delay into the system for control purposes. Such systems exist in various fields of application, such as in physics, engineering, biology, medicine, and economics. Into a mathematical framework, such systems can be described in several ways, and we mention, for example, differential inclusions. In this work we prove the existence of solutions of a class of time-delay differential inclusions. We use a fixed point theorem to obtain a solution and then provide an estimate for the solution.

Stability of functional differential equations with variable impulsive perturbations via generalized ordinary differential equations

Marcia Federson
Universidade de Sao Paulo, Brazil

We consider a class of functional differential equations with variable impulses and we establish new stability results which encompass previous ones. We discuss the variational stability and variational asymptotic stability of the zero solution of a class of generalized ordinary differential equations where our impulsive functional differential equations can be embedded and we apply that theory to obtain our results, also using Lyapunov functionals.

Unique periodic orbits of a DDE with piecewise linear feedback function

Ábel Garab
University of Szeged, Hungary

We study the delay differential equation $x'(t) = -a \cdot x(t) + b \cdot f(x(t-1))$ with feedback function $f(y) = (|y+1| - |y-1|)/2$ and with real parameters $0 < a < |b|$. This equation is often applied in models of neural networks. We give necessary and sufficient conditions for existence and uniqueness of periodic orbits with prescribed oscillation frequencies (characterized by the values of a discrete Lyapunov functional). We also investigate the period function of the unique, slowly oscillating periodic solution, which turns out to be important in examining periodic orbits of analogous systems of DDE's.

On differentiability of solutions with respect to parameters in neutral differential equations with state-dependent delays

Ferenc Hartung
University of Pannonia

In this paper we consider a class of nonlinear neutral differential equations with state-dependent delays in both the neutral and the retarded terms. We study well-posedness and continuous dependence issues and differentiability of the parameter map with respect to the initial function and other possibly infinite dimensional parameters in a pointwise sense and also in the C-norm.

On permanence of a class of delayed Lotka-Volterra systems with variable growth rates

Zhanyuan Hou
London Metropolitan University, UK

In a recently published paper, the author investigated the asymptotic behaviour of a class of competitive Lotka-Volterra systems with delays and variable growth rates and found an algebraic condition for all small perturbations of the system and their subsystems to be permanent. This condition is also proved necessary for such properties. In this paper, the above result is effectively extended to a more general class of Lotka-Volterra systems including competitive, cooperative, prey-predator and mixed type systems. Firstly, a condition is established for the existence and boundedness of solutions on a half line. Secondly, a necessary condition on the limits of the average growth rates is provided for permanence of all subsystems. Then the result for competitive systems is also proved for the general systems by using the same techniques.

Bifurcations of a differential equation with linearly state dependent delays

Tony Humphries
McGill University

We consider a linear scalar delay differential equation

$$\dot{u}(t) = -\gamma u(t) - \sum_{i=1}^{2} \kappa_i u(t - a_i - c_i u(t))$$

which has trivial dynamics with fixed delays ($c_1 = c_2 = 0$), and show that if the delays are allowed to be linearly state-dependent then very complex dynamics can arise. We will present a study of the bifurcation structures that occur including bi-stability of periodic orbits, invariant tori, double Hopf bifurcations and period doubling.

Well-posedness of initial value problems for functional differential-algebraic equations of mixed type

Hermen Jan Hupkes
University of Missouri - Columbia, USA

We study the well-posedness of initial value problems for scalar functional differential-algebraic equations of mixed type. We provide a practical way to determine whether such problems admit unique solutions that grow at a specifed rate. In particular, we exploit the fact that the answer to such questions is encoded in an integer n-sharp. We show how this number can be tracked as a problem is transformed to a reference problem for which a Wiener-Hopf splitting can be computed. Once such a splitting is available, results due to Mallet-Paret and Verduyn-Lunel can be used to compute n-sharp. We illustrate our techniques by studying the well-posedness of two macro-economic overlapping generations models for which Wiener-Hopf splittings are not readily available.

Quiescent phases and delay equations

Karl-Peter Hadeler
Universität Tübingen

An autonomous system of differential equations is interpreted as an "active phase" and it is coupled to a "quiescent phase" (represented by the zero vector field). The sojourn time (exit time) in the active phase is exponentially distributed while the sojourn time in the quiescent phase follows an arbitrary (for example Dirac) distribution. The coupled system can be reduced to a delay equation. This delay equation (even in the scalar case with the Dirac distribution) looks rather different from the delay equations motivated by population dynamics (Hutchinson-Wright and blowfly equations). The main question is how the dynamics of a given system (e.g. stability properties of stationary points) changes when a quiescent phase with a given exit distribution is introduced.

Existence and stability of periodic solutions of a state-dependent delay equation

Benjamin Kennedy
Gettysburg College, USA

We discuss existence and stability of multiple periodic solutions of a scalar state-dependent delay equation of the form

$$x'(t) = f(x(t - d(x(t))))$$

where f is close, in a suitable sense, to a step function.

Non-linear oscillations of differential equations with two time lags

Gabor Kiss
University of Exeter, USA

We consider first-order scalar differential equations with two delays and report on coexistence of periodic solutions and irregular oscillations.

A local Hopf bifurcation theorem for differential equations with state-dependent delays

Tibor Krisztin
University of Szeged, Hungary

We consider a class of functional differential equations which include equations with state-dependent delays, and prove a local Hopf bifurcation theorem by applying a recently obtained result on smooth center manifolds at stationary points.

Analysis of synchronisation in networks with time-delayed coupling

Yuliya Kyrychko
University of Sussex, UK

In this talk I will discuss the dynamics of synchronization in networks with time-delayed connections between nodes. I will present a new generic framework for analysing stability of synchronization in the presence of time delay and illustrate its application to several systems. In the case of distributed time delay, I will present some analytical and numerical results on synchronization and show its dependence on the variation of time delay.

Positive operators, tensor products and differential-delay equations

Roger Nussbaum
Rutgers University, USA

We consider the operation U(t) of translation along trajectories of solutions of

$$x'(s) = a(s)x(s) - b(s)x(s-1),$$

for $s \geq 0$, where x restricted to $[-1, 0]$ is a given element of $X := C([-1, 0])$. We assume that $a(.)$ and $b(.)$ are continuous and $b(s) > 0$ for $s \geq 0$. For a fixed$t > 0$, $U(t)$ is a bounded linear map of $C([-1, 0])$ to itself. For m a positive even integer, we consider the mth exterior product of $U(t)$, $U(t)^m$, so $U(t)^m$ maps the mth exterior product of X, X^m, to itself. We prove that $U(t)^m$ is positive (in the sense of mapping a cone of "nonnegative elements" in X^m to itself). We also show that $U(t)^m$ is "u_0 positive", in Krasnoselskii's sense. We show that these results have a variety of strong consequences, even in the special case that $a(t)$ and $b(t)$ are constant.

Slowly oscillating periodic solutions of a delay differential equation

Eugen Stumpf
Universität Hamburg, Germany

We consider slowly oscillating solutions of the scalar delay differential equation

$$x'(t) = f(x(t-1))$$

of negative feedback type. In particular, we discuss the existence of multiple slowly oscillating periodic solutions in the situation where f is equal to $-\mathrm{sign}$ outside a sufficiently small neighborhood of the origin and the trivial solution is (locally) asymptotically stable.

Infinite number of stable periodic solutions for an equation with negative feedback

Gabriella Vas
University of Szeged, Hungary

For all $a > 0$, a locally Lipschitz continuous map f is constructed such that the scalar equation $x'(t) = -ax(t) + f(x(t-1))$with delayed negative feedback has an infinite sequence of periodic orbits. All periodic solutions defining these orbits oscillate slowly around 0 in the sense that they admit at most one sign change in each interval of length of 1. If f is continuously differentiable, then the periodic orbits are hyperbolic and stable.

Unbounded state-dependent delays

Hans-Otto Walther
Universität Giessen, Germany

For functional differential equations $x'(t) = g(x_t)$ which include equations with finite but unbounded state-dependent delays we find a semiflow on a manifold of functions on the negative real axis, with local stable and unstable manifolds at equilibria.

DYNAMICAL SYSTEMS TECHNIQUES FOR FLUIDS

Organisers: Margaret Beck (Boston University, USA),
James Robinson (University of Warwick, UK)

The structure of phase flow and nonlocal stabilization for semilinear parabolic equations of normal type

Andrei Fursikov
Moscow State University, Russia

Energy estimate has important role in investigation of 3D Navier-Stokes system. Absence of analogous estimate in phase space H^1 is very serious obstacle to prove nonlocal existence of smooth solution.

Semilinear parabolic equation is called equation of normal type, if its nonlinear term B satisfies the property: $B(v)$ is collinear to vector v for each v. Equations of normal type does not satisfy energy estimate in the greatest degree, since energy bound is derived from the property $B(v) \perp V$.

For some parabolic equations of normal type their dynamical properties including the structure of their phase flow will be described. Construction of nonlocal stabilization by some types of control will be given.

Invariant measures of the 2D Euler and Navier-Stokes equations

Freddy Bouchet
ENS Lyon, France

I will explain how it is possible to explicitly built sets of invariant measures that generalize statistical equilibrium measures for the two dimensional Euler.

For the two-dimensional Navier-Stokes equations with weak stochastic forcing and dissipation, the existence of an invariant measure has been mathematically proved recently, together with mixing and ergodic properties. I will sketch how to use the invariant measures of the two dimensional Euler equations to describe self-consistently the invariant measures for the two dimensional Navier-Stokes equations. We predict for instance non-equilibrium phase transitions, and observe them in numerical experiments.

Finally I will very briefly describe recent results on finite dimensional Hamiltonian truncations of the 2D Euler equations and the associated Gibbs measures.

Large time behavior decay and growth for a viscous Boussinesq system

Lorenzo Brandolese
Université Lyon 1, France

We analyze the decay and the growth for large time of weak and strong solutions to the three-dimensional viscous Boussinesq system. We show that generic solutions blow up as $t \to \infty$ in the sense that the energy and the L^p-norms of the velocity field grow to infinity for large time for $1 \leq p < 3$. In the case of strong solutions we provide sharp estimates both from above and from below and explicit asymptotic profiles. We also show that solutions arising from (u_0, θ_0) with zero-mean for the initial temperature θ_0 have a special behavior as $|x|$ or t tends to infinity: contrarily to the generic case, their energy dissipates to zero for large time.

On the existence and regularity of pullback attractors for non-autonomous 2D-Navier-Stokes equations

Julia Garcia-Luengo
Universidad de Sevilla, Spain

In this talk we will study the asymptotic behaviour of the solutions to a non-autonomous 2D-Navier-Stokes model, in the framework of pullback $\mathcal{D}$-attractors. In particular, the existence of pullback $\mathcal{D}$-attractors in V-norm is analyzed, for the universe of fixed bounded sets and also for another universe given by a tempered condition. Finally, the relationship between these families and some regularity properties of them are established.

Time-periodic solutions to the full Navier–Stokes–Fourier system

Milan Pokorny
Charles University, Czech Republic

We consider the system of partial differential equations describing the flow of a Newtonian compressible heat conducting fluid in a bounded three-dimensional domain. We consider homogeneous Dirichlet condition for the velocity and Newton-type boundary condition for the temperature. Under certain assumptions on the model (which still include e.g. the monoatomic gas) we show that for arbitrarily large time-periodic force and arbitrarily large data there exists a time periodic weak solution to our problem.

Global existence and Long-Time Asymptotics for Rotating Fluids in a 3D layer

Violaine Roussier-Michol
INSA Toulouse, France

The Navier-Stokes-Coriolis system is a simple model for rotating fluids, which allows to study the influence of the Coriolis force on the dynamics of three-dimensional flows. In this talk, I will consider the Navier-Stokes-Coriolis system in an infinite three-dimensional layer delimited by two horizontal planes, with periodic boundary conditions in the vertical direction e_3:

$$\partial_t u + (u \cdot \nabla)u + \Omega e_3 \wedge u \;=\; \Delta u - \nabla p \;, \qquad \text{div}\, u \;=\; 0 \;, \quad t > 0 \quad (x,z) \in \mathbb{R}^2 \times \mathbb{T} \quad (1)$$

where $u \in \mathbb{R}^3$ is the velocity field of the fluid, and $p \in \mathbb{R}$ is the pressure field.

The main goal of this talk is to investigate the long-time behavior of the solutions of the NSC system for a fixed, but typically large, value of the rotation speed. I shall use the effect of the Coriolis force to prove global existence of solutions for large initial data. As for the long-time asymptotics, they turn out to be essentially two-dimensional and are therefore not affected by the rotation. Thus, I shall recover as a leading term in my expansion the Lamb-Oseen vortices which play a similar role for the usual Navier-Stokes system in the plane $\mathbb{R}^2$ or in the three-dimensional layer $\mathbb{R}^2 \times (0,1)$.
If the angular velocity parameter is sufficiently large, depending on the initial data, I will show the existence of global, infinite-energy solutions with nonzero circulation number. I also prove that these solutions converge towards two-dimensional Lamb-Oseen vortices as time goes to infinity. This is joint work with Professor Thierry Gallay from Institut Fourier, Grenoble, France.

Uniqeness of particle trajectories for weak solutions of the 3D Navier-Stokes equations

James Robinson
University of Warwick

We show that for any given suitable weak solution u of the three-dimensional Navier-Stokes equations, the particle trajectories (i.e. solutions of the ordinary differential equation dX/dt=u(X,t)) are unique for almost every choice of initial X(0). The proof uses a simple bound on the box-counting dimension of the set of space-time singularities and results on avoidance of 'small' sets by volume-preserving flows.

Uniqueness and blow–up for a noisy viscous dyadic model of turbulence

Marco Romito
Università di Firenze, Italy

Motivated by the recent work on the stochastic Navier–Stokes equations, we analyse an oversimplified model which nevertheless preserves most of the main characteristics of the original model.

We show well–posedness of the problem with nonlinearity of mildly strong intensity and blow–up with positive probability with nonlinearity of strong intensity. Both results depend on a careful analysis of the dynamical properties of the drift.

On the box-counting dimension of a singular set for 3D Navier-Stokes equations

Witold Sadowski
University of Warwick, UK

The talk considers suitable weak solutions to the 3D Navier-Stokes equations. Upper bounds on the box-counting dimension of a singular set in space-time are given under the assumption of additional integrability properties of such weak solutions.

Dynamical systems and vortex methods

David Uminsky
University of California at Los Angeles, USA

In this talk we will show how dynamical systems and invariant manifold theory for PDEs naturally suggest ways to improve computational fluid dynamics (CFD). Specifically we will demonstrate that these ideas yield a generalization of traditional vortex methods which allow the shape of each particle to dynamically adapt to the flow. This dynamical adaptation improves the accuracy of the vortex method and we will include several computed examples.

On the problem of moments for 3D Navier-Stokes equations

Alejandro Vidal-Lopez
University of Warwick, UK

Following work of Fursikov, we consider some properties of the solutions of the chain of moments corresponding to the 3D Navier-Stokes equations. We also discuss how those properties can be used in order to obtain some information about the solutions of Navier-Stokes

Counterexamples in the attractors theory

Sergey Zelik
University of Surrey, UK

A number of known and new examples/counterexamples related with global/exponential attractors and inertial manifolds will be discussed. These examples indicate the limitations of the theory and show the sharpness of the results previously obtained. In particular, in the class of abstract semilinear parabolic equations, we present an example of a global attractor which cannot be embedded in any finite-dimensional Lipschitz manifold. In addition, in the class of abstract semilinear damped wave equation, we give an example of a regular (exponential) attractor whose Hausdorff dimension equals two and the fractal (box-counting) dimension is greater than two and is not the same in different Sobolev spaces.

EPDIFF@EQUADIFF

Organisers: Darryl Holm (Imperial College London, UK),
David Ellis (Imperial College London, UK)

Fractional Sobolev metrics on diffeomorphism groups

Martin Bauer
Universität Wien, Austria

We prove that, for any compact Riemanninan manifold M geodesic distance vanishes on the diffeomorphism group $\mathrm{Diff}\,(M)$ for the right invariant metric induced by the Sobolov metric H^s of order $0 \le s < \frac{1}{2}$. We prove positivity of geodesic distance for $\dim(M) = 1$ and $\frac{1}{2} < s$, and for $\dim(M) \ge 2$ and $1 \le s$. We derive and discuss the geodesic equations for the H^s-metric on $\mathrm{Diff}\,(\mathbb{R}^n)$.

Multiresolution diffeomorphic matching methods using EPDiff

Martins Bruveris
Imperial College London, UK

Large deformation matching methods (LDM) are used in computational anatomy to register biological images. Often these images contain information on different length scales. We present a way to introduce multiple length scales into the framework to increase the accuracy of the matching. We also show how this framework allows for a continuous spectrum of scales to be used for registration.

Variational integrators for higher order mechanics on Lie groups

Christopher Burnett
Imperial College London, UK

This talk will present variational integrators on Lie groups for higher-order Lagrangians, for instance Lagrangians that depend on acceleration. Derived from discrete variational principles, such integrators in the first order case have many desirable properties, including being symplectic and having good long time behaviour. The goal is to bring integrators with similarly useful properties to higher-order mechanics. Examples include cubic splines on $\mathrm{SO}(3)$.

Undreduction

David Ellis
Imperial College London, UK

his talk describes a geometric development of a new technique, called 'un-reduction', for dealing with dynamics and optimal control problems posed on spaces that are unwieldy for numerical implementation. The technique, which was originally concieved for an application to image dynamics, uses Lagrangian reduction by symmetry in reverse.

On the well posedness of some EPDiff type equations

François Gay-Balmaz
ENS Paris, France

In this talk I will present the rigorous formulation of some EPDiff equations such as the higher dimensional Camassa-Holm equations and the Euler-Poincaré equation on the universal Teichmuller space, using the tools of calculus on infinite dimensional Banach manifolds. From this formulation I will then deduce the well-posedness properties of the associated PDEs.

EPDiff momentum maps for image analysis

Darryl Holm
Imperial College London,UK

This short talk focuses on shared mathematical properties of ideal fluid flows and shape transformations. It discusses some opportunities for geometric analysis in the problem of comparison of shapes, particularly closed curves in the plane. Many types of mathematics apply in this problem, including soliton theory and singular momentum maps. Much of this talk is based on work done with Jerry Marsden (1942 - 2010).

Singular solutions of cross-coupled EPDiff equations: waltzing peakons and compacton pairs

Rossen Ivanov
Imperial College London, UK

We consider singular solutions of a system of two cross-coupled Camassa-Holm (CCCH) equations. This CCCH system admits peakon solutions, but it is not integrable. The system is a pair of coupled Hamiltonian partial differential equations for two types of solutions on the real line, each of which separately possesses $\exp(-|x|)$ peakon solutions. However, there are no self-interactions, so each of the two types of peakon solutions moves only under the induced velocity of the other type. We analyse the 'waltzing' solution behaviour of the cases with a single bound peakon pair (a peakon couple), as well as the over-taking collisions of peakon couples and the antisymmetric case of the head-on collision of a peakon couple and a peakon anti-couple. We discuss compacton couple solutions of the cross-coupled Euler-Poincaré (CCEP) equations and illustrate the same types of collisions as for peakon couples, with triangular and parabolic compacton couples. The cross-coupled generalization of the EPDIff equation also posesses solutions in the form of waltzing concentric peakons whose interaction involves also rotation around their center.

Numerical solutions of singular cross-coupled EPDiff equations

James Percival
Imperial College London, UK

The Camassa-Holm equation and its many extensions are famous for their peakon solutions: singular, soliton-like solutions with discontinuities in their first derivative. Here we discuss new results from numerical solutions of a family of 'cross-coupled' EPDIff equations, in which each species of the momentum generating the flow is carried by the induced velocity of the other type, without a self-interaction term. Such equations preserve the variational structure of the CH equations and have singular solutions of similar form, but appear not to be integrable. The data presented here illustrate a variety of interesting 'waltzing' behavioursin the interactions and collisions of peakon and compacton solutions.

Modeling water monolayers as interacting rolling particles: liquid and gas states, statistical mechanics and geometric Vlasov theory

Vakhtang Putkaradze
Colorado State University, USA

We consider the ordered and disordered dynamics for monolayers of rolling self-interacting particles modeling water molecules. The rolling constraint represents a simplified model of a strong, but rapidly decaying bond with the surface. We show the existence and nonlinear stability of ordered lattice states, as well as disturbance propagation through and chaotic vibrations of these states. We study the dynamics of disordered gas states and show that there is a surprising and universal linear connection between distributions of angular and linear velocity, allowing definition of temperature. As a first step towards the continuum description of the model, we also derive the non-holonomic version of Vlasov equation, and show that it leads to appropriate conservation laws.

Euler-Poincaré approach to hybrid Vlasov-fluid models

Cesare Tronci
EPFL Lausanne, Switzerland

Hybrid models are used in plasma physics to study how the presence of energetic particles affects magnetohydrodynamics (MHD). These models couple a given kinetic equation for the energetic particles with the continuum MHD equations for the fluid. This talk presents the Euler-Poincaré formulation of several hybrid models, whose kinetic species is governed by the Vlasov equation. In this construction, the Vlasov kinetic equation is transported along the fluid flow, which moves with the total velocity of the system. The Euler-Poincaré approach introduces a new fluid transport feature based on two different diffeomorphism groups that interplay at a deep geometric level. In this setting, various MHD fluid properties still persist, such as Ertel's theorem and the cross-helicity invariant.

Euler-Poincaré equations on automorphism groups of principal bundles and dual pairs

Cornelia Vizman
West University of Timisoara, Romania

We formulate Euler-Poincaré dynamics (EPAut) on the Lie group $\mathrm{Aut}(P)$ of automorphisms of a principal bundle P, and its incompressible correspondent on $\mathrm{Aut}_{\mathrm{vol}}(P)$ (Yang-Mills version of Euler's equation). We focus on the geometry underlying these systems: the associated dual pairs of momentum maps which extend the well known dual pairs for EPDiff and Euler equation.

EPDiff and computational anatomy

Laurent Younes
Johns Hopkins University, USA

Because it is a geodesic equation on groups of diffeomorphisms, and (via Riemannian submersion) also on shape spaces considered as homogeneous spaces under diffeomorphic action, EPDiff is the principal equation for the construction of exponential charts on spaces of landmarks, images, or, more generally, shapes. Because of this, it provides a very important tool for the development of analyses in shape spaces, and has important applications to studies of the variations of human organs based on medical images, which is one of the main topics of interest in computational anatomy.

This talk will describe the general approach for building spaces of anatomies centered around suitably chosen templates, then focus on experimental results including medical studies related to brain and heart diseases.

EXPONENTIALLY SMALL PHENOMENA

Organisers: Carles Simo (Universitat Politècnica de Catalunya, Spain),
Tere Seara (Universitat Politècnica de Catalunya, Spain)

The asymptotic wavenumber in point-defect solutions of the complex Ginzburg-Landau equation

Maria Aguareles
Universitat de Girona, Spain

Point-defect solutions of the complex Ginzburg-Landau equation in the plane exhibit patterns in the shape of rotating waves. Such waves are archimedean waves. This means that, far enough from the center, the fronts of these waves tend to have a constant separation length which is usually known as the asymptotic wave number. Spiral or rotating waves in the complex Ginzburg-Landau equation, and in general in $\lambda - \omega$ systems, exist only for a very particular choice of the asymptotic wave number. In particular, solutions with a single point-defect have an asymptotic wave number that is found to be exponentially small in one of the parameters of the equation and that depends on the size of the domain. When the domain is a disk, this type of solutions may be written in terms of a system of ordinary differential equations in which the asymptotic wave number arises as a nonlinear eigenvalue that can be obtained with the method of matched asymptotic expansions, despite of the fact of having an exponentially small dependence on the small parameter.

Breakdown of heteroclinic orbits for analytic unfoldings of the Hopf-zero singularity: the singular case

Oriol Castejón
Universitat Politècnica de Catalunya, Spain

We study the exponentially small splitting of a heteroclinic connection in a one-parameter family of analytic vector fields in R^3, which arises from the conservative analytic unfoldings of the Hopf-zero singularity. Previous work showed that this heteroclinic connection is destroyed if one considers perturbations of a higher order (the so-called regular case), and an asymptotic formula of the distance between the stable and unstable manifolds when they meet at the plane $z = 0$ was given. Moreover, its main term was a suitable version of the Melnikov integral. Here, we study the singular case, where we show that Melnikov theory is no longer valid, and we give an expression of the splitting distance.

The reason to study the breakdown of the heteroclinic orbit is that it can lead to the birth of some homoclinic connection to one of the critical points in the unfoldings of the Hopf-zero singularity, producing what is known as a Shilnikov bifurcation.

Splitting of invariant manifolds near a Hamiltonian-Hopf bifurcation

Jose Pedro Gaivao
Technical University of Lisbon, Portugal

We study homoclinic orbits near a Hamiltonian-Hopf bifurcation. It is well known that in this case the normal form of the Hamiltonian is integrable at all orders. Therefore the difference between the stable and unstable manifolds is exponentially small and the study requires a method capable to detect phenomena beyond all algebraic orders provided by the normal form theory. We establish an asymptotic expansion for a homoclinic invariant which quantitatively describes the transversality of the invariant manifolds. An application of these methods to the Swift-Hohenberg equation is considered.

Exponentially small splitting of separatrices for the pendulum with fast periodic or quasiperiodic meromorphic perturbation

Marcel Guardia
Fields Institute, Canada

The problem of the exponentially small splitting of separatrices for one degree of freedom Hamiltonian System with a fast non-autonomous periodic or quasi-periodic perturbation has been widely studied in the past years. However, in most of the results achieved up to now, some restrictive hypotheses about the analyticity of the Hamiltonian have been imposed. In particular, one usually assumes that the Hamiltonian System is an algebraic or trigonometric polynomial in the pendulum variables, namely in all variables but time. Nevertheless, in many applications (for instance, in celestial mechanics) both the unperturbed system and the perturbation are not entire but have singularities in the complex domain.

The work explained in this talk is a very first step towards understanding the exponentially small splitting of separatrices for non-entire Hamiltonian Systems. We consider several toy models in which the unperturbed system is the classical pendulum (and thus still entire) but the perturbation is meromorphic since has polar singularities in the complex domain. We will show, either in the periodic or the quasiperiodic case, how the exponentially small distance between the perturbed invariant manifolds depends strongly on the width of the analyticity strip, becoming non-exponentially small if the analyticity strip is too narrow.

Normal forms, invariant manifolds and exponentially small phenomena

Eric Lombardi
Université de Toulouse, France

This talk is devoted to analytic vector fields near an equilibrium for which the linearized system is split in two invariant subspaces E_0 (dim m_0), E_1 (dim m_1). Under light diophantine conditions on the linear part, we prove that there is a polynomial change of coordinate in E_1 allowing to eliminate, in the E_1 component of the vector field, all terms depending only on the coordinate $u_0 \in E_0$, up to an exponentially small remainder. This main result enables to prove the existence of analytic center manifolds up to exponentially small terms and extends to infinite dimensional vector fields. In the elliptic case, our results also proves, with very light assumptions on the linear part in E_1, that for initial data very close to a certain analytic manifold, the solution stays very close to this manifold for a very long time, which means that the modes in E_1 stay very small.

Exponential homogenisation of elliptic PDE

Karsten Matthies
University of Bath, UK

We consider quasilinear divergence type elliptic equation $-\text{div}A(x/\epsilon, Du) = f(x)$ for $x \in \Omega \subset \mathbb{R}^d$ with rapidly oscillating stored energy functional $W(x/\epsilon, e)$ such that $A = D_e W(y, e)$. The homogenisation of this problem gives an effective description of fast-scale periodic oscillations just using certain known solutions to cell problems. By truncating the full two-scale asymptotic expansion for the solution one obtains an approximation with an exponentially small error in the period of the rapid oscillation under suitable analyticity conditions on W and f. The optimality of the exponential error bound is established for a linear one-dimensional example by giving the analogous lower bound.

Multi-site breathers in Klein-Gordon lattices: bifurcations, stability, and resonances

Dmitry Pelinovsky
McMaster University, Canada

We prove the most general theorem about bifurcations and spectral stability of multi-site breathers in the discrete Klein–Gordon equation with a small coupling constant. This result includes multi-site breathers that represent excited oscillations at different sites of the lattice separated by a number of non-excited sites with no oscillations in the anti-continuum limit. Previously, only multi-site breathers with adjacent excited sites were considered within the first-order perturbation theory. We show that the stability of multi-site breathers change for large-amplitude oscillations in soft nonlinear potentials near the resonance points. At the $1:3$ resonance points, we discover the symmetry-breaking bifurcation of periodic breathers, which can be understood using exponentially small splitting phenomena.

Resonant chaotic zones: dynamical consequences of the difference between the inner/outer splittings of separatrices

Arturo Vieiro
Universitat de Barcelona, Spain

Let F_ϵ be a one-parameter family of area-preserving maps (APMs) having an elliptic fixed point E_0. Typically, when changing ϵ, different chains of resonant Birkhoff islands of stability $I_{p/q}$ bifurcate from E_0. Generically, these stability islands have a pendulum-like phase space structure. Hence, for a given island $I_{p/q}$ one should consider two "main" splittings of separatrices, geometrically related to the upper and lower separatrices of the classical pendulum. We shall refer to these splittings as the inner/outer splitting, according to their distance to E_0. They are generically different, the outer being the largest one (for islands located close enough to E_0). We will comment on the use of the Chirikov separatrix map to quantitatively describe the dynamics within the chaotic region that the inner/outer splittings create around $I_{p/q}$. In particular, we will describe the consequences that produce the difference between these splittings on the shape and size of the chaotic region. Some examples will illustrate the theoretical results on this point.

Finally, we will derive a modified standard map as a more accurate model, which takes into account the difference between the splittings, to describe the geometry of $I_{p/q}$. Using this model we will comment on how to (numerically) check the exponentially small behaviour of the splittings for a family of maps F_ϵ (if given in a closed-form).

FRONT PROPAGATION IN HETEROGENEOUS MEDIA

Organisers: Elaine Crooks (Swansea University, UK),
Grégoire Nadin (Université Paris 6, France)

Planar Travelling waves of reaction diffusion equations in periodic media

Adam Boden
University of Bath, UK

This talk looks at reaction diffusion equations in the plane with rapid spatially periodic dependent nonlinearities. Existence of generalised travelling wave solutions, which incorporate the spatial periodicity, will be discussed. The approach taken is to write the problem as an infinite dimensional dynamical system and apply a centre manifold reduction. Existence of solutions can then be proved by studying the dynamics on the centre manifold using Conley Index. Once the existence of solutions has been proved we consider the homogenisation problem as the speed of oscillation in the nonlinearity tends to infinity.

Front-like entire solutions for reaction-diffusion equations with convection

Elaine Crooks
Swansea University, UK

This talk is concerned with families of front-like entire solutions for problems with convection, both for bistable and monostable reaction-diffusion-convection equations, and, via vanishing-viscosity arguments, for bistable and monostable balance laws. Unlike convectionless problems, the equations studied here lack symmetry between increasing and decreasing fronts, which affects the possible choice of the front-dependent sub and super-solutions used in the construction.

Reversing invasion in bistable competition models

Fordyce Davidson
University of Dundee, UK

We discuss a class of bistable reaction-diffusion systems used to model the competitive interaction of two species. The interactions are assumed to be of classic "Lotka-Volterra" type and we will consider a particular problem with relevance to applications in population dynamics: essentially, we study under what conditions the interplay of relative motility (diffusion) and competitive strength can cause waves of invasion to be halted and reversed. By establishing rigorous results concerning related degenerate and near-degenerate systems, we build a picture of the dependence of the wave speed on system parameters. Our results lead us to conjecture that this class of competition model has three "zones of response" in which the wave direction is left-moving, reversible and right-moving, respectively and indeed that in all three zones, the wave speed is an increasing function of the relative motility.

Fronts for periodic KPP equations

Steffen Heinze
Universität Heidelberg, Germany

We consider the KPP equation in a periodic environment:

$$u_t(t,x) = \nabla(A(x)\nabla u(t,x)) + b(x) \cdot \nabla u(t,x) + f(u,x)$$

where $A(x), f(u,x)$ are L-periodic with respect to all x_i. The nonlinearity $f(x,u)$ is of KPP type with respect to. u. A periodic travelling wave in direction e and velocity c has the form $u(t,x) = U(\xi,x)$, $\xi = x \cdot e + ct$, $U(\xi,x)$ is 1-periodic with respect to all x_i. It is well known that a travelling wave exists iff $c \geq c^*(e)$, where $c^*(e)$ is obtained from a nonselfadjoint linear eigenvalue problem. We will derive a new saddle point characterization of $c^*(e)$. Dualizing yields a maximization problem which seems to be new even in one dimension. This allows for a quantative analysis of the dependence of $c^*(e)$ on the parameters A, b, f, L, e of the problem. Examples are: In the limit $L \to 0$ the minimal speed converges to the speed of the homogenized equation. If $b(x)$ equals to zero, then $c^*(e)$ is nondereasing with respect to the period L. Also the limit $L \to \infty$ can be studied. $c^*(e)$ as a function of e is the support function of a convex set. The support function of its convex polar set is the inverse of the closely related concept of the asymptotic spreading speed. Hence we obtain also variational principles for the asymptotic spreading speed. A drift term enhances the speed due to enlargement and mixing of the reaction zone. Asymptotics for a large drift $b(x)$ can be derived. Generalizations for perforated domains und time periodic coefficients are possible.

Pulsating traveling wave in nonlocal reaction diffusion equation

Jerome Coville
INRA, France

In this session, I will present some results concerning the existence of pulsating wave for non-local reaction-diffusion equations of KPP type. I will also give a variational characterization of the minimal speed of such pulsating fronts and exponential bounds on the asymptotic behaviour of the solution.

Spreading and vanishing in nonlinear diffusion problems with free boundaries

Bendong Lou
Tongji University, China

We study nonlinear diffusion problems of the form $u_t = u_{xx} + f(u)$ with free boundaries. Such problems may be used to describe the spreading of a biological or chemical species, with the free boundary representing the expanding front. For special $f(u)$ of the Fisher-KPP type, the problem was investigated by Du and Lin. Here we consider much more general nonlinear terms. For any $f(u)$ which is C^1 and satisfies $f(0) = 0$, we show that every bounded positive solution converges to a stationary solution as $t \to \infty$. For monostable, bistable and combustion types of nonlinearities, we obtain a complete description of the long-time dynamical behavior of the problem; moreover, by introducing a parameter σ in the initial data, we reveal a sharp threshold σ^* such that spreading ($\lim_{t\to\infty} u = 1$) happens when $\sigma > \sigma^*$, vanishing ($\lim_{t\to\infty} u = 0$) happens when $\sigma < \sigma^*$, and at the threshold value σ^*, $\lim_{t\to\infty} u$ is different for the three different types of nonlinearities. When spreading happens, we make use of "semi-waves" to determine the asymptotic spreading speed of the front.

Continuous dependence in front propagation for convective reaction-diffusion models with aggregative movements

Luisa Malaguti
University of Modena and Reggio Emilia, Italy

In this talk we deal with a degenerate reaction-diffusion equation, including aggregative movements and convective terms with nonlinear velocity. The model further incorporates a real parameter causing the change from a purely diffusive to a diffusive-aggregative and to a purely aggregative regime. Existence and qualitative properties of traveling wave solutions are investigated and estimates of their threshold speeds are furnished. Further, the continuous dependence of the threshold wave speed and of the wave profiles is studied, both when the process maintains its diffusion-aggregation nature and when it switches from it to another regime.

Asymptotic spreading for general heterogeneous Fisher-KPP equations

Grégoire Nadin
Université Paris 6, France

This talk is devoted to the propagation phenomenon for the heterogeneous Fisher-KPP equation

$$\partial_t u - a_{ij}(t,x)\partial_{x_i x_j} u - b_i(t,x)\partial_{x_i} u = c(t,x)u(1-u)$$

where a_{ij}, b_i and c are only assumed to be uniformly continuous and bounded, the matrix field (a_{ij}) being uniformly elliptic and $\inf c > 0$. We will give sharp estimates of the lower and upper spreading speeds, defined for all unit vector e as the largest (resp. smallest) $w \geq 0$ such that $u(t, wte) \to 1$ (resp. 0) as $t \to +\infty$. These estimates involve a new notion of generalized principal eigenvalues for the linear parabolic operator associated with the linearization of the equation near $u = 0$. Our result is optimal when the coefficients are assumed almost periodic, asymptotically almost periodic or constant at infinity in every direction.

Existence of recurrent traveling waves in a two-dimensional cylinder with undulating boundary — virtual pinning case

Ken-Ichi Nakamura
Kanazawa University, Japan

In this talk we study traveling wave solutions for a curvature-driven motion of plane curves in a two-dimensional infinite cylinder with undulating boundary. Here a traveling wave in non-periodic inhomogeneous media is defined as a time-global solution whose shape is "a continuous function of the current environment". Under suitable conditions on the boundary undulation we show the existence of traveling waves which propagates over the entire cylinder with zero lower average speed. Such a peculiar situation called "virtual pinning" never occurs if the boundary undulation is periodic.

Propagation phenomena for time heterogeneous KPP equations

Luca Rossi
Universitá di Padova, Italy

We investigate the existence of generalized transition waves for a reaction-diffusion equation with a monostable nonlinearity depending in a general way on time. It is well known that in the homogeneous case the family of speeds associated with traveling fronts is given by a right half-line. We extend this result by introducing a suitable notion of mean. As an application, we obtain the existence of random traveling waves when the nonlinearity is stationary ergodic. We further present some spreading properties for solutions of the Cauchy problem associated with compactly supported initial data.

Travelling waves in reaction-diffusion equations with nonlinear boundary conditions

Vitaly Volpert
Université Claude Bernard Lyon 1, France

We will discuss existence of travelling waves for reaction-diffusion equations with nonlinear boundary conditions. Applications to a model of atherosclerosis development will be presented.

G-equations in the modeling of the turbulent flame speed

Yifeng Yu
University of California at Irvine, USA

G-equations are well-known front propagation models in turbulent combustion and describe the front motion law in the form of local normal velocity equal to the laminar flame speed plus the normal projection of fluid velocity. According to this model, the turbulent flame speed s_T is the effective Hamiltonian associated with the cell problem. In this talk, I will present results and open problems of the existence of s_T, its dependence on the turbulent intensity and the effects of flame stretch. If time permits, I will also talk about comparisons between G-equation and other models. This talk is based on joint works with Jack Xin.

FUNCTIONAL-DIFFERENTIAL EQUATIONS WITH RESCALING

Organisers: Leonid Bogachev (University of Leeds, UK),
Gregory Derfel (Ben-Gurion University, Israel),
Arieh Iserles (University of Cambridge, UK)

Balanced pantograph equation revisited

Leonid Bogachev
University of Leeds, UK

We have previously shown that the functional-differential equation with rescaling (called the *balanced pantograph equation*) $y'(x) + y(x) = \sum_j p_j\, y(a_j x)$ (with $a_j > 0$, $p_j > 0$, $\sum_j p_j = 1$) has no nontrivial (i.e., nonconstant) bounded solutions $y(x)$ ($x \in \mathbb{R}$) if and only if $\sum_j p_j \ln a_j \le 0$. In the present talk, we report similar results for a more general equation $y(x) = \iint y(\alpha x + \beta)\, \mu(d\alpha, d\beta)$, where μ is a probability measure on $\mathbb{R}_+ \times \mathbb{R}$. Particular cases specified by a suitable choice of the measure μ include (i) the functional equation $y(x) = \sum_j p_j\, y(a_j x + b_j)$, and (ii) the balanced pantograph equation with rescaling and shifts, $y'(x)+y(x) = \sum_j p_j\, y(a_j x+b_j)$, and its higher-order generalizations. Derfel has given a classification of bounded continuous solutions provided that $K := \iint \ln(\alpha)\, \mu(d\alpha, d\beta) \neq 0$, while the critical case $K = 0$ has remained open.

We prove that, under the additional assumption of uniform continuity on $\mathbb{R}$, any bounded solution $y(x)$ is trivial if and only if $K \le 0$. The proof is based on the observation that $y(x)$ is a harmonic function of the associated random walk $X_n = \alpha_n X_{n-1} + \beta_n$, $X_0 = x$, where (α_n, β_n) are independent random vectors with common distribution μ, and exploits martingale techniques applied to the martingale $y(X_n)$. Furthermore, we show that the uniform continuity of solution $y(x)$ is guaranteed under mild regularity assumptions on the conditional density of the random shift β conditioned on the rescaling coefficient α, which are automatically satisfied for the pantograph case (ii) mentioned above.

Orthogonal polynomials on the unit circle and functional differential equations

María-José Cantero
Escuela de Ingeniería y Arquitectura de Zaragoza, Spain

Numerous examples of orthogonal polynomials on the real line are known in an explicit form, but this is not the case for orthogonal polynomials on the unit circle. In this talk we present recent results concerning a far-reaching generalization of the Rogers–Szegő polynomials. A generating function of these polynomials obeys a functional differential equation of the pantograph type, and this allows us to deduce the explicit form of these polynomials in terms of q-hypergeometric functions.

Asymptotic behavior of solutions for the Poincaré equation

Gregory Derfel
Ben-Gurion University, Israel

In 1886 Poincaré introduced and studied the equation $f(qz) = R(y(z)$, where $R(z)$ is a rational function. Later on, Valiron elaborated on the case, where $R(z) = P(z)$ is a polynomial. He obtained conditions for the existence of an entire solution $f(z)$ and derived the asymptotic formula for $M(r) = \max_{|z|\leq r} |f(z)|$.

In our talk we plan to discuss further results of Valiron's type. Namely, in addition to asymptotics of $M(r)$ we obtain asymptotics of entire solutions $f(z)$ in certain angular regions and even on specific rays of the complex plane . It turns out that this heavily depends on the arithmetic nature of q.

The Poincaré equation has important applications in brancing processes, random walks on fractals, etc.

The Best constant of Sobolev-type inequality corresponding to higher-order heat operator

Yoshinori Kametaka
Osaka University, Japan

We found the best constant of Sobolesv-type inequality, which estimates the square of supremum of absolute value of $u(x,t)$ from above by L_2 norm of $(\partial_t - \Delta + a_0) \cdots (\partial_t - \Delta + a_{M-1})u(x,t)$, where $0 < a_0 < a_1 < \cdots < a_{M-1}$. The best constant of its inequality is L_2 norm of Green function corresponding to boundary value problem for the higher-order heat operator $(\partial_t - \Delta + a_0) \cdots (\partial_t - \Delta + a_{M-1})$. To obtain this constant easily, we use identity theorem.

A functional linear operator arising from a model of dynamo growth

Ben Mestel
Open University, UK

In this talk I will outline a stretch-fold-shear model of magnetohydrodynamical dynamo growth studied by Andrew Gilbert. This model gives rise to an interesting one-parameter family of functional linear operators, the spectral properties of which have been studied numerically but have only been rigorously analysed in special cases.

The germination of the Pantograph equation

John Ockendon
University of Oxford, UK

This talk will give a brief review of the events of the 1970's which put the Pantograph equation on the map. The key role that multiscale asymptotics can play will also be discussed.

The best constant of a Sobolev-type inequality which corresponds to Heaviside and Thomson cable with priodic boundary condition

Kazuo Takemura
Nihon University, Japan

A periodic boundary value problem for an n-th order linear ordinary differential equation which appears typically in the theory of Heaviside cable and Thomson cable is treated. By using its Green function, we found the best constant of a Sobolev-type inequality which estimates the square of supremum of absolute value of AC output voltage from above by the power of input voltage.

GEOMETRIC ALGORITHMS FOR PARTIAL DIFFERENTIAL EQUATIONS

Organisers: Elizabeth Mansfield (University of Kent, UK),
Snorre Christiansen (University of Oslo, Norway)

Microlocal methods in nonlocal quantum theories

Dorothea Bahns
Universität Göttingen, Germany

I will briefly review how microlocal analysis is employed in the theory of renormalization of quantum field theories. I will then report on attempts to generalize such methods in an appropriate way to theories with nonlocal interaction term, which have appeared in models of quantum fields on noncommutative spaces.

Diffeomorphism symmetry, constraints and discretization independence in discrete gravity

Bianca Dittrich
Max Planck Institute for Gravitational Physics, Germany

Diffeomorphism symmetry is the underlying symmetry of general relativity and deeply intertwined with its dynamics. This symmetry is however broken upon discretization leading to the well known problems of constraint preservation and non-conservation of energy and momentum in the discrete evolution equations. After a short explanation of these issues we will discuss a scheme to construct a discrete formulation which preserves diffeomorphism symmetry using renormalization techniques and outline its application to gravity and (parametrized) field theories related for instance to the Klein-Gordon equation.

Preconditioning techniques for systems of partial differential equations using algebraic tools

Victorita Dolean
Université de Nice, France

The purpose of this work is the use of algebraic and symbolic techniques such as Smith normal forms and Grobner basis techniques in order to develop new Schwarz algorithms and preconditionners for linear systems of partial differential equations (PDEs). This work is motivated by the fact that in some sense these methods applied systems of partial differential equations (such as Stokes, Oseen, linear elasticity) are less optimal than the domain decomposition methods for scalar problems. Indeed, in the case of two subdomains consisting of the two half planes it is well known, that the Neumann-Neumann preconditioner is an exact preconditioner for the Schur complement equation for scalar equations like the Laplace problem. A preconditioner is called exact, if the preconditioned operator simplies to the identity. Unfortunately, this does not hold in the vector case. In order to achieve this goal we use algebraic methods developed in constructive algebra, D-modules (differential modules) and symbolic computation such as the so-called Smith or Jacobson normal forms and Grobner basis techniques for transforming a linear system of PDEs into a set of independent scalar PDEs. Decoupling linear systems of PDEs leads to the design of new numerical methods based on the efficient techniques dedicated to scalar PDEs (e.g., Laplace equation, advection-diffusion equation). Moreover, these algebraic and symbolic methods provide important intrinsic information (e.g.,invariants) about the linear system of PDEs to solve which need to be taken into account in the design of new numerical methods which can supersede the usual ones based on a direct extension of the classical scalar methods to the linear systems.

Noether's second theorem for finite difference Euler Lagrange systems

Elizabeth Mansfield
University of Kent, UK

Noether's second theorem gives interdependencies between the equations in an Euler-Lagrange systems for smooth variational systems, in the event the Lagrangian is invariant under a Lie pseudogroup action, where the "parameters" of the group action are arbitrary smooth functions. In this talk I show how the theorem can be proved rather easily, extend the original result to where the pseudogroup functions have dependencies themselves, and further show how the result carries over to finite-difference variational problems. This means that the dependencies can be carried through to finite difference approximations of the Lagrangian, as well as the theorem being valid for inherently discrete variational problems. Applications will be given.

Matrix geometry for discrete gravity

Dmitry Pavlov
EPFL Lausanne, Switzerland

In this talk we will introduce a discrete model of gravity preserving constraints of the Einstein's equations. This model is based on matrix geometry developed to discretize infinite-dimensional systems such as Eulerian fluid, magnetohydrodynamics and complex fluids. In these cases we've been able to discretize underlying symmetries and variational principles to construct numerical schemes preserving geometric structures of the equations. We will discuss how to extend these methods using ideas of noncommutative geometry in order to to discretize the Einstein's equations while preserving its symmetries.

This work was started as joint with Jerrold E. Marsden (1942-2010)

Preserving Noether's conservation laws using compatible and incompatible finite element schemes

Tristan Pryer
University of Kent

Noether's (1st) Theorem guarantees conservation laws for a variational problem which is invariant under a smooth group action. A discretisation of this problem will in general not inherit such conservation laws.

We examine certain finite element schemes for these variational problems that are of compatible type (e.g. mixed Raviart Thomas) and not compatible type (e.g. Lagrangian). We show that compatible schemes inherit discrete counterparts of the conservation laws. We also demonstrate that there is a superconvergence of discrete conservation laws arising from certain incompatible schemes to the continuous conservation law. We show that the violation of the discrete conservation laws arising from the incompatible schemes can be controlled to machine precision using an h-refinement algorithm.

A numerical study of the Maxwell Klein Gordon equation using lattice gauge theory.

Claire Scheid
Université de Nice Sophia-Antipolis, France

This work intends to go deeper into the numerical analysis of nonlinear wave equations arising in theoretical physics. One especially would like to develop numerical schemes that are compatible with the geometrical properties of such equations, and in particular the gauge invariance. We will focus as a first attempt on the Maxwell Klein Gordon equation. A classical finite element scheme ignoring the inner geometrical properties of this equation, leads to a scheme that violates the constraint arising from the gauge invariance. To avoid having to use a Lagrange multiplier to discretely impose this constraint, we propose instead to use the discretization procedure from Lattice Gauge Theory to preserve the gauge invariance at the discrete level, and in that way naturally preserve the constraint. We then develop and study the convergence of a fully discrete scheme. The discretization in time is performed by a Leap Frog scheme leading to a CFL like condition for the convergence of the scheme.

Geometric singularities of differential equations

Werner Seiler
Universität Kassel, Germany

Based on the jet bundle formalism, we will discuss various types of geometric singularities of differential equations like singular integrals, impasse points or funnels with the help of the Vessiot distribution. We will show that in the case of equations with polynomial nonlinearities the differential-algebraic Thomas decomposition provides us with an algorithmic approach to the detection of singularities.

HOMOGENISATION

Organisers: Grigorios Pavliotis (Imperial College London, UK),
Konstantinos Zygalakis (University of Oxford, UK)

Homogenisation in finite elasticity for composites with a high contrast in the vicinity of rigid-body motions

Mikhail Cherdantsev
Cardiff University, UK

A multiscale asymptotic framework is proposed for analysing the overall behaviour of high-contrast nonlinear periodic elastic composites in the regime when the deformations are situated in the vicinity of a rigid-body motion. The corresponding minimising sequences are shown to retain the multiscale behaviour in the homogenisation limit, which is determined rigorously via a new multiscale version of Γ-convergence.

Two-scale homogenisation of a periodic elastic composite with partial degeneracies

Shane Cooper
University of Bath, UK

Following recent ideas of V.V.Zhikov, some most recent developments have been made in the two-scale homogenisation of second order, linear, elliptic PDEs with a certain class of partial degeneracies by I.V. Kamotski and V.P. Smyshlyaev. We shall use these new techniques to derive the two-scale homogenised equations for a periodic elastic composite material with partially high contrasting phases. In particular we will consider a two-phase elastic body whose inclusion phase is an isotropic material with very small shear modulus.

By considering the elastostatic equations with possible microscopically dependent body forces we shall derive the two-scale homogenised limit equations and observe the homogenised limit's dependence on the microscopic scale is intrinsically linked to the microscopic behaviour of the body force. The limit appears to be "classical" for macroscopically varying forces, and even for microscopically varying but irrotational forces. However for microscopically solenoidal forcing the limits are genuinely two-scale, with a nontrivial coupling between the micro and macro scales leading to microresonances.

Diffusion on rapidly varying surfaces

Andrew Duncan
University of Warwick, UK

In this presentation we propose a homogenisation approach to analysing the effective behaviour of lateral diffusions on surfaces having high-frequency low-amplitude random perturbations. This is motivated by several problems in molecular biology, for example, where lateral diffusion models the transport of molecules over cells. We also discuss different approaches to approximating the effective behaviour of the diffusion.

Radial symmetry of point defects in nematic liquid crystals

Apala Majumdar
University of Oxford, UK

Point defects are ubiquitous in nematic liquid crystal samples. We study the structure of radially-symmetric point defects in uniaxial nematic samples in the low-temperature limit analytically. This limit elucidates the close mathematical analogies between radially-symmetric point defects in uniaxial nematics and three-dimensional vortices in the Ginzburg-Landau theory of superconductivity. This analytic study is complemented by a multiple scale computational study of the defect structure in all temperature regimes. We use the "Alpha Method for Solving Differential-Algebraic Inequality Systems" to study the core size of point defects and their multiplicity as a function of the material parameters, with emphasis on both the local and global structures.

Averaging over fast variables in the fluid limit of Markov chains

James Norris
University of Cambridge,UK

Explicit estimates controlling the deviation of a Markov chain from the solution of a differential equation are preferable to weak limit results when the speed of convergence is crucial to asymptotic properties of interest. We will describe a fairly general procedure to obtain such estimates and illustrate their use.

Diffusive limits for non Markovian Langevin equations

Grigorios Pavliotis
Imperial College London, UK

In this talk I will present some recent results on the long time asymptotics for a particle moving in a periodic potential which is coupled to a harmonic heat bath. We first derive an integrodifferential stochastic equation of Langevin type for the particle position and then show how we can approximate it by an auxiliary degenerate Markovian processes in an extended phase space. For this model we show that under the diffusive rescaling the particle position converges weakly to a Brownian motion and obtain a formula for the diffusion coefficient. The proof is based on a careful analysis of the generator of the auxiliary Markov process, together with the central limit theorem for additive functionals of Markov processes.

Derivation of effective equations for electronkinetic transport

Markus Schmuck
Imperial College London, UK

We consider a well-established continuum model for binary symmetric dilute electrolytes. The model accounts for relevant electrokinetic phenomena such as electro-phoresis and -osmosis. Applications range from microfluidic devices and energy storage devices to semiconductors. We review basic analytical results such as existence and properties of weak solutions.

We derive effective macroscopic equations with a multiscale approach. The inhomogeneous structure of porous materials naturally induces additional nonlinearities which we refer to as "material tensors". This resulting upscaled system obtained here for the first time reveals certain geometric influences on ionic transport in porous materials.

We conclude with error bounds between the exact microscopic solution and its upscaled macroscopic approximation.

Multi-scale homogenization of degenerating PDEs and applications

Valery Smyshlyaev
University College London, UK

We present a general theory for multi-scale homogenization of a broad class of boundary value problem for PDEs or PDE systems whose coefficients may not only rapidly oscillate but may also (fully or partially) asymptotically degenerate.

For a generalization of a critical high-contrast scaling, we derive, under a generic "decomposition" condition, a two-scale limit problem in (two-scale) subspaces with appropriately constrained microscopic part. We discuss relevant issues of two-scale operator and spectral convergence and compactness, and motivate the approach by applications ranging from linear elasticity to electromagnetics, where the two-scale nature of the limit equations reveals such interesting physical effects as localization and dispersion due to microresonances. This is joint work with I.V. Kamotski.

INFINITE-DIMENSIONAL DYNAMICAL SYSTEMS

Organiser: Peter Bates (Michigan State University, USA)

Pulse solutions of some hydrodynamic problems and reversible Takens-Bogdanov bifurcation without parameter

Andrei Afendikov
Keldysh Institute of Applied Mathematics, Russia

We consider several hydrodynamic problems in unbounded domains where in the vicinity of the instability threshold the dynamics is governed by the generalized Cahn-Hilliard equation. For time independent solutions of this equation we recover Bogdanov-Takens bifurcation without parameter in the 3-dimensional reversible system with a line of equilibria. This line of equilibria is neither induced by symmetries, nor by first integrals. At isolated points, normal hyperbolicity of the line fails due to a transverse double eigenvalue zero. In case of bi-reversible problem the complete set B of all small bounded solutions consists of periodic profiles, homoclinic pulses and a heteroclinic front-back pair. Later the small perturbation of the problem, where only one symmetry is left was studied. Then B consist entirely of trivial equilibria and multipulse heteroclinic pairs. Our aim is to discuss hydrodynamic problems, where the reversibility breaking perturbation cant be considered as small. We obtain the existence of a pair of heteroclinic solutions and partial results on their stability.

True invariant manifolds from approximations

Peter Bates
Michigan State University, USA

The concepts of 'approximately invariant manifold' and 'approximate normal hyperbolicity' are introduced and a theorem is established giving a true invariant manifold when only approximations are able to be constructed. This is in the setting of maps or semiflows in a Banach space. Applications to singularly perturbed nonlinear parabolic PDEs are given.

A centre-stable manifold for Schrödinger's equation

Marius Beceanu
Rutgers University, USA

Consider the Schrödinger equation with a focusing cubic nonlinearity in R^3, $\mathrm{i}\partial_t\psi + \Delta\psi + |\psi|^2\psi = 0$. I will describe a certain codimension-one real-analytic centre-stable manifold that is stable globally in time in the critical space for this equation, homogenous $H^{1/2}$, in a neighborhood of the eight-dimensional ground state soliton manifold.

Metastability and global invariant manifolds for Burgers equation

Margaret Beck
Boston University, USA

The large-time behavior of solutions to Burgers equation with small viscosity is described using invariant manifolds. In particular, a geometric explanation is provided for a phenomenon known as metastability, which in the present context means that solutions spend a very long time near the family of solutions known as diffusive N-waves before finally converging to a stable self-similar diffusion wave.

Multiple-spike solutions in singularly perturbed reaction-diffusion equations with nonlocal interaction

Oleh Omelchenko
WIAS, Berlin

We consider a general singularly perturbed second order semilinear parabolic equation with a nonlinear integral term describing nonlocal interaction in the system. For this equation, we construct a sequence of approximate multiple-spike solutions. Then using the center manifold reduction technique we prove existence and local uniqueness of exact multiple-spike solutions close to the approximate ones, and we estimate the distance between the approximate and the exact solutions.

Convergence theorems for asymptotically autonomous parabolic equations on $\mathbb{R}^N$

Peter Polacik
University of Minnesota, USA

This lecture will be devoted to parabolic equation on $\mathbb{R}^N$ whose nonlinearities are asymptotically autonomous, in space and time, as time approaches infinity. We will present convergence theorems for positive solutions of such asymptotically autonomous problems and discuss key tools of their proofs.

Topology and dynamics of finite-dimensional attractors

James Robinson
University of Warwick, UK

Suppose that A is the global attractor for a discrete map on a Hilbert space H, with finite upper box-counting dimension d. I will show that one can find a discrete map on Euclidean space of dimension $2d + 1$ that reproduces the dynamics on A and has an attractor arbitrarily close to a homeomorphic image of A.

Nonlinear stability of defects

Kevin Zumbrun
Indiana University Bloomington, USA

Defects are interfaces that mediate between two wave trains with possibly different wave numbers. Of particular interest in applications are sources for which the group velocities of the wave trains to either side of the defect point away from the interface. While sources are ubiquitous in experiments and can be found easily in numerical simulations of appropriate models, their analysis still presents many challenges. One difficulty is that sources are not travelling waves but are time-periodic in an appropriate moving coordinate frame. A second difficulty is that perturbations are transported towards infinity, so that weighted norms cannot be used. In this talk, I discuss a different approach that relies on pointwise estimates. I will focus on preliminary nonlinear-stability results for a toy problem that captures the essential features of general sources and for the Nozaki-Bekki holes of the complex Ginzburg-Landau equation.

KINETIC EQUATIONS

Organiser: Barbara Niethammer (University of Oxford, UK),
Juan Velazquez (Universidad Complutense de Madrid, Spain)

Selfsimilar solutions of the second kind representing gelation in finite time for the Smoluchowski equation

Giancarlo Breschi
ICMAT, Spain

Smoluchowski's equation has its origin in physical chemistry and represents a fundamental mean-field model describing the formation of clusters by aggregation of particles. In this talk, I will present the result we obtained studing the selfsimilar solution for the Smoluchowski's equation with kernel $K(x,y) = x^{1+\varepsilon}y^{1+\varepsilon}$ for $\varepsilon < 0$ and $|\varepsilon| \ll 1$. We proved that by choosing the similarity exponents as suitable functions of ε, the selfsimilar solutions present correct behavior at the origin and at infinity, maintaining their $(7/2)$-th moment bounded. This characterizes the selfsimilar solution found as being of the second kind in the notation introduced by Barenblatt.

A nonautonomous predator-prey system arising from coagulation theory

Fernando da Costa
Universidade Aberta, Portugal

A recent investigation of Budáč et al. on the self-similar behaviour of solutions to a model of coagulation with maximum size led us to consider a related non-autonomous Lotka-Volterra predator-prey system in which the vector field of the predator equation converges to zero as $t \to +\infty$. This system helped us understand the different behaviour of subcritial and supercritical self-similar solutions in Budáč et al. The Lotka-Volterra system shows a behaviour distinct from that of either autonomous or periodic analogs. A partial numerical and analytical study of these systems is presented. An possible ecological interpretation of this type of systems is proposed.

On spacial inhomogeneous coagulation-fragmentation models with diffusion

Klemens Fellner
Universität Graz, Austria

We consider existence, large time behaviour, and fast-reaction limits of coagulation-fragmentation models with spatial diffusion. Ascontinuous in size model we study the Aizenman-Bak model of coagulation/fragmentation. Discrete in size models are addressed with more general coagulation/fragmentation coefficients. The diffusion coefficients are allowed to degenerate in size. The main applied techniques include a-priori estimates based on the dissipation of an entropy functional, entropy entropy-dissipation approaches, moment bounds, and duality methods.

Dispersion and resonances for the Schrödinger flow on the torus

Fabricio Macià
Universidad Politécnica de Madrid, Spain

We study the limiting behavior of high-frequency solutions to the Schrödinger equation on the torus via their corresponding Wigner distributions. Our analysis ammouts to perform the semiclassical limit for the Schrödinger equation at times of the order of $1/h$, the length-scale of the characteristic momenta, or equivalently, to study the limits of the corresponding Wigner distributions at times that tend to infinity. Although for fixed h the Wigner distributions solve the free transport equation, the limit objects exhibit complex behavior, related to energy concentration on resonant frequencies. A complete description can be obtained by introducing a second microlocalization around the set of resonant frequencies. Some applications to the study of the dispersive behavior of the Schrödinger flow and to unique continuation-type problems will be also presented. This is a work in collaboration with Nalini Anantharaman.

Post-gelation behavior of Smoluchowski's equation

Raoul Normand
Université de Paris 6, France

We will introduce and study a variant of Smoluchowski's equation, modeling the evolution of the concentrations of coalescing particles as time passes. We will show that it has a unique solution, even when gelation (i.e. appearance of a particle with an infinite mass) occurs, and study the asymptotic behavior of this solution. In particular, the expression of the limiting concentrations is very simple. To explain it, we will provide a microscopic model for Smoluchowski's equation and explain how it is related to some random graphs models.

Hastings-Levitov aggregation in the small-particle limit

James Norris
University of Cambridge, UK

The small-particle scaling limit for the Hastings-Levitov planar aggregation model of parameter 0 is a disc, whose radius grows exponentially with time. Over suitably long time scales, in logarithmic coordinates, the ancestral lines of the cluster perform coalescing Brownian motions, as do the gaps between these lines. These properties are closely related to the fact that the harmonic measure on the cluster boundary converges to the coalescing Brownian flow.

Strong Semiclassical approximation of Wigner functions for the Hartree fynamics

Frederica Pezzotti
Universidad del Pais Vasco, Spain

We consider a quantum nonlinear self-consistent dynamics in a smooth setting (i.e., for smooth potentials and for sufficiently smooth initial data - for instance, a smooth mixture of coherent states). We show that the time evolved Wigner function converges, in the L^2 sense, to the corresponding solution of the (classical) Vlasov equation, when the Planck constant goes to zero. In contrast with previous results formulated in terms of compactness and weak convergence arguments, we improve (loosing generality) the convergence and give explicit estimates of the error. In the proof we crucially make use of the Husimi transform as a natural bridge between the Wigner formalism and the classical phase space description.

A 1D inelastic collision model arising from biology

Gael Raoul
University of Cambridge, UK

We are interested in a model describing the resistance of cancer cells to chemotherapy. The resistance comes from an abnormally large number of pumps able to pump out the chemicals from the treatment. The cells are able to exchange those pumps, which has an impact on the evolution of the resistance in the tumour. This biological problem leads to a 1D inelastic collision model, that we study in an homogeneous case. We consider the non-homogeneous case, where those inelastic collision process then couple this model to a diffusion in space.

LARGE SCALE NUMERICAL BIFURCATION PROBLEMS

Organisers: Andrew Cliffe (University of Nottingham, uk),
David Lloyd (University of Surrey, UK)

Numerical continuation of oscillons in reaction-diffusion dquations

Daniele Avitabile
University of Surrey, UK

Oscillons are spatially-localised, time-periodic coherent structures observed in experiments of vertically-vibrated granular media and in chemical processes such as the Belousov-Zhabotinsky reaction.

In this talk, I will focus on a system of reaction–diffusion equations originally proposed by Vanag and Epstein. The system has previously been studied using direct numerical simulations and oscillons were found in the proximity of a Turing–Hopf codimension-two bifurcation point.

Oscillons are believed to form via a subcritical Hopf bifurcation of a stationary localised spot, and we expect them to be unstable close to the bifurcation point. In order to study the emergence of oscillons, we pose an appropriate space-time boundary-value problem and employ numerical continuation to explore the parameter space. We show that oscillons can form via a homoclinic bifurcation in time, as an alternative to the subcritical Hopf mechanism mentioned above.
This is joint work with David Lloyd (University of Surrey) and Bjorn Sandstede (Brown University)

Numerical methods for large scale bifurcation problems

Andrew Cliffe
University of Nottingham, UK

This talk will review developments in numerical methods for solving large scale bifurcation problems. Applications to fluid mechanics will be presented and some open problems will be discussed. Promising directions for future research will be identified.

The ocean circulation as a complex dynamical system

Henk Dijkstra
Utrecht University, Netherlands

The large-scale ocean circulation is driven by wind stress and buoyancy fluxes at the ocean-atmosphere interface. The Atlantic ocean circulation appears sensitive to freshwater perturbations and may undergo relatively rapid flow transitions. In this presentation, I will present results of efforts to understand the physics of these transitions using numerical bifurcation techniques applied to a hierarchy of (PDE) ocean models. I will focus on the numerical problems encountered in applying these techniques to ocean models and the solutions to these problems.

Discontinuous Galerkin methods for bifurcation phenomena in the flow through open systems

Edward Hall
University of Nottingham, UK

In the past, studies of bifurcation phenomena of flow in a cylindrical pipe with a sudden expansion have proven inconclusive. In a recent study we sought to exploit the O(2)-symmetric properties of the problem, thus making it tractable by reducing a 3-dimensional problem to a series of 2-dimensional ones. In this talk we will advocate the use of a discontinuous Galerkin method for the numerical solution of the incompressible Navier-Stokes equations and develop goal-oriented error estimation techniques and an hp-adaptive strategy to ensure the accurate location of any bifurcation points. We then apply the method to the flow in a suddenly expanding pipe.

The role of exact solutions in the non-linear behaviour of the Navier–Stokes equations

Andrew Hazel
University of Manchester, UK

Exact solutions of the Navier–Stokes equations have particular functional forms that permit solution of the governing equations without approximation, but require only the solution of a reduced equation. In other words, exact solutions reduce the dynamics to a particular subspace of the full system, but a tacit assumption is that the flow domain is infinite in a particular dimension. Classical examples include solutions of stagnation-point form and the Jeffrey–Hamel solution for flow in an expanding channel.

Exact solutions exhibit complex behaviour including symmetry-breaking, and transition to chaos, but it is not clear how, or whether, these dynamics are ever realised in the equivalent finite domains that could be constructed experimentally. In order to address this question, we have been using numerical bifurcation detection and continuation methods to examine the behaviour of solutions to the Navier–Stokes equations in finite domains equivalent to classical exact solutions.

We find that an appropriate choice of (non-physical) boundary conditions permits the resolution of the exact solution and its non-linear behaviour within the finite domain. For general boundary conditions, however, the nonlinear behaviour is typically very different. Nonetheless, recent results have shown that in Jeffrey-Hamel flow, approximation of the finite-dimensional eigenfunction can be constructed using a few exact-solution eigenfunctions, providing an important link between the exact solution and finite-domain results.

Bifurcations in data assimilation for 2D Navier-Stokes

Kody Law
University of Warwick, UK

Data assimilation is the procedure of incorporating noisy observations of a physical system with an underlying model in order to infer the properties of the system, such as the state and/or parameters. From the Bayesian approach, this consists of determining the posterior distribution for the quantities of interest given the observations. We investigate sequential approximations to the filtering posterior for the Navier-Stokes equations on the 2D torus. These approximations are themselves dynamical systems, and their performance depends on parameters of the physical model and the observations. For instance, the dimension of the global attractor increases as a function of the Reynolds/Grashof number, hence the system becomes less predictable and the assimilation becomes more difficult. We compare the Bayesian posterior distribution (obtained by MCMC) as well as the maximum a posteriori (MAP) estimator (obtained by 4DVAR) with sequential approximations (3DVAR and approximate Kalman filters). The performance of the approximate filtering distributions is measured by relative error in comparison to the moments of the true posterior distribution.

On the use of approximate macroscopic models in equation-free coarse bifurcation analysis

Giovanni Samaey
Katholieke Universiteit Leuven, Belgium

Equation-free methods have been advocated to allow for the coarse (macroscopic) bifurcation analysis of fine-scale (microscopic) problems. They allow to compute coarse asymptotic states (steady states, periodic solutions, etc.) even when the underlying fine-scale system keeps evolving. (Think of molecules in a gas at equilibrium density.) One approach is to use a Newton-Krylov method, in which fine-scale time integration is used to estimate both the coarse residuals and the coarse Jacobian-vector products used to solve the linear systems in each Newton iteration. Several aspects influence the computational efficiency. First, the number of Krylov iterations can be influenced by preconditioning the system's Jacobian. Second, for stochastic fine-scale models, the matrix-vector products will be affected by numerical noise. We discuss these issues and show how the availability of an approximate macroscopic model can alleviate the numerical difficulties. This work involves a number of collaborations, which will be mentioned throughout the talk.

Continuation in physical experiments

Jan Sieber
University of Portsmouth, UK

Recent mechanical oscillator experiments have shown that it is possible to perform simple periodic orbit continuation in physical experiments. The only requirement is the presence of a stabilizing feedback control loop. Using feedback control has the advantage that only inputs into the experiment act as variables in the nonlinear problem but no internal states of the experiment.

In the original experiments most aspects of the numerical side were chosen because they were easy to implement and worked in the simple prototype experiments: projection onto the subspace lowest-order Fourier modes, time-delayed feedback control of higher-order Fourier modes, and Broyden updating of the Jacobian. In order to perform more complex tasks (for example, continuation of folds of periodic orbits) or to extend this method to more complex environments (for example, dynamically clamped neurons) one needs to improve these choices. One direction of improvement is to incorporate know-how that has been developed for equation-free bifurcation analysis of simulators.

LIMIT CYCLES

Organisers: Magdalena Caubergh (Universitat Autònoma de Barcelona, Spain), Maite Grau (Universitat de Lleida, Spain)

Local integrability of three dimensional Lotka-Volterra systems

Waleed Aziz
School of Computing and Mathematics, University of Plymouth UK

The local integrability of two dimensional Lotka-Volterra systems has been investigated by many authors. Our aim here is to generalize this problem to three dimensional Lotka-Volterra systems with (λ, μ, ν) resonance. The main method which we have used is the Darboux method of integrability and Jacobi multipliers together with some more explicit power series arguments.

Persistence of equilibria as periodic solutions of forced systems

Adriana Buica
Universitatea Babes-Bolyai, Romania

We obtain in dimension two a characterization of the fact that an isolated equilibrium of an autonomous system persists as T-periodic solution of T-periodic forced systems. Results in arbitrary dimension will be also presented.

Hilbert's 16th Problem, large amplitude and alien limit cycles

Magdalena Caubergh
Universitat Autònoma de Barcelona, Spain

In this talk we discuss some recent developments around Hilberts 16th problem, that essentially asks for a uniform upper bound for the number of limit cycles of a polynomial vector field only depending on its degree. In particular we focus on two simplified versions of the general problem: Smales 13th problem and the tangential Hilberts 16th problem.

The first one deals with the restriction to Liénard equations, that Smale put forward on his list of challenging problems for the 21st century. In this direction we recall the main results with special attention to large amplitude limit cycles.

The second one is based on the study of the so-called associated Abelian integral, a linearization of the governing equation for limit cycles perturbing from a period annulus of a Hamiltonian vector field. It is well-known that the bifurcation diagram of zeroes of the Abelian integral, when it is generic, reflects the one for limit cycles perturbing from a compact set in the interior of the period annulus. However when studying limit cycles from the boundary one needs, even in the generic case, to take into account the possible presence of alien limit cycles; these limit cycles are not controlled by zeroes of the Abelian integral. We will illustrate this fact in a concrete example.

The tangential center-focus problem for Darboux centres

Colin Christopher
University of Plymouth, UK

We show that under some explicit genericity conditions, a perturbation of a Darboux center which preserves the center to first order is necessarily Darboux relatively exact. In particular, the perturbation lies in the tangent space to the space of Darboux centers. This generalizes the result of Movasati in that we work directly from the Darboux center via pseudoabelian integrals and hence obtain explicit conditions for the rigidity of a Darboux center.

Eventual stability properties of a non-autonomous Lotka-Volterra equation

Attila Dénes
University of Szeged, Hungary

We investigate different variants of a non-autonomous population dynamical model which describes the change in time of the amount of two fish species - a herbivore and a carnivore - living in Lake Tanganyika and the amount of the plants eaten by the herbivores. The model consists of two parts: reproduction taking place at the end of each year is described by a discrete dynamical system, while the development of the population during a year is described by a non-autonomous system of differential equations that is discussed in the talk. For the first variant of the model we show that the equilibrium of the limit equation of our system (which does not have an equilibrium itself) is a globally eventually uniform-asimptotically stable point of the non-autonomous system. In the proof we use linearization, the method of limit equations and Lyapunov's direct method. For the second variant of the system we show that the limit of each solution of our system is a closed curve which is a solution of the limit equation, which is a Lotka-Volterra equation.

Remarkable values of Darboux first integrals: The infinity and the inverse integrating factor

Antoni Ferragut
Universitat Politècnica de Catalunya, Spain

The notion of remarkable values associated to rational first integrals of planar polynomial differential systems was first introduced by Poincaré, and afterwards studied by several authors. We provide here a definition for polynomial differential systems having a Darboux first integral and extend some results which are already known for systems having a rational first integral, as the one which characterizes the existence of a polynomial inverse integrating factor for this kind of systems. Furthermore we study the relation between singular points at infinity and the inverse integrating factor.

Some new types of attractors

Yulij Ilyashenko
Cornell University, USA

The following new types of attractors will be described:

- attractors with invisible parts;
- bony attractors;
- thick attractors.

All these attractors occur in the open subsets of the corresponding functional spaces. Also attractors with intermingled basins form an open set in the space of all boundary preserving diffeomorphisms of a product of a two torus to a segment.

These are the results of the speaker and A.Negut, V.Kleptsyn, P.Saltykov, Yu.Kudryashov, D.Volk.

Darboux theory of integrability for nonautonomous systems.

Chara Pantazi
Universitat Politecnica de Catalunya, Spain

For planar polynomial differential(autonomous) systems there is a method (starting with Darboux) to construct first integrals/integrating factors using its invariant algebraic curves. This theory has been used in some problems related with limit cycles. In this talk we generalize these classical results for a class of nonautonomous polinomial differential systems. We will use the invariant hypersufaces of such vector fields in order to construct first integrals/Jacobi multipliers. We prsent several examples to illustrate the theory and and we will make several useful remarks related to this generalization.

Limit cycles of some perturbations of linear center

Salomón Rebollo Perdomo
Universitat Autònoma de Barcelona, Spain

The study of limit cycles of perturbed Hamiltonian systems has been a classical idea. The linear center is one of the simplest Hamiltonian systems. We will study special perturbations of linear center and we will give upper bounds for the number of limit cycles, of the perturbed systems, which bifurcate from periodic orbits of the linear center.

Fractal analysis of Hopf bifurcation at infinity

Goran Radunovic
University of Zagreb, Croatia

We are interested in fractal analysis of bifurcations of polynomial dynamical systems at infinity and in the connection between box dimension and limit cycle multiplicity of such systems. We illustrate some of the results for systems in $\mathbb{R}^4$, where at the moment of bifurcation one encounters double spirals and spiral chirps that are unbounded. As a natural extension we also consider the Hopf bifurcation from infinity of a class of nonlocal Schrödinger evolution boundary value problems, which contains polynomial dynamical systems as a special case.

Connection between box dimension and cyclicity for planar systems

Maja Resman
University of Zagreb, Croatia

We consider polynomial systems of differential equations in the plane and try to give a connection between the cyclicity of limit periodic sets (i.e. the maximal number of limit cycles that can bifurcate from these sets) and the box dimension of nearby trajectories. In computing dimension and cyclicity we use information about asymptotic behaviour of the Poincare map around limit periodic sets.

Polynomial growth of cyclicity for elementary polycycles and Hilbert-Arnold problem

Ilya Schurov
Moscow State University, Russia

We consider bifurcations of polycycles in generic k-parametric families of smooth vector fields on the 2-sphere. We are interested in the number of limit cycles that are born near a polycycle when one perturbs the parameter slightly (so-called cyclicity of polycycle). For the polycycles whose vertices are only elementary singular points, V.Kaloshin has obtained (2003) an upper bound for the cyclicity. However, this upper bound seems overstated: it has an exponential growth in k. Following the ideas of Ilyashenko, Yakovenko and Kaloshin, we obtain another upper bound, that seems more moderate: it depends on both codimension k and number of vertices on the polycycle n, and has a polynomial growth as a function of k for any fixed n.

MATHEMATICAL NEUROSCIENCE

Organisers: Paul Bressloff (University of Oxford, UK),
Stephen Coombes (University of Nottingham, UK)

Nonlinear synchrony dynamics of coupled neuronal bursters

Abul Kalam al Azad
University of Plymouth, UK

We study the appearance of a novel phenomenon for coupled identical bursters: synchronized bursts where there are changes of spike synchrony within each burst. The examples we study are for normal form elliptic bursters where there is a periodic slow passage through a Bautin (codimension two degenerate Andronov-Hopf) bifurcation. This burster has a subcritical Andronov-Hopf bifurcation at the onset of repetitive spiking while the end of burst occurs via a fold limit cycle bifurcation. We study synchronization behavior of two Bautin-type elliptic bursters for a linear direct coupling scheme as well as demonstrating its presence in an approximation of gap-junction and synaptic coupling. We also find similar behaviour in system consisted of three and four Bautin-type elliptic bursters. We note that higher order terms in the normal form that do not affect the behavior of a single burster can be responsible for changes in synchrony pattern; more precisely, we find within-burst synchrony changes associated with a turning point in the spontaneous spiking frequency (frequency transition). We also find multiple synchrony changes in similar system by incorporating multiple frequency transitions. To explain the phenomenon we considered a burst-synchronized constrained model and a bifurcation analysis of the this reduced model shows the existence of the observed within-burst synchrony states.

Global bifurcation diagrams for models of two coupled class 1 neurons

Claude Baesens
University of Warwick, UK

The saddle-node bifurcation on an invariant circle (SNIC) is one of the codimension-one routes to creation or destruction of a periodic orbit. It governs the transition from resting to periodic spiking in many class 1 neurons, for example. Here, the effect of weak coupling between two systems with a SNIC is analysed. The global bifurcation diagrams are obtained for the principal cases.

Propagation to chaos and information processing in large assemblies of neurons

Olivier Faugeras
INRIA Sophia-Antipolis, France

We present the mean-field equations of completely connected networks of excitatory/inhibitory Hodgkin-Huxley and Fitzhugh-Nagumo neurons and prove that there is propagation to chaos, i.e. that in the limit the neurons become a) independent (this is the propagation to chaos) and b) a copy (with the same law) of a new individual, the mean field limit. This is possibly related to some recently published experimental work by Ecker et al. We show the results of numerical experiments that confirm the propagation to chaos and indicate, through the notion of Fischer information, that this is optimal in terms of information processing. We also consider finite size effects, i.e. the difference between the mean field situation when neuronal populations are of infinite size and the real situation, when the size is finite and show that the mean field approximation is very good for populations of reasonable size.

This is joint work with Diego Fasoli, Geoffroy Herrman and Jonathan Touboul.

Analysis of a geometric model for visual edges and textures perception

Gregory Faye
INRIA Sophia-Antipolis, France

We study the specific problem of visual edges and textures perception and suggest that these features may be represented at the population level in the visual cortex as a specific second-order tensor, the structure tensor, perhaps within a hypercolumn. The key entity, the structure tensor, intrinsically lives in a non-Euclidean, in effect hyperbolic, space. Its spatio-temporal behaviour is governed by nonlinear integro-differential equations, analog of the classical Wilson and Cowan equations, defined on the Poincar? disc model of the two-dimensional hyperbolic space. We propose to present a study, based on non-Euclidean analysis, of a spatially localised bump solution in a limiting case and an equivariant bifurcation analysis of our equations leading to octagonal H-planforms.

Continuation-based computation of global isochrons

Hinke Osinga
University of Bristol, UK

Isochrons are foliations of phase space that extend the notion of phase of a stable periodic orbit to the basin of attraction of this periodic orbit. Each point in the basin of attraction lies on only one isochron and two points on the same isochron converge to the periodic orbit with the same phase. Global isochrons, that is, isochrons extended into the full basin of attraction rather than just a neighborhood of the periodic orbit, can form remarkable foliations. For example, accumulations of all isochrons can occur in arbitrarily small regions of phase space; the limit of such an accumulation is called the phaseless set, which lies on the boundary of the basin of attraction of the periodic orbit. Since global isochrons must typically be approximated numerically, such complicated geometries are often difficult to realize for actual examples. Indeed, the computation of global isochrons can be challenging, particularly for systems with multiple time scales. We present a novel method for computing isochrons via the continuation of a two-point boundary value problem, which is particularly effective for systems with multiple time scales. We use this method to compute global isochrons for a two-dimensional reduced Hodgkin–Huxley model, and illustrate that the one-dimensional isochrons for a planar multiple-time-scale system can accumulate in the interior of the basin of attraction of the periodic orbit in a similar way as can happen with two-dimensional isochrons accumulating on the boundary of a three-dimensional basin of attraction.

Macroscopic entrainment of neuronal ensembles with application in medicine

Oleksandr Popovych
Research Center Jülich, Germany

We show that if a neuronal population receives an external periodic input, the population local field potential may be entrained by the input, whereas the individual neurons are phase desynchronized both mutually and with their field potential. Such a state of macroscopic entrainment is characterized by a relatively large amplitude of the population mean field which is generated by an ensemble of desynchronized neurons firing at different frequencies shifted far away from the frequency of the macroscopic field potential. The individual neurons can get entrained by a periodic driving only for much larger strength of the forcing. This property is used for the functional target localization during deep brain stimulation, which is a standard therapy for medically refractory movement disorders. We developed a stimulation technique that effectively evokes the tremor in a well-defined and quantifiable manner, which is phase locked to the stimulus. We show that a weak patterned low-frequency stimulation may cause low-amplitude, but strongly phase-locked tremor, which is also in accordance with our computational results.

Limit theorems for stochastic spatio-temporal models

Martin Riedler
Heriot-Watt University, UK

Various models in mathematical neuroscience yield for a description of emergent spatio-temporal dynamics, i.e., transmission of signals in models of excitable membranes or spatial models of the activity in the brain. In the literature deterministic models are predominant, although the underlying processes generating this dynamics are best described stochastically. The deterministic modelling approach is understood to capture the averaged dynamics of a large number of individual stochastic events. However, such models may not be able to capture some qualitative dynamics due to the inherent stochasticity, so called 'finite size effects'.

In my talk I present limit theorems that establish a precise mathematical connection between stochastic models and well-established deterministic models as their limit. In particular, we present a law of large numbers and a central limit theorem for stochastic hybrid systems modelling spatially extended structures. In this case, firstly, the law of large numbers provides for large homogeneous structures, e.g., neuronal membranes with a high density and homogeneous distribution of ion channels, a qualitative justification of an approximation by partial differential equations, e.g., the cable equation. Secondly, the central limit theorems provides the basis for a diffusion approximation of hybrid models by stochastic partial differential equations.

Towards a new computational framework for studying the role of gap junctions on neural network dynamics

Yulia Timofeeva
University of Warwick, UK

The complex structure of dendritic trees combined with the connectivity of neural networks and properties of individual synapses are known to play a significant role in neuronal computation. A brute-force numerical simulation is one of the approaches used for studying dynamics of large networks of spatially extended neurons. However, this can be computationally expensive and restricts any mathematical insight. We aim to apply a mixture of mathematics and computation to develop an efficient framework for studying the dynamics of neural networks connected by electrical synapses. We propose to use a Green's function approach for calculating the dynamics of the network and generalise the "sum-over-trips" formalism for taking into account the boundary conditions at gap junctions.

Propagation of spike sequences in neural networks

Arnaud Tonnelier
INRIA Grenoble, France

Among the dynamical states exhibit by homogeneous networks of pulse emitting units, propagating activity waves have retained a great attention. The vast majority of studies use the continuum approximation that implicitly assumes that an infinite number of neurons are involved in the travelling wave propagation. However the synaptic coupling between neurons can be sufficiently strong so that relatively few presynaptic spikes are required to initiate propagation. Such finite-size property is expected in sparsely connected networks supporting travelling waves but has been poorly investigated. Here preliminary results on propagation in discrete-space networks of integrate-and-fire neurons are presented. We report the existence of spatiotemporal periodic traveling waves (composite waves) that support the transmission of sequences of precisely timed action potentials. The stability of composite waves is related to the roots of a system of multivariate polynomials reflecting the underlying discrete topology of the network. Analytical and numerical results are obtained for networks with simple synaptic architectures.

Dynamics of nonlinear integrate-and-fire neurons

Jonathan Touboul
INRIA Paris, France

Nonlinear bidimensional integrate-and-fire neurons are very popular models in the neuroscience community, and widely used for large-scale simulations. These models consists of a nonlinear ordinary differential equation that blows up in finite time, coupled to a discrete mechanism of spike emission and reset. We show how the analysis of the bifurcations of the continuous dynamical system accounts for the excitability properties of the neurons and for their subthreshold behavior, and then show how the complex interplay between the continuous and the discrete dynamical system accounts for the spike pattern fired. We analyze the well-posedness of these equations and show that the quadratic (Izhikevich) model is singular and ill-posed in that framework. We conclude the talk on a revue of different simulation methods for these models together with a precision and complexity analysis.

Homogenization of neural field models

John Wyller
Norwegian University of Life Sciences, Norway

There is a long history of using integro-differential neural field models to understand the properties of waves in neural media. For mathematical convenience these models are often assumed to be spatially translationally-invariant. However, the brain is obviously not a homogeneous media. Hence it is a pressing need to develop mathematical tools for the study of waves in heterogeneous media that can be used in brain modeling. One tool which can be useful in the study of such problems is homogenization techniques.

Modern homogenization theory based on multiscale convergence techniques provides efficient methods for studying the coupling between the microstructure and macroscopic levels. This approach to homogenization theory was originally presented by Nguetseng. A careful treatment of the theoretical foundation of the method can be found in Lukkassen et al. While these techniques have been extensively used in the study of partial differential equation models in many applied fields for several years, they are apparently not known in the neural field community.

In the present talk I will talk about the application of the multiscale convergence technique to neural field models with periodic microstructure.

Possible role for coherence in neuronal communication

Magteld Zeitler
Radboud University Nijmegen, Netherlands

Our brain is continuously bombarded by sensory information. However, the resources to process information are restricted. Therefore, our brain has to select the behaviorally most relevant parts of all incoming information to be transmitted through and processed by the brain. This requires a flexible reorganization of various brain structures depending on the specific task. Although a lot of research has been done, it is still not clear what the exact neuronal mechanisms are which underlie the flexible task-dependent routing of neuronal signals. The communication-through-coherence hypothesis suggests that the flexible communication structure is implemented by coherence within and between communicating neuronal populations.

We discuss this possible mechanism in more depth. Our in silico results show that neuronal coherence can indeed be used as a mechanism for selective information processing and that the effectiveness of the information transfer is determined by the relative phase between two coherent populations and by the amount of synchronized activity within the receiving neuronal population.

NONLINEAR WAVES IN LATTICES

Organisers: Herman Jan Hupkes (Brown University, USA), Dmitry Pelinovsky (McMaster University, Canada)

Continuum limits for localised patterns in lattices

Jonathan Dawes
University of Bath

Localised states, arranged in a typical 'homoclinic snaking' bifurcation diagram, are well-known to exist in simple spatially discrete systems with a bistable nonlinearity:

$$\dot{u}_n \;=\; h^{-2}(u_{n+1} + u_{n-1} - 2u_n) + \mu u_n + s u_n^3 - u_n^5, \tag{2}$$

where the $u_n(t)$, for $n \in \mathbb{Z}$, are real variables on an infinite 1D lattice and $h, s > 0$ and $\mu < 0$ are real parameters (Taylor & Dawes 2010). Steady states of (2) are relevant to many fields including nonlinear optics and biological pattern formation at a cellular scale. As the lattice spacing parameter h decreases, the interval in μ over which the localised states persist shrinks. In the natural continuum limit in which $h \to 0$, the coupling term is replaced by u_{xx}: there is no pinning and hence no steady localised states exist. Intriguing questions then arise concerning higher-order PDE approximations to (2), the simplest of which is the sixth-order PDE

$$u_t \;=\; \left[1 + h^2/(2\pi)^2 \partial_x^2\right]^2 u_{xx} + \mu u + s u^3 - u^5,$$

which explicitly contain the coupling parameter h. I will discuss to what extent they are able to preserve the snaking behaviour in the process of taking a continuum limit.

Oscillatory waves in discrete scalar conservation laws

Michael Herrmann
Universität des Saarlandes, Germany

We study lattice equations that can be derived from scalar nonlinear conservation laws by discretising the space variable in the underlying Lagrangian action integral. The resulting ODEs inherit the KdV-type Hamiltonian structure from the PDE and serve as toy models for more complicate lattices such as FPU-type chains. We prove the existence of highly oscillatory waves and develop the corresponding Whitham theory. Afterwards we discuss some open problems concerning the macroscopic lattice dynamics.

Localised patterns in an urban crime model

David Lloyd
University of Surrey, UK

Short *et al* (2008) proposed a stochastic agent-based model (where criminals move around on a square lattice) to describe spatio-temporal clusters of crime in cities. They then showed that a mean field PDE could be derived from the agent-based model where various periodic structures can be found.

In this talk, we will show that the 1D version of the PDE possesses localised states that undergo homoclinic snaking. Interestingly, the snaking region can coincide with a singular limit of the system allowing for greater insight. We will then show the effect of the lattice and noise on these localised structures.

Periodic traveling waves in the Burridge-Knopoff model

Marion Lebellego
Université de Toulouse, France

In this presentation, we will discuss about the Burridge-Knopoff model, which is used in geology to simulate earthquakes. It consists of a chain of blocks of same mass connected to each other and to an upper moving surface by springs. The blocks are in contact with a rough fixed surface. The aim is to prove the existence of periodic traveling waves in the system, which have been pointed out by geophycists. The problem is described by an infinite system of coupled planar differential inclusions, due to the Coulomb friction law that introduces a multivalued nonlinear term in the equations. Making a traveling wave ansatz, we obtain a planar differential inclusion with an advance-and-delay term. We first prove the existence with a smoothened friction law and without advance-and-delay, and then come back to the non-smooth problem by some perturbation methods.

Crossings of global minimizers for finite-range variational monotone recurrence relations

Blaz Mramor
VU University Amsterdam, Netherlands

Monotone recurrence relations such as the Frenkel-Kontorova crystal model, arise in Hamiltonian mechanics, as models for ferromagnetism and as discretization of elliptic ODEs. They often admit a variational structure, so that their solutions are the stationary points of a formal action function. Classical Aubry-Mather theory establishes the existence of a large collection of such solutions of rational and irrational rotation vectors: they form the Aubry-Mather sets, that consist of global minimizers and may have gaps.

It is well known for first order monotone recurrence relation that global minimizers have simple crossings which in particular implies that they are all Birkhoff. This is not the case for higher order monotone recurrence relations. Nevertheless, we show that in our setting global minimizers are either Birkhoff, and thus very regular, or they grow exponentially and oscillate, in other words, they are very irregular. For the Birkhoff global minimizers, we also prove strong ordering properties, as are well known in classical Aubry-Mather theory.

Shilnikov chaos in parametrically-driven coupled nonlinear lattices: application in two coupled rc-SQUIDs

Vassilis Rothos
Aristotle University of Thessaloniki, Greece

We study the chaotic dynamics of a pair of parametrically-driven coupled nonlinear lattice equations. One of the most popular application of this work is the construction of SQUID (Superconducting Quantum Interference Device). SQUIDs have a lot of applications, especially on medical. There are two main kinds of SQUIDs, the dc and the rc. The main difference of them is that the first has got two Josepson Junctions JJ whereas the rc SQUID has only one. We take advantage of the weak damping that characterizes these systems to perform a multiple-scales analysis and obtain amplitude equations, describing the slow dynamics of the system. This picture allows us to expose the existence of Shilnikov homoclinic orbits in the dynamics of the near-integrable system. We investigate the existence of chaotic behavior near resonances applying methods of normal form, singular perturbation theory and Melnikov analysis.

Spontaneous symmetry breaking phenomenon in nonlinear Schrödinger equations with double well potential

Andrea Sacchetti
University of Modena and Reggio Emilia, Italy

We consider a class of Schrödinger equations with a symmetric double-well potential and a nonlinear perturbation with nonlinearity power μ.

In the semiclassical limit we show that the stationary states may bifurcate as the strength of the nonlinear term increases and we observe two different pictures depending on the value μ of the nonlinearity power: a supercritical pitch-fork bifurcation, and a subcritical pitch-fork bifurcation with two asymmetric branches occuring as result of saddle-node bifurcations.

The first kind of bifurcation always occurs when $\mu < \mu_{\text{threshold}}$, where

$$\mu_{\text{threshold}} = \frac{1}{2}\left[3 + \sqrt{13}\right]$$

is a given critical value; in contrast, when $\mu > \mu_{\text{threshold}}$ then we always observe the second scenario. The remarkable fact is that such a critical value μ_{theshold} is *a universal constant* in the sense that it does not depend on the shape of the double well potential and on the dimension n.

We then discuss the stability/instability properties of each branch of the stationary solutions.

Dynamics of breathing in DNA

Jonathan Wattis
University of Nottingham, UK

We analyse base-pair breathing in a DNA sequence of 12 base-pairs with a defective base at its centre. We use both all-atom molecular dynamics (MD) simulations and a Hamiltonian lattice model consisting of two coupled chains described by ODEs with damping and stochastic forcing terms.

We discuss how the Hamiltonian lattice model is parameterised from the MD simulations, and describe how the lattice stiffness and interaction parameters vary with twist on the double helix. We discuss the breathing mode caused by the introduction of a defect at the central site, which permits breathing to occur on the faster nanosecond timescale which is accessible to simulations.

In both MD and SDE simulations, Fourier analysis of the trajectories reveals self-organised critical behaviour in the breathing of base-pairs. The scale-invariant behaviour we have found provides evidence for the view that base-pair breathing corresponds to the nucleation stage of large-scale DNA opening (or 'melting') and that this process is a phase transition.

PATTERN FORMATION

Organisers: Jonathan Dawes (University of Bath, UK), Alastair Rucklidge (University of Leeds, UK)

Pattern formation in the hyperbolic plane

Pascal Chossat
Université de Nice Sophia Antipolis, France

We consider the analogue of Turing pattern formation for systems defined on the hyperbolic plane (or Poincaré disc) instead of the Euclidean plane. The symmetry group of the system is then the isometry group of the hyperbolic plane. This problem has been motivated by a model of image features detection by the visual cortex of primates which makes use of the concept of "structure tensor". As for the Euclidean case the problem can be greatly simplified by assuming bifurcation of periodic patterns which are invariant under the action of a discrete subgroup whose fundamental domain is compact (a "lattice" group). Significant differences exist however with the Euclidean case, due to the different geometry. In particular an infinite number of periodic lattices can be considered while only three basic types exist in the Euclidean plane. On the other hand the bifurcation problem in this context reduces to a problem of pattern formation on a compact manifold with a finite group of automorphisms. In contrast, in the Euclidean case, the problem reduces to a torus, whose group of automorphisms contains the torus itself. This is illustrated by the case when the fundamental domain of the lattice is the regular octagon, which we have completely solved and shows unexpected properties.

Exponential asymptotics of homoclinic snaking in two-dimensional lattices

Andrew Dean
University of Nottingham, UK

Snaking bifurcations, describing localised solutions existing within an exponentially small region of parameter space, are widely observed in discrete systems. We consider a general class of two-dimensional nonlinear difference equations, and use the method of exponential asymptotics to derive the snaking bifurcation diagrams of solutions which are localised in one direction only. Seeking an asymptotic expansion in the continuum limit, we find the leading order approximation to be a nonlinear generalisation of Laplaces equation, and assume the existence of a stationary front solution. Localised solutions with arbitrary orientation in the plane can thus be constructed by placing two fronts back-to-back. Rigorous matching requires the inclusion of exponentially small effects, derived via optimal truncation of the divergent asymptotic expansion. The matching process results in a set of equations which describe the snaking bifurcations. In particular, we derive a formula for the (exponentially small) width of the snaking region and show that it depends upon the orientation of the solution in the plane. The process is illustrated by specific examples, and compared with numerical simulations.

Quasipatterns in a parametrically forced fluid film

Gérard Iooss
Université de Nice, France

We shake harmonically a thin horizontal fluid layer (frequency forcing ω, only *one harmonic*), to reproduce the Faraday experiment invariant under horizontal rotations. When the Reynolds number and the Weber number (built with surface tension) are suitably chosen, there is a critical value of the amplitude of the forcing such that instability occurs with at the same time the mode oscillating at frequency $\omega/2$, and the mode with frequency ω. Moreover, at criticality the corresponding wave lengths k_c and k'_c are such that there are integers $q \geq 4$ and $p \geq 1$ such that $k'_c = 2k_c \cos p\pi/q$. This means that if we define the families of equally spaced (horizontal) wave vectors

$$\begin{aligned} \mathbf{k}_j &= k_c(\cos(j-1)\pi/q, \sin(j-1)\pi/q), \\ \mathbf{k}'_j &= k'_c(\cos(j-1)\pi/q, \sin(j-1)\pi/q), \qquad j = 1, ...2q, \end{aligned}$$

then

$$\mathbf{k}_j + \mathbf{k}_{j+2p} = \mathbf{k}'_{j+p}, \qquad j = 1, ...2q.$$

It results under the above conditions that 0 is an eigenvalue of the linearized operator in a space of time-periodic functions (frequency $\omega/2$) having a spatially quasiperiodic pattern. Restricting our study to *solutions invariant under rotations of angle* $2\pi/q$, gives a kernel of dimension 4.

We derive formally amplitude equations for perturbations possessing this symmetry for q odd ≥ 5. Then we give simple conditions on coefficients which may be easily computed, for obtaining the bifurcation of (formally) stable time-periodic (frequency $\omega/2$) quasipatterns such that *a time shift by half the period, is equivalent to a rotation of angle* π/q *of the pattern*. This type of behavior has been recently observed experimentally by J.Rajchenbach.

We finally explain why this derivation is formal, no center manifold reduction being available, because of the *occurence of small divisors*, and the fact that *the 0 eigenvalue is not isolated* in the spectrum of the linearized operator.

Multimode localized structures far from equilibrium

Ehud Meron
Ben-Gurion University, Israel

Localized spatial structures are ubiquitous in non-equilibrium systems. Understanding the mechanisms by which they form, their stability and how to manipulate them, is significant for exploiting them in technological applications. A localized structure may involve a single mode, e.g. a spiral wave in an oscillating medium (showcasing a Hopf mode), but quite often richer structures appear. This is particularly the case when a system is driven far from thermal equilibrium and the number of growing modes increases. The system may still be governed by a single dominant mode that damps all other modes by means of nonlinear mode coupling. However, localized structures of the dominant mode, where its amplitude vanishes or becomes sufficiently small, can host the hidden damped mode, giving rise to multimode structures.

In this talk I will describe recent studies of multimode structures in systems that go through dual Hopf-Turing and cusp-Hopf bifurcations. Among the results to be presented are dual-mode spiral waves, which can destabilize to form a novel form of spatio-temporal chaos. I will conclude by discussing additional possible realizations of multimode localized structures, such as hole structures in systems undergoing subcritical Turing instabilities that host damped modes.

Energy-driven pattern formation via competing long- and short-range interactions

Mark Peletier
TU Eindhoven, Netherlands

I will discuss patterns in block copolymer melts. This is a model system that is mathematically tractable, physically meaningful (and experimentally accessible) and representative for a large class of energy-driven pattern-forming systems. Such systems show a remarkable variety of different patterns, of which only a small fraction is well understood.

In this talk I will focus on a variational model for this system, in a parameter regime in which the system forms regular patterns of small spheroid blobs, called particles. The energy for these structures is dominated by a single-particle term, which penalizes each particle independently. This term drives the system towards particles of a well-defined size. At the next level the interaction between the particles is given by a Coulomb interaction potential, giving rise to approximately periodic arrangements.

Approximate quasipattern solutions of PDEs

Alastair Rucklidge
University of Leeds, UK

Quasipatterns are patterns that have 8-, 10- or 12-fold rotational symmetry but no translation symmetry. We investigate how the Fourier spectra of approximate quasipattern solutions of various model PDEs depends on the parameters in the PDE and on the size of the domain in which the problem is posed. We identify which computational domains provide the most accurate quasipatterns, and how the small divisors that are important for exact quasipatterns can amplify round-off error in the numerically determined Fourier spectra.

Resonant triad interactions and spatio-temporal chaos

Anne Skeldon
University of Surrey, UK

Simple regular patterns such as stripes, squares and hexagons that tile the plane appear in many systems that have planar Euclidean symmetry, such as the Rayleigh-Bénard convection and the Faraday experiment. The Faraday experiment shows a rich variety of other patterns such as superlattice patterns and quasipatterns that consist of nonlinear superpositions of hexagons rotated by a particular angle. The occurrence of such patterns can be understood theoretically by three wave interactions (triad interactions) between critical modes and weakly damped modes.

However, the Faraday experiment exhibits many other phenomena, including spatio-temporal chaos (STC) that onsets close to the critical transition from no pattern to a patterned state. We show that this can also be a natural consequence of resonant triad interactions.

This new mechanism for generating STC is supported by the comparison of a weakly non-linear analysis of the Navier-Stokes equations with some experimental results from the Faraday experiment and with simulations from a model PDE.

Pattern formation in chemotaxis-like systems

Angela Stevens
Universität Münster, Germany

In this talk variations of the classical Keller-Segel model for chemotaxis are presented and analyzed with respect to their pattern forming properties. Especially models which couple parabolic and ordinary differential equations and multispecies chemotaxis models are considered. Applications are cellular self-organization due to non-diffusive signals and cell sorting.

Pattern formation in colloidal explosions: theory and experiments

Arthur Straube
Humboldt Universität zu Berlin, Germany

We study the non-equilibrium pattern formation that emerges when magnetically repelling colloids, trapped by optical tweezers, are abruptly released, forming colloidal explosions. For multiple colloids in a single trap we observe a pattern of expanding concentric rings. For colloids individually trapped in a line, we observe explosions with a zigzag pattern that persists even when magnetic interactions are much weaker than those that break the linear symmetry in equilibrium. Theory and computer simulations quantitatively describe these phenomena both in and out of equilibrium. Colloidal explosions provide a new way to generate well-characterised non-equilibrium behaviour in colloidal systems.

Variational approximations to homoclinic snakings

Hadi Susanto
University of Nottingham, UK

In this talk, we will present our study on the snaking of localised patterns, seen in numerous physical applications, using a variational approximation. This method naturally introduces the exponentially small terms responsible for the snaking structure, that are not accessible via standard multiple-scales asymptotic techniques, yet it is considerably simpler than an exponential asymptotic method. We apply the method in particular to the quadratic and the cubic Swift-Hohenberg equations and the discrete Allen-Cahn equation. Using the variational formulation, we obtain the symmetric snaking solutions and the asymmetric 'ladder' states, and predict the stability of the states. We will show that the resulting approximate formulas for the width of the snaking region is in good agreement with numerical results.

Self-assembly, defect motion and rheology of mesophases

Jorge Vinals
University of Minnesota, USA

Mesophases are intermediate between unstructured fluids and fully ordered crystalline solids. They often self-assemble at the mesoscale, albeit into de fected microstructures. We describe research on a mesoscopic description of the response of these phases to shears, including elastic and dissipative contributions. Particular applications to lamellar, hexagonal, and gyroid phases are considered. We also use this description to analyze the motion of extended defects such as grain boundaries, and address the issue of orientation selection under imposed oscillatory shears.

Pattern formation on small world networks

Thomas Wagenknecht
University of Leeds, UK

The Turing instability is a classic mechanism for the formation of spatial structures in non-equilibrium systems. Recent work by Nakao and Mikhailov has shown how this instability leads to the emergence of patterns in large random networks, thereby revealing different properties to the case of continuous media.

In this talk, we will investigate Turing patterns in complex networks of small world type. We study stationary and oscillatory patterns on small-world networks and especially analyse the effects of random rewiring on the patterns. We also present some results concerning localised patterns in these networks and discuss extensions to two-dimensional problems, that is, to square-lattice networks with random rewiring.

PROBLEMS WITH MOVING INTERFACES

Organisers: Pavel Grinfeld (Drexel University, USA), Jean-Christophe Nave (McGill University, Canada)

On motions of Prandtl-Eyring fluids in 2D

Lars Diening
LMU München, Germany

The stationary flow of a fluid of Prandtl-Eyring type is described by the equation of motion

$$-\mathrm{div}\sigma + \nabla q + \mathrm{div}(u \otimes u) = f,$$

with $\sigma = DW(\epsilon(u)$ and $W(\epsilon) = |\epsilon(u)|\ln(1 + |\epsilon(u)|)$, where $\epsilon(u) := \frac{1}{2}(\nabla u + \nabla u^T)$. In particular, the potential is only super linear by a logarithmic factor. This results in severe mathematical problems in the existence theory of weak solutions already in two dimensions. Several standard tools like Korn's inequality fail in such a functional setting. We show how to overcome these difficulties by a subtle modification of the Lipschitz truncation technique.

Fluid film equations and other applications of the calculus of moving surfaces

Pavel Grinfeld
Drexel University, USA

I will give an overview of the CMS and illustrate its capability by demonstrating a number of applications. Applications will include: 1. Boundary variation problems – what is the change in solution of a boundary value problem induced by a change in shape? 2. Shape optimization problems – what shape delivers an extremal value of a shape dependent objective function? 3. Dynamic problems – I am excited to present the recently proposed exact nonlinear equations of fluid film dynamics. Derived from the Least Action Principle, these equations are a direct analogue of the Navier-Stokes equations and therefore possess the same key characteristics: conservation of mass and, in the case of inviscid equations, conservation of energy, pointwise conservation of vorticity and conservation of circulation around a closed loop.

Some high-order, optimally local schemes for interface problems

Jean-Christophe Nave
McGill University, Canada

I will present two schemes, one for the advection equation and the other for Poisson's equation with interface discontinuities. The particularity of these schemes is that they are local, but manage to achieve 4th order convergence (in the L^∞ norm). The basic idea hinges on the locality of Hermite basis, and that of the ghost fluid method. I will discuss some applications and current thoughts on various extensions.

A projection-less method for the incompressible Navier-Stokes equations on irregular domains.

David Shirokoff
MIT, USA

In this talk we discuss solving the incompressible Navier-Stokes equations on domains with irregular boundaries. Our interest is in the evaluation of interfacial stresses, which require an accurate computation of the pressure and velocity gradients near the domain boundaries. Since common efficient schemes, such as the projection or fractional-step methods, can introduce numerical boundary layers, we take an alternative approach and recast the Navier-Stokes equations as an equivalent pressure-Poisson system. The resulting numerical schemes exactly preserve the velocity divergence constraint and hence no projection step is required. In practice, the implementation details closely parallel that of the projection method, with the primary difference being the implementation of boundary conditions. Time permitting, we will discuss the numerical implementation of the scheme for i) an irregular domain embedded in a regular grid, and ii) an extension to the finite element framework.

SINGULAR PERTURBATION THEORY

Organisers: Freddy Dumortier (Universiteit Hasselt, Belgium), Peter De Maesschalck (Universiteit Hasselt, Belgium)

Exponentially slow solutions in viscous balance laws

Julia Ehrt
Humboldt Universität zu Berlin, Germany

The talk investigates global solutions of viscous balance laws on the circle with small viscosity. These equations can be understood as singular perturbed hyperbolic balance laws where the viscosity term enters as a singular perturbation in the PDE. I will first present a result on non- persistence of heteroclinic connections for vanishing viscosity and then investigate some of the consequences of this result for the viscous equation: exponentially slow solutions.

True slow surfaces and dynamical bifurcations

Yulij Ilyashenko
Cornell University, USA

In the first part we consider slow-fast systems whose fast part has smooth normally hyperbolic attracting manifolds for all values of the slow variables. After perturbations these families of attracting manifolds form an "invariant attracting true slow surface" for the slow-fast system.

In the second part we study dynamical bifurcations of the two-torus and the Klein bottle.

In the third part we study the bifurcation scenario on the homoclinic Klein bottle of a semistable periodic orbit.

The results of the second part are joint with Olga Anosova; the result of the first and the third parts were obtained by O.Anosova and A.Borisyuk respectively at the time when they were the graduate students of the speaker.

Invariant cones in 3D piecewise linear systems via Melnikov function

Soledad Fernandez-Garcia
Universidad de Sevilla, Spain

Nowadays, we can affirm that piecewise linear dynamical systems are being widely studied. This is due, for instance, to its ability to model accurately some mechanical devices and electronic circuits. On the other hand, they are also able to explain, in an easy way, the appearance of periodic orbits due to a change on the stability of an equilibrium point. For instance, in the case of planar continuous piecewise linear systems with two zones of linearity, the appearance of this periodic orbits is perfectly established. In fact, the study of periodic orbits begins with the analysis of the stability of the equilibrium points of the system which are in the separation line of the linearity zones. This analysis is simple for planar systems with two zones of linearity, but it is uncompleted for three-dimensional systems. For example, the continuous matching of two stable linear systems can be unstable. This instability is closely related with the appearance of an invariant cone for the three-dimensional system, in such way that the absence of invariant cones guarantees the stability when the linear systems coupled are stable. Therefore, it is highly interesting the study of the existence of invariant cones in three-dimensional continuous homogeneous piecewise linear systems. V. Carmona *et al* perform a very complete study of the existence of invariant cones for this class of systems and they conjecture the existence of a saddle-node bifurcation of invariant cones, which takes place when two invariant cones with exchanged stability collide and disappear.

In this talk, we will center on the proof of the existence of one saddle-node bifurcation of invariant cones conjectured by Carmona *et al*. For this, the appearance of invariant cones is related one-to-one with the existence of periodic orbits in a class of planar hybrid piecewise linear systems. Starting from a very specific situation, in which the space $\mathbb{R}^3$ is foliated of invariant cones, it is possible to describe the planar hybrid systems as the perturbation of continuous piecewise linear systems which have an unbounded continuum of periodic orbits. Thus, the existence of periodic orbits in the hybrid systems (i.e., the invariant cones of the three-dimensional system) can be determined from the simple zeros of a real function of real variable, by extending the Melnikov theory to a class of planar hybrid systems. Furthermore, a double zero of this function is related to the saddle-node bifurcation of invariant cones, which let us to prove the conjecture.

Delayed exchange of stability and relaxation oscillations of a new type in an enzyme reaction

Ilona Kosiuk
Max Planck Institute for Mathematics in the Sciences, Germany

We present a geometric analysis of a new type of relaxation oscillations in an enzyme reaction. The model developed by A. Goldbeter describes at the molecular level the mitosis part of the cell division cycle in eukaryotes. We rewrite the model as a three-dimensional singularly perturbed system and analyze its dynamics in the spirit of geometric singular perturbation theory. Relaxation oscillations of a new type arise from the phenomenon of a delayed exchange of stability, which occurs at non-hyperbolic lines along which branches of the two-dimensional critical manifold intersect. This novel type of relaxation oscillations is studied by means of several blow-up transformations.

Canards in the dynamics of aircraft as ground vehicles

Bernd Krauskopf
University of Bristol, UK

Aircraft are meant to fly, but they also need to operate efficiently and safely on the ground. As ground vehicles, commercial aircraft are quite special; in particular, they feature a tricycle configuration and very strong deformations of the tyres.

In this talk we perform a bifurcation analysis of a nonlinear aircraft ground dynamics model, where we concentrate on the standard ground manoeuvre of aircraft turning. More specifically, it is shown that a canard explosion in the system explains that the aircraft may undergo a sudden loss of turning stability to enter a spin, which is physically associated with a rapid loss of tyre holding force.

Canards and inflection

Martin Krupa
INRIA Rocquencourt, France

In this talk, I will revisit the "inflection line method" introduced in the early 1990s to characterise canard explosions geometrically. From the dependence of the inflection curves of the flow on the small parameter epsilon, I will propose an upper bound in epsilon for canard cycles to possess their classic features. Finally, I will highlight an application of this approach to neuronal dynamics.

Hunting French ducks in a noisy environment

Christian Kuehn
Max Planck Institute for the Physics of Complex Systems, Germany

We consider the influence of noise on oscillations in multiple time scale systems. In particular, we analyze folded node singularities in a normal form system with with two slow variables and one fast variable. In this context, it is well-known that canard ("duck") orbits can generate local oscillations. A general method to carry over results from deterministic to stochastic fast-slow systems will be outlined. The main techniques are the analysis of variational equations and concentration estimates for metastable sample paths near invariant manifolds. The results are expected to form a main building block to understand mixed-mode oscillations that appear in many applications.

Periodic orbits near common slow-fast cycles in planar slow-fast systems

Peter De Maesschalck
Universiteit Hasselt, Belgium

We study limit cycles of planar slow-fast vector fields, appearing near a given slow-fast cycle, formed by an arbitrary sequence of slow parts and fast parts, and where the slow parts can meet the fast parts in a nilpotent contact point of arbitrary order. In most cases, the stability of the limit cycle can be concluded from the study of the sign of the divergence integral calculated along the slow parts. We delimit a large subclass of slow-fast cycles where this is true, but we also provide examples of cycles with a negative divergence integral (hence seeming attracting) out of which more than one limit cycle can perturb, one of which is repelling.

Time-periodic perturbation of a Liénard equation with an unbounded homoclinic loop

Marcelo Messias
UNESP, Brasil

We consider a quadratic Liénard equation with an unbounded homoclinic loop, which is a solution tending in forward and backward time to a non-hyperbolic equilibrium point located at infinity. Under small time-periodic perturbation this equilibrium becomes a normally hyperbolic line of singularities at infinity. We show that the perturbed system may present homoclinic bifurcations, leading to the existence of transverse intersections between the stable and unstable manifolds of such a normally hyperbolic line of singularities. The global study concerning infinity is performed using the Poincaré compactification in polar coordinates, from which we obtain a system defined on a solid torus in $\mathbb{R}^3$, whose boundary plays the role of the infinity. The transversality of the manifolds is proved using the Melnikov method and implies, via the Birkhoff-Smale Theorem, in a complex dynamical behaviour of the perturbed system solutions. Numerical simulations are performed in order to illustrate this behaviour, which could be called "the chaos arising from infinity", since it depends on the global structure of the Liénard equation, including the points at infinity. Although applied to a particular case, the analysis presented here provides a geometrical approach to study periodic perturbations of homoclinic (or heteroclinic) loops to infinity of any planar polynomial vector field.

Slow-fast dynamics of a charged particle interacting with an oblique electromagnetic field

Anatoly Neishtadt
Loughborough University, UK

We study interaction of a charged particle with a high-frequency electromagnetic wave that propagates obliquely to a background uniform magnetic field. Dynamics of this particle is described by a slow-fast Hamiltonian system. In the process of slow evolution the fast dynamics may approach a resonant state, and the particle might be captured into the resonance with the wave. We describe dynamics of the captured particle and subsequent escape from the resonance. This process may lead to a substantial acceleration of the particle.

The singular limit of a Hopf bifurcation

Hinke Osinga
University of Bristol, UK

Hopf bifurcation in systems with multiple time scales is influenced by the singular limit of the fast time scale, that is, when the ratio ε of the slowest and fastest time scales goes to zero. In general, bifurcations in the full slow-fast system have a close cousin in the fast subsystem obtained from this singular limit. However, a Hopf bifurcation of the fast subsystem does not necessarily have the same criticality as the corresponding Hopf bifurcation of the full slow-fast system, even in the limit $\varepsilon \to 0$ when the two bifurcations occur at the same point. We investigate this situation by presenting a normal form to explain the expected structure of the bifurcation diagram. We show that the family of periodic orbits that emanates from the Hopf bifurcation accumulates onto the corresponding family of the fast subsystem in the limit as $\varepsilon \to 0$; furthermore, the stability of the orbits is dictated by that of the fast subsystem, and we show that a torus bifurcation must occur $O(\varepsilon)$ near the Hopf bifurcation of the full system to change the stability of a family of periodic orbits if the criticality of the respective Hopf bifurcations is not the same.

Geometric singular perturbation theory beyond the standard form

Peter Szmolyan
TU Wien, Austria

In many applications multiple time scale dynamics occurs due to the presence of variables and parameters of very different orders of magnitudes. Situations with a clear "global" separation into fast and slow variables governed by singularly perturbed ordinary differential equations in standard form have been investigated in great detail. For multi-scale problems depending on several parameters it can already be a nontrivial task to identify meaningful scalings. Typically these scalings and the corresponding asymptotic regimes are valid only in certain regions in phase-space or parameter-space. Another issue is how to match these asymptotic regimes to understand the global dynamics. In this talk I will show in the context of selected examples that geometric methods based on the blow-up method provide a systematic approach to problems of this type.

SPECTRAL THEORY AND DYNAMICS OF COCYCLES

Organisers: David Damanik (Rice University, USA),
Roberta Fabbri (Università di Firenze, Italy)

Perturbative reducibility results for quasi-periodic cocycles without diophantine conditions

Claire Chavaudret
Scuola Normale Superiore, Italy

A theorem by Eliasson says that analytic Schrödinger cocycles are reducible whenever they have a diophantine frequency, a diophantine rotation number and are close enough to a constant. Using Pöschel's modified KAM method and Rüssmann's approximation functions, we can obtain reducibility under slightly less restrictive conditions.

Lyapunov spectrum of nonautonomous linear stochastic differential algebraic equations of index -1

Nguyen Dinh Cong
Vietnam Academy of Science and Technology, Vietnam

We introduce a concept of Lyapunov exponents and Lyapunov spectrum of a stochastic differential algebraic equation (SDAE) of index -1. The Lyapunov exponents are defined samplewise via the induced two-parameter stochastic flow generated by inherent regular stochastic differential equations. We prove that Lyapunov exponents are nonrandom.

Genericity of exponential dichotomy for $\mathbf{SL(2,\mathbb{R})}$-valued cocycles

Roberta Fabbri
Vietnam Università di Firenze, Italy

We present some results for smooth $\mathrm{SL}(2,\mathbb{R})$-valued cocycles defined over a flow. In particular, we discuss the question of the density in the Hoelder class of the set of $\mathrm{SL}(2,\mathbb{R})$-valued cocycles exhibiting an exponential dichotomy (uniformly hyperbolic cocycles) when the base flow is of Kronecker type on a two dimensional torus.

The Atkinson spectral problem and applications

Russell Johnson
Università di Firenze, Italy

We derive some basic facts regarding Atkinson-type spectral problems using methods of nonautonomous dynamical systems. Then we review some applications which center on the nonautonomous version of the Yakubovich frequency theorem.

Linearization of hyperbolic finite-time processes

Daniel Karrasch
TU Dresden, Germany

We adapt the notion of processes to introduce an abstract framework for dynamics on compact time sets. For linear finite-time processes a notion of hyperbolicity namely exponential monotonicity dichotomy (EMD) is introduced, thereby generalizing and unifying several existing approaches. We present a spectral theory for linear processes in a coherent way, based only on a logarithmic difference quotient, prove robustness of EMD with respect to a suitable (semi-)metric and provide exact perturbation bounds. Furthermore, we show a local stable / unstable cone theorem, which extends a finite-time analogue of the local stable / unstable manifold theorem.

Typical properties within special classes of smooth $\mathrm{SL}(2,\mathbb{R})$ valued cocycles

Mahesh Nerurkar
Rutgers University, USA

We review some recent results (and techniques) related to the density and genericity of special classes of smooth $\mathrm{SL}(2,\mathbb{R})$ valued cocycles based on rotation flows with super Liouvillian rotation numbers.

Limit-periodic Verblunsky coefficients for OPUC

Darren Ong
Rice University, USA

Avila recently introduced a new method for the study of the discrete Schrödinger operator with limit periodic potential. We adapt this method to the context of orthogonal polynomials in the unit circle with limit periodic Verblunsky coefficients. Specifically, we represent these Verblunsky coefficients as a continuous sampling of the orbits of a Cantor group by a minimal translation. We then investigate the measures that arise on the unit circle as we vary the sampling function.

Linearization of quasiperiodically forced circle flow beyond Brjuno condition

Qi Zhou
Nanjing University, China

In this talk, we consider analytic nonlinear quasiperiodically forced circle flow with two frequencies. If the forced frequency $\omega = (1, \alpha)$, then for positive measure parameter set, the system is C^∞ rotations linearizable and C^ω almost linearizable provided that α is not super-liouvillean and the fibre flow is close to rotation. Moreover, if $\widetilde{\omega} = \frac{1}{\lambda}\omega$, we obtain the same results, and the perturbation does not depend on λ. As a corollary, we obtain results on local denseness of linearization and mode-locking. These results can be seen as the nonlinear generalization of Avila-Fayad-Krikorian's theorem, and give positive answer to the linearization problem of quasiperiodically forced circle flow beyond Brjuno condition.

STATISTICAL PROPERTIES OF DYNAMICAL SYSTEMS

Organisers: Henk Bruin (University of Surrey, UK),
Matthew Nicol (University of Houston, USA)

Hitting times in dynamics: old and new

Zaq Coelho
University of York, UK

After an initial motivation to study asymptotic hitting times of rare events in dynamics, we will state some known results for the limit law of these hitting times. We will also discuss the question of whether these (scaled) hitting times which are known to converge in law, could converge strongly (i.e. almost surely). We will finish with some on going work to extend some of the results to Axiom A diffeormorphisms.

Statistical problems and phenomena in some models of asynchronous dynamics

Michael Field
University of Houston, USA

We describe some recent work on a model for asynchronous dynamics that involves a mix of random and deterministic dynamics. The model was inspired by some discussions with David Broomhead (Manchester) on 'partially ordered time'.

Robustness of extremes for chaotic dynamical systems

Mark Holland
University of Exeter, UK

For chaotic dynamical systems we can explore their reucrrence properties such as the statistics of extremes. Furthermore we can determine how these recurrence properties change with system parameters. We present preliminary restuls for the Lorenz equations. We also explore this question more generally for non-uniformly hyperbolic dynamical systems.

Multifractal analysis and frequency of digits for countable branch expanding maps

Thomas Jordan
University of Bristol, UK

We consider an expanding interval map, T, with a countable number of inverse branches. We then consider a countable family of bounded potentials f_i and a vector $(a_1, a_2, a_3, \ldots)$. We will look at the Hausdorff dimension of the set of points x where for each i we have that the Birkhoff averge of f_i at x will converge to a_i. We will show that if the set is nonempty then the Hausdorff dimension is uniformly bounded below by a value s_∞ which is determined by the map T. We will also show in which cases the dimension of such sets can be given by a conditional variational principle. A particular example which can be considered is where the frquency of digits in the symbolic coding for x is specified. We will point out several differences between this case and the case where there are only a finite number of inverse branches.

Robustness and synchronisation of non-autonomous oscillators

Robert MacKay
University of Warwick, UK

A limit cycle subject to weak time-dependent forcing produces a normally hyperbolic cylinder in extended state-space. To estimate how much it deforms and for how large coupling the cylinder persists, we propose a quantitative approach to the theory of normally hyperbolic submanifolds. The dynamics on the cylinder may well collapse onto one or more isolated trajectories, which we call synchronisation to the forcing and can be estimated using the quantitative uniform hyperbolicity estimates of Bishnani & MacKay. In a weakly coupled network of oscillators, possibly with weak time-dependent forcing, to any subgroup of N oscillators there corresponds a family of normally hyperbolic N-tori x time, parametrised by the input forcing functions to the group. The subgroup may partially or fully synchronise, meaning that the dynamics on the normally hyperbolic N-torus x time collapses onto one or more normally hyperbolic M-tori x time for some $M \in \{0, \dots, N-1\}$. We propose use of our normal hyperbolic submanifolds estimates, and a hierarchical aggregation scheme to treat synchronisation in large networks of oscillators.

Statistical properties for interval maps with critical points and singularities

Ian Melbourne
University of Surrey, UK

Araújo, Luzzatto and Viana recently established the existence of absolutely continuous ergodic invariant probability measures for a very general class of interval maps with critical points and singularities. Whereas previous approaches relied on inducing to an expanding map with full branches and good distortion properties, here the induced map is required only to be of Rychlik-type. Building on these results, we give conditions under which the central limit theorem and vector-valued almost sure invariance principle hold for bounded variation observables.

A mechanism for producing SRB measures in certain evolution PDEs

William Ott
University of Houston, USA

We examine the idea that SRB measures can be produced when a flow with a weakly stable limit cycle is subjected to a periodic pulsatile drive. The key ingredient is 'shear' near the limit cycle. For finite-dimensional systems, SRB measures have been shown to exist in the contexts of supercritical Hopf bifurcations and general limit cycles by Wang/Young and Ott/Stenlund, respectively. Lu, Wang, and Young have extended the analysis of supercritical Hopf bifurcations to parabolic PDEs. In this talk we treat macroscopic limit cycles of certain evolution PDEs. Central to the analysis is the notion of 'shear in function space'.

The SRB measures discussed above are associated with chaotic behavior that is both sustained in time and physically observable. The results for PDEs are proved using a combination of invariant manifold techniques and the theory of rank one maps. Crucially, they are applicable to concrete models.

Fluctuation theorems, large deviations and shrinking intervals

Richard Sharp
University of Manchester

We will discuss large deviations and fluctuation theorems for reversible hyperbolic maps with respect to slowly shrinking intervals. (This is joint work with Mark Pollicott.)

First and higher order limit theorems for dynamical systems with infinite measure

Dalia Terhesiu
University of Surrey, UK

We generalize the proof of Karamata's Theorem by the elementary method of approximation by polynomials to the operator case. As a consequence, we ofer a simple proof of uniform pointwise dual ergodicity with remainders in the implied convergence for a very large class of dynamical systems with infnite measure. Also, building on the techniques of complex remainder theory for the scalar case, we develop a method that provides second (and higher) order asymptotics of the average operator $\sum j = 0^{n-1} L_j$ associated with a large class of dynamical systems with infnite measure, including the Pommeau Mannevile map. The techniques developed allow us to derive a higher order tauberian theorem, which to our knowledge, has not previously covered.

Equilibrium measures for beta-shifts and their factors

Dan Thompson
The Pennsylvania State University, USA

This talk is based on joint work with Vaughn Climenhaga (Maryland), in which we show that every shift space which is a factor of a beta-shift has a unique measure of maximal entropy. This provides an affirmative answer to Problem 28.2 of Mike Boyle's article 'Open problems in symbolic dynamics'.

A measure of maximal entropy is a measure which witnesses the greatest possible complexity in the orbit structure of a topological dynamical system. Establishing when a system has a unique measure of maximal entropy is a fundamental topic in ergodic theory and has been studied extensively since the 1960's. The beta-shifts are a class of symbolic spaces with an extremely rich structure and a profound connection to number theory.

Our method actually applies to a rather large general class of shift spaces, and can also be applied to non-symbolic systems. We have recently extended our results to establish uniqueness of equilibrium measures for a large class of potential functions. We obtain new results in the setting described above, and even in the case of the full shift. I will give a detailed explanation of the problems described above and their motivation. I will also describe, via a detailed description of the beta-shift, the key ideas behind our method.

Transience in dynamical systems

Mike Todd
University of St Andrews, UK

A classical question in the theory of random walks, Markov chains and ergodic theory is whether a system is recurrent or transient. The notion of recurrence and its consequences are well understood in the former two cases, but in the context of the ergodic theory of dynamical systems transience, very little is known. In this talk will discuss an elementary family of interval maps which give a very clear presentation of the transition from recurrence to transience. This is related to the the thermodynamic formalism for these maps which can be studied via Markov chain models.

Recent results on the statistical properties of non-uniformly expanding maps in any dimension

Sandro Vaienti
Centre de Physique Théorique de Luminy, France

We give a survey on some recent results on the statistical properties of non-uniformly expanding maps in any dimension: invariant measures, rate of mixing, statistical stability, Borel-Cantelli like theorems.

Limit laws for iterated function systems that contract-on-average

Charles Walkden
The University of Manchester, UK

Let T_j be a family of maps of some (non-compact) space X. Form an iterated function system by starting at $x_0 \in X$, and then randomly choosing and applying a map T_j chosen with place-dependent probabilities. If the T_j uniformly contract, then such systems are well-understoof. If, however, the system 'contracts-on-average' then there are still many open questions. (As an example, take X to be the real line, and take two maps $T_0(x) = x + 1, T_1(x) = x/2$ each chosen with probability $1/2$. In this case, the system contracts on average and there is a unique invariant set $[0, \infty)$. One can look at statistcal properties of such IFSs, for example by taking a function $f : X \to R$ and summing it along a typical orbit of the IFS. The purpose of this talk is to discuss limiting properties of such sums and in particular to discuss convergence in distribution to stable laws in the case where f has infinite variance.

WATER WAVES

Organisers: Vera Hur (University of Illinois at Urbana-Champaign, USA),
Erik Wahlén (Lund University, Sweden)

On the Cauchy problem for water gravity waves in a channel

Thomas Alazard
École Normale Supérieure de Paris, France

I will present a paradifferential approach to water gravity waves. Our main result is that the water wave system can be arranged into an explicit symmetric system of wave type. Following this approach, we are able to obtain a sharp result in terms of regularity indexes of the initial data as for the smoothness of the bottom of the domain (namely no regularity assumption is assumed on the bottom). This allows to prove that the Cauchy problem for 3D water gravity waves in a channel is well-posed. This is a joint work with Nicolas Burq and Claude Zuily.

Dynamical behavior near solitary waves obtained by minimax methods

Boris Buffoni
EPFL Lausanne, Switzerland

In infinite depth, the existence of two symmetric waves has been known since the work by Iooss and Kirrmann. The solitary waves propagate on the free surface of a bidimensional layer of irrotational fluid that is submitted to gravity and surface tension. On the other hand, by minimizing the total energy among configurations of fixed horizontal impulse, a solitary wave is obtained that can be shown to be stable in some weak sense (Buffoni, Groves-Wahlén).

I shall speak about a work in progress that deals by variational methods with multiplicity of solitary waves and the behavior in time of nearby waves. It relies on a variational reduction recently developed by Groves et Wahlén that transforms the problem to a standard four-dimensional ordinary differential "model" equation. Their reduction can be modified in a way that is compatible with the time invariance of the total horizontal impulse.

A set A of localized waves is obtained that is conditionally globally stable (a wave that starts near A remains near A as long as it stays in the region where the reduction is performed). The free surfaces of the waves in A can be described quite precisely and it contains at least two distinct solitary waves: one minimizes and one maximizes the total energy restricted to A.

Turning waves and breakdown for incompressible flows

Angel Castro
ICMAT, Spain

We consider the evolution of an interface generated between two immiscible, incompressible, and irrotational fluids. Specifically we study the Muskat and water wave problems. We show that starting with a family of initial data given by $(x, f_0(x))$, the interface reaches a regime in finite time in which is no longer a graph. Therefore there exists a time t where the solution of the free boundary problem parameterized as $(x, f(x,t))$, blows up: $\|\partial_\alpha f\|_{L^\infty(t)} = \infty$. In particular, for the Muskat problem, this result allows us to reach an unstable regime, for which the RayleighTaylor condition changes sign and the solution breaks down.

A variational approach to a class of nonlocal evolution equations and existence of solitary waves of the Whitham equation

Mats Ehrnström
Universität Hannover, Germany

We prove the existence of solitary-wave solutions for a class of nonlocal evolution equations of the form $u_t + [n(u) + Lu]_x = 0$. The linear operator L is nonlocal of negative order, whereas the nonlinearity n is local and of superlinear growth near the origin. Using the methods of minimisation–penalisation and concentration–compactness we find periodic solutions converging to conditionally stable, smooth minimisers of small amplitude.
Our analysis includes the case of the Whitham equation, the linear terms of which match the dispersion relation for gravity water waves on finite depth. The Whitham equation has a global bifurcation branch of 2π-periodic, smooth, traveling-wave solutions and is conjectured to admit a 'highest', cusped, wave. For the solitary case, we show that the Whitham minimisers approximate the KdV-solitons in the small-amplitude limit.

Existence and stability of fully localised three-dimensional gravity-capillary solitary water waves

Mark Groves
Universität des Saarlandes, Germany

A solitary wave of the type advertised in the title is a critical point of the Hamiltonian, which is given in dimensionless coordinates by

$$H(\eta,\xi) = \int_{\mathbb{R}^2} \left\{ \frac{1}{2}\xi G(\eta)\xi + \frac{1}{2}\eta^2 + \beta\sqrt{1+\eta_x^2+\eta_z^2} - \beta \right\},$$

subject to the constraint that the impulse

$$I(\eta,\xi) = \int_{\mathbb{R}^2} \eta_x \xi$$

is fixed. Here $\eta(x,z)$ is the free-surface elevation, ξ is the trace of the velocity potential on the free surface, $G(\eta)$ is a Dirichlet-Neumann operator and $\beta > 1/3$ is the Bond number.

In this talk I show that there exists a minimiser of H subject to the constraint $I = 2\mu$, where $0 < \mu \ll 1$. The existence of a solitary wave is thus assured, and since H and I are both conserved quantities its stability follows by a standard argument. 'Stability' must however be understood in a qualified sense due to the lack of a global well-posedness theory for three-dimensional water waves.

Non-symmetric periodic three-dimensional water waves

Gérard Iooss
Université de Nice, France

We consider travelling water waves in a potential flow on an infinitely deep fluid layer, which form a bi-periodic horizontal pattern on the free surface, *in absence of surface tension*. The waves may be considered as the nonlinear superposition of two plane waves, with corresponding wave vectors K_1 and K_2, (of a priori different lengths) and amplitudes ϵ_1 and ϵ_2, provided that at the bifurcation, K_1, K_2 and the bifurcation parameters μ and the direction of propagation $\mathbf{u}_0$, satisfy the dispersion relation. A formal asymptotic expansion of bifurcating 3-dimensional waves may be built as a power series of the amplitudes ϵ_1, ϵ_2, the direction of propagation being close to $\mathbf{u}_0$. Due to the *occurence of small divisors*, the main difficulty for proving the existence of solutions, possessing the above asymptotic expansions, is the inversion of the linearized operator at a non trivial point, for applying the Nash Moser theorem. This operator is the sum of a second order differentiation along the horizontal projection of the velocity field (having an *unknown rotation number*), and an integro-differential operator of first order, both depending periodically of coordinates. Thanks to a diophantine condition on the rotation number, an appropriate *descent method* allows to transform the above linear operator into a diagonal operator on which a diophantine estimate applies, plus a smoothing operator. We are then able to prove that, for nearly all choices of wave vectors K_1 and K_2, and choosing amplitudes ϵ_1, ϵ_2 in a set of asymptotically full measure near 0, there exist bifurcating doubly-periodic non-symmetric waves corresponding to the above asymptotic expansion.

A side result is a phenomenon of *directional Stokes drift*, i.e. the trajectories of particles at the free surface have an asymptotic direction which differ slightly from the direction of propagation of the waves (angle of the order of $\epsilon_1^2 + \epsilon_2^2$).

On estimates of slopes for steady gravity water waves in a channel of finite depth.

Vladimir Kozlov
Linköping University, Sweden

The nonlinear problem of two-dimensional, steady, gravity waves on water of finite depth is considered. One of the main results to be presented is the following theorem. Let a steady wave have the free-surface profile of a sufficiently small height, then the slope of this wave is also small. There is an important consequence of this assertion when it is combined with the following theorem proved by V. Kozlov and N. Kuznetsov. All steady waves corresponding to near-critical values of Bernoullis constant have sufficiently small heights. Moreover, wave slopes are also small provided they are bounded a priori; the smallness of a slope depends on this bound and on how close Bernoullis constant is to the critical value. The above result shows that the assumption about a priori boundedness of slopes is superfluous in the latter theorem. Hence its improved formulation is as follows. If the value of Bernoullis constant is near-critical, then all corresponding waves have sufficiently small heights and slopes. This proves, in particular, the BenjaminLighthill conjecture for near-critical values of Bernoullis constant without the assumption that slopes are bounded.The results are obtained in collaboration with N. Kuznetsov (Russian Academy of Sciences, St Petersburg).

Transverse instability of line solitary waves

Frédéric Rousset
Université de Rennes 1, France

For the water-waves equation with large surface tension, we study the instability of line solitary waves when submitted to general perturbations.

Exact theory on asymptotic linear stability of solitary gravity waves

Shu-Ming Sun
Virginia Polytechnic Institute and State University, USA

The recent result on the stability of two-dimensional solitary waves on water of finite depth will be discussed. It is assumed that the fluid is bounded by a free surface and a rigid horizontal bottom and a solitary wave is moving under the gravity (here ignoring surface tension). It was well known that the exact governing equations (or called the Euler equations) have a solitary-wave solution. In this talk, it will be shown that the linear operator, which is obtained by linearizing the Euler equations around the solitary-wave solution, has no spectrum points on the right half of the complex plane. Moreover, the solutions of the linearized Euler equations decay at an exponential rate in an energy norm with an exponential weight, under the condition that the solutions have no components in a two-dimensional neutral-mode space arising from the solitary waves.

Surface waves on steady perfect-fluid flows with vorticity

John Toland
University of Bath, UK

This is about a theory of two-dimensional steady periodic surface waves on flows under gravity in which the given data are three quantities that are independent of time in the corresponding evolution problem: the volume of fluid per period, the circulation per period on the free stream line and the rearrangement class (equivalently the distribution function) of the vorticity field. A minimizer of the total energy per period among flows satisfying these constraints is shown to be a weak solution of the surface wave problem for which the vorticity is a decreasing function of the stream function. This decreasing function can be thought of as an infinite-dimensional Lagrange multiplier corresponding to the vorticity rearrangement class being specified in the minimization problem. (Note that functional dependence of vorticity on the stream function was not specified *a priori* but is part of the solution to the problem and ensures the flow is steady.) The theory applies equally to irrotational flows and to flows with locally square-integrable vorticity.

Existence of steady free-surface waves with corners of 120 degrees at their crests in the presence of vorticity

Eugen Varvaruca
University of Reading, UK

We present some recent results on singular solutions of the problem of travelling gravity surface water waves on flows with vorticity. It has been known since the work of Constantin and Strauss (2004) that there exist spatially periodic waves of large amplitude for any vorticity distribution. We show that, for any nonpositive vorticity distribution, a sequence of large-amplitude regular waves converges in a weak sense to an extreme wave with stagnation points at its crests. The proof is based on new a priori estimates, obtained by means of the maximum principle, for the fluid velocity and the wave height along the family of regular waves whose existence was proved by Constantin and Strauss. We also show, by new geometric methods, that this extreme wave, which is symmetric and monotone between crests and troughs, has corners of 120 degrees at its crests, as conjectured by Stokes in 1880.

Regularity of two dimensional steady capillary gravity water waves

Guanghui Zhang
Universität Düsseldorf, Germany

We prove that suitable weak solutions of the two-dimensional steady capillary gravity water wave problem (with vorticity and without vorticity) are smooth. On a technical level, solutions are closely related to critical points of the Mumford-Shah functional, so that our main task is to exclude cusps pointing into the water phase. We prove that cusps do not exist, and that the free surface is smooth.

Equadiff 2011

Contributed talks

Integrability of polynomial fields in the plane by means of Picard-Vessiot rheory: statements and examples

Primitivo Acosta-Humanez
Universidad del Norte, Colombia

In this talk we study the integrability of polynomial vector fields using Galois theory of linear differential equations when the associated foliations is reduced to a Riccati type foliation. In particular we obtain integrability results for some families of quadratic vector fields, Liénard equations and equations related with special functions such as hypergeometric and Heun ones. We also study the Poincaré problem for some of the families.

Energy preserving methods for nonlinear Schrödinger equations

Canan Akkoyunlu
Istanbul Kultur University, Turkey

The energy preserving method, average field integrator (AVI) is applied to the single and coupled nonlinear Schrödinger (NLS) equations with soltion and with travelling wave solutions. The NLS is discretized in space by using finite differences under preservation of the symplectic structure. Application of the AVI to the single and coupled NLS equations shows the excellent preservation of the Hamiltonians and other integrals in long time integration. Numerical solutions are compared with those obtained by symplectic and multisymplectic methods. Numerical dispersion behavior of AVI for the NLS equation is analyzed and the Fermi-Pasta-Ulam recurrence of the wave packets is investigated.

Analysis of a dengue disease transmission model with delay

Eric Avila
Universidad Autonoma de Yucatan, Mexico

We study the effect of time delay on the transmission of a dengue fever model. The delay represents the incubation time that mosquitoes need to become infectious. The incidence term for human population is saturated while for vectors is bilinear. The model shows that equilibria is determined by the basic reproduction number. We give conditions under which our model exhibits a Hopf bifurcation so that periodic solutions arise. We illustrate our findings with simulations for different parameter settings.

Semilinear differential inclusions without compactness

Irene Benedetti
University of Perugia, Italy

The talk deals with the study of the following semilinear differential inclusion

$$\begin{aligned} &x'(t) \in A(t)x(t) + F(t, x(t)), \quad \text{for a.a. } t \in [a, b], \\ &Lx = M(x) \end{aligned}$$

in a reflexive Banach space E. We assume that $\{A(t)\}_{t\in[a,b]}$ is a family of linear not necessarily bounded operators with $A(t) : D(A) \subset E \to E$, $D(A)$ is dense in E, generating an evolution operator. We consider the nonlinear term F measurable in t and upper semicontinuous in x with respect to the weak topology of E. Moreover we assume that $L : C([a,b];E) \to E$ and $M : C([a,b];E) \to E$ are two operators, respectively linear and sublinear, both continuous with respect of the weak topology of $C([a,b];E)$.

We stress the fact that the above boundary condition is very general and includes the initial valued problem, the periodic and antiperiodic problem, the Floquet problem, and non local initial conditions. The proposed results are based on classical fixed point theorems. The main novelty of this work consists in the use of weak topology. In fact, this allow to avoid any compactness condition. In addition some applications to partial differential equations will be presented.

From applications point of view there are some interesting examples with nonlinear terms that are upper semicontinuous from E to E_w, where E_w denotes the space E endowed with weak topology. In order to solve this type of problems, we will show some original fixed point theorems based on a midpoint convexity type condition.

Local strong solutions to non-stationary channel flows of heat-conducting viscous incompressible fluids

Michal Benes
CTU in Prague, Czech Republic

We study an initial-boundary-value problem for time-dependent flows of heat-conducting viscous incompressible fluids in channel-like domains on a time interval $(0,T)$. For the parabolic system including the artificial (the so called "do nothing") boundary conditions, we prove the local in time existence, global uniqueness and smoothness of the solution on a time interval $(0,T^*)$, where $0 < T^* \leq T$.

Symmetry and synchronization in models of antigenic variation

Konstantin Blyuss
University of Sussex, UK

In this talk I will discuss the dynamics of interactions between antigenic variants and the human immune system during immune escape. Using the methods of equivariant bifurcation theory, I will show on the example of a model of antigenic variation in malaria the effects of symmetry on possible dynamical regimes and (de)synchronization of antigenic variants. The results of the analysis are quite generic, and I will also discuss their wider applications to the studies of multi-strain diseases.

Evolutionary PDE's in perfectly plastic fluid theory

Dominic Breit
University of Oxford, UK

The non-stationary slow motion of a homogeneous fluid is described by the equations of motions

$$-\partial_t u + \operatorname{div} \sigma = \nabla \pi - f$$

on the parabolic cylinder $Q = (0,T) \times \Omega$ where $\Omega \subset \mathbb{R}^d$ with $d = 2,3$ and $T > 0$. Here $u : Q \to \mathbb{R}^d$ is the velocity field, $\sigma : Q \to \mathbb{R}^{d\times d}_{sym}$ the extra stress, $\pi : Q \to \mathbb{R}$ the pressure and $f : Q \to \mathbb{R}^d$ an external volume force. We consider the constitutive relation

$$\varepsilon(u) = 0 \quad \Rightarrow \quad |\sigma| \leq g, \qquad \varepsilon(u) \neq 0 \quad \Rightarrow \quad \sigma = \frac{g}{|\varepsilon(u)|}\varepsilon(u)$$

where $\varepsilon(u) = 1/2(\nabla u + \nabla u^T)$. Incompressible flows whose constitutive law is given by this equation are called perfectly plastic fluids (or von Mises solids) with yield value $g > 0$. We prove the existence of a weak solution $(u, \sigma) \in L^1(0,T; \mathrm{BD}(\Omega)) \times L^\infty(Q, \mathbb{R}^{d\times d}_{sym})$ where the constitutive relation is to be understood in a measure theoretic fashion (BD denotes the space of L^1-functions whose symmetric gradient is a bounded Radon measure).

Periodic solutions of neural network models

Inese Bula
University of Latvia, Latvia

The delay differential equation

$$x'(t) = -f(x(t-\tau))$$

is used as the model for a single neuron with no internal decay, where $f : \mathbb{R} \to \mathbb{R}$ is either the sigmoid or a piecewise linear signal function and $\tau \geq 0$ is the synaptic transmission delay. We consider model a single neuron with no internal decay by $x'(t) = -f(x([t]))$, where $[t]$ denotes the greatest integer function. To study this equation we consider the corresponding difference equation

$$x_{n+1} = x_n - f(x_n), x_{n+1} = \beta x_n - f(x_n). \tag{1}$$

These equations arises as a discrete-time network of single neuron and in second case β is the internal decay rate. We assume that signal function f is of McCulloch-Pitts non-linearity or certain types of sigmoid function. We discuss about periodicity of solutions of difference equations (1).

On the solution set of a class of fractional differential inclusions

Aurelian Cernea
University of Bucharest, Romania

We consider the following Cauchy problem associated to a fractional differential inclusion

$$D_c^{\alpha}x(t) \in F(t, x(t)) \quad \text{a.e. } ([0,T]), \quad x(0) = x_0, \quad x'(0) = x_1, \tag{1}$$

where $\alpha \in (1,2]$, D_c^{α} is the Caputo fractional derivative, $F : [0,T] \times \mathbf{R} \to \mathcal{P}(\mathbf{R})$ is a set-valued map and $x_0, x_1 \in \mathbf{R}$, $x_0, x_1 \neq 0$.

We establish several topological properties of the solution set of problem (1). First, we prove the arcwise connectedness of the solution set of problem (1) when the set-valued map F has nonconvex values and is Lipschitz in the second variable. Then, under such type of hypotheses on the set-valued map, we prove that the set of selections of the set-valued map F that correspond to the solutions of problem (1) is a retract of $L^1([0,T], \mathbf{R})$. Afterwards the last result is extended to problems defined on unbouded intervals.

All the results are essentially based on Bressan and Colombo results concerning the existence of continuous selections of lower semicontinuous multifunctions with decomposable values.

Family of Julia sets as orbits of differential equations

Yi-Chiuan Chen
Academia Sinica, Taiwan

The Julia set of the quadratic map $f_\mu(z) = \mu z(1-z)$ for μ not belonging to the Mandelbrot set is hyperbolic, thus a continuous curve in the exterior of the Mandelbrot set induces a continuous family of Julia sets. The focus of this talk is to present that this family can be obtained explicitly by solving the initial value problem of a system of infinitely coupled differential equations. A key point is that the required initial values can be obtained from the anti-integrable limit $\mu \to \infty$. We conduct numerical approximations to the Julia sets when parameter μ is located at the Misiurewicz points with external angle $1/2$, $1/6$, or $5/12$. When μ is at the Misiurewicz point of angle $1/128$, a 98-period orbit of prescribed itinerary is presented, without having to find a root of a 2^{98}-degree polynomial.

The probabilistic method and large initial conditions for the Navier-Stokes equation

Jean Cortissoz
Universidad de los Andes, Colombia

It is still unknown if given an initial data in $L^2(\mathbb{R}^3)$ with nice enough decay properties generate a global regular solution to the Navier-Stokes equation. So far, the best known results for existence of global regular solutions for the Navier-Stokes equation have been proved for small initial data in certain critical spaces as $L^3(\mathbb{R}^3)$ and certain homogeneous Besov spaces $B_{p,\infty}^{-1+\frac{3}{p}}(\mathbb{R}^3)$. Recently, Chemin, Gallagher and Paicu have constructed families of examples of large initial data in the homogeneous Besov space $B^{-1}_{\infty,\infty}(\mathbb{R}^3)$ for which the Navier-Stokes equation generates a global regular solution (since all critical spaces for the Navier-Stokes equation are continuously embedded in this space, their results cannot be a consequence of a small initial data implies global regular solution theorem, so the initial data constructed by Gallagher, Chemin and Paicu are truly large initial conditions). In this talk, we will introduce probabilistic and combinatorial methods (slightly related to the methods employed by Burq and Tzvetkov in the context of the supercritical wave equation), to produce large initial conditions in certain critical spaces with arbitrarily large initial kinetic energy (we expect that the examples thus produced are also large in $B^{-1}_{\infty,\infty}(\mathbb{R}^3)$). We also hope that the results presented in this talk will be a first step towards showing that generic data with finite kinetic energy generate global regular solutions to the Navier-Stokes equation.

On the (n,k)-stacked central configurations.

Antonio Carlos Fernandes
Universidade Federal de Itajub, Brazil

In this presentation we shall talk about the (n,k)-stacked central configurations in the n-body problem.

Consider a configuration of n bodies, with positions $r(1)$, $r(2)$, ..., $r(n)$ in an euclidean space and masses $m(1)$, $m(2)$, $\ldots m(n)$, respectively. Such configuration is called (n,k)-stacked central configuration, iff "The n bodies form a central configuration and there exist a proper subset with $(n-k)$ bodies, which also form a central configuration."

This type of question was posed firstly by Hampton. In his work Hampton has provided an example of $(5,2)$ - stacked planar central configuration. In which, three bodies are posed at the vertices of an equilateral triangle and the other two bodies are posed in the interior of this triangle, symmetrically with respect to one mediatrix. Under some hypothesis, these five bodies form a central configuration, with an interesting particularity: the three bodies at the vertices of an equilateral triangle always form a central configuration.

Another example has found by Mello and Llibre. Mello and Llibre has consider a $(5,2)$-stacked central configurations too. But, they consider three bodies at the vertices of an equilateral triangle and two bodies posed on a straight line that contains one mediatrix of the triangle. Again, with appropriate hypothesis this five bodies form a central configuration, which is in particular a $(5,2)$-stacked planar central configuration.

Recently, Hampton and Santoprete have provided a new example of (7,3)-stacked central configuration. They consider four bodies at the vertices of a regular tetrahedron and three bodies are posed in the interior of the tetrahedron at the vertices of an equilateral triangle parallel to one basis of the tetrahedron. Under appropriate hypothesis this seven bodies form a central configuration, which is in particular a (7,3)-stacked central configuration since that four bodies at the vertices of a regular tetrahedron always form a central configuration.

Our result is an extension of the result due to Hampton and Santoprete, cited above. We also consider four bodies at the vertices of a regular tetrahedron and three bodies at the vertices of an equilateral triangle parallel to one basis of the tetrahedron, however for our case the triangle belongs to the exterior of the tetrahedron. We prove that this type of (7,3)-stacked central configurations are obtained.

Shall also talking about the case of $(n,1)$-stacked central configurations, shortly. The $(n,1)$-stacked central configurations has a peculiarity, they not depend on the value of one mass (specifically they do not depend on the mass of the body to be removed in order to become a central configuration with $(n-1)$ bodies). We give some sufficient conditions for this situation happens.

Global bifurcation analysis of planar neural dynamical systems

Valery Gaiko
National Academy of Sciences, Belarus

We consider two planar cubic dynamical systems which are used for neural modeling. First, we study the classical FitzHugh-Nagumo planar cubic dynamical system which models the spike dynamics in biological neurons. Such a cubic model was studied earlier. However, the qualitative analysis carried out was incomplete, since the global bifurcations of multiple limit cycles could not be studied properly by means of the methods and techniques which were used earlier in the qualitative theory of dynamical systems. Applying the Wintner-Perko termination principle for multiple limit cycles and new geometric methods of global bifurcation theory, we prove that the FitzHugh-Nagumo model can have at most two limit cycles. Then, we carry out the global bifurcation analysis of a higher-dimensional polynomial dynamical system as a learning model of neural networks (the Oja model). Learning models are algorithms, implementable as neural networks, that aim to mimic an adaptive procedure. A neural network is a device consisting on interconnected processing units, designated neurons. An input presented to the network is translated as a numerical assignment to each neuron. This will create a sequence of internal adjustments leading to a learning process. For two input neurons, e.g., the model can be written as a planar cubic centrally symmetric dynamical system. Applying to this system the Wintner-Perko termination principle and our bifurcationally geometric methods, we prove that the planar Oja neural network model has a unique limit cycle.

Reversible periodic orbits in piecewise linear systems

Elisabeth Garcia-Medina
Universidad de Sevilla, Spain

We focus on periodic orbits of the piecewise linear system

$$\dot{x} = y, \quad \dot{y} = z, \quad \dot{z} = 1 - y - \lambda(1+\lambda^2)|x|, \tag{1}$$

where $\lambda > 0$. This system can be considered as a continuous piecewise linear version of the well-known Michelson system [5]. Both systems are volume preserving and time reversible with respect to the involution $\mathbf{R}(x, y, z) = (-x, y - z)$. Some other dynamical aspects of the Michelson system also remain in this piecewise linear version.

We study the reversible periodic orbits which have two intersection points with the separation plane $\{x = 0\}$. These orbits organize the most interesting periodic behaviour of system (1) and will be denoted by RP2. The main result is the following theorem: There exist two values $0 < \lambda_C < \lambda_F$ such that the following statements hold:

1. If $\lambda \in (0, \lambda_C)$ system (1) has a unique RP2-orbit whose period is less than 4π.
2. For $\lambda = \lambda_C$ system (1) has exactly two RP2-orbits with periods less than 4π. Moreover, those periods are different and the corresponding RP2-orbit of longer period crosses tangentially the plane $\{x = 0\}$.
3. If $\lambda \in (\lambda_C, \lambda_F)$ system (1) has exactly two RP2-orbits with periods less than 4π. Moreover, those periods are different.
4. For $\lambda = \lambda_F$ system (1) has a unique RP2-orbit whose period is less than 4π.
5. If $\lambda > \lambda_F$ system (1) does not have any RP2-orbits with period less than 4π.

We also analyze the bifurcations of these RP2-orbits and show that the RP2-orbit which crosses tangentially the plane $\{x = 0\}$ generates a curve of reversible periodic orbits which have exactly four intersection points with the separation plane. The complete bifurcation diagram (known as *noose* bifurcation) coincides with Michelson system's one.

Nonexistence of positive supersolutions for nonlinear elliptic equations in $\mathbb{R}^N$

Jorge Garcia Melian
University of La Laguna, Spain

We analyze the question of nonexistence of positive supersolutions in exterior domains of $\mathbb{R}^N$ of the elliptic problem $-\Delta u + |\nabla u|^q = f(u)$, where f is a continuous positive function which verifies $f(t) \geq Ct^p$ for some $p > 0$ for small positive t. The nonexistence depends on some relations between the values of p, q and N. Our results are optimal.

Asymptotic bifurcation for the asymptotically linear NLS

Francois Genoud
Heriot-Watt University, UK

This talk is about a (stationary) nonlinear Schrödinger equation arising in the physics of nonlinear waveguides. The nonlinearity is asymptotically linear, describing the saturation of the refractive index at high power. Due to the unboundedness of the domain, it is not possible to use standard bifurcation theory and more sophisticated degree theory is required.

Conservation laws in the nonlinear Schrödinger equations

Marisela Guzmán-Gómez
Universidad Autónoma Metropolitana, Mexico

In this talk we study the behaviour of solutions of Nonlinear Schrödinger equations (NLS) through the three main conservation laws. Important interst is devoted to the Zakharov system as an example of a system with less conservation laws; eventhough global solutions and existence of blow up of solutions is stablished if the system is studied as NLS equation.

Non-existence of one-signed solutions of evolutionary differential equations

Leopold Herrmann
Czech Technical University in Prague, Czech Republic

A class of partial differential equations of evolution (stemming from the groundwater flow problems) depending on a parameter τ is studied. The existence of an open interval $\mathcal{T}$ of parameters τ is proved with the property that for any compact subinterval $T \subset \mathcal{T}$ there exists a constant $\Theta(T) > 0$ such that for any $\tau \in T$ all non-zero global solutions $u\colon \mathbb{R}^+ \times \Omega \to \mathbb{R}$ of the equation cannot remain non-negative (non-positive) throughout the set $J \times \Omega$, where $J \subset \mathbb{R}^+$ is the interval the length of which is greater than $\Theta(T)$.

Interacting global manifolds in a 2D noninvertible map model of wild chaos

Stefanie Hittmeyer
University of Bristol, UK

We study a noninvertible planar map that has been suggested by Bamon, Kiwi and Rivera as a model for a new type of chaotic dynamics in continuous-time dynamical systems of dimension at least five; one also speaks of wild Lorenz-like chaos. This map opens up the origin (the critical point) to an open disk and wraps the plane twice around it; inside this disk there are no preimages. The bounding critical circle and its images, together with the critical point and its preimages form the so-called critical set. This set interacts with a saddle fixed point and its stable and unstable sets.

Advanced numerical techniques enable us to study how the stable and unstable sets change as a parameter is varied along a path towards the chaotic regime. We find sequences of bifurcations, which are of two types. First, there are bifurcations that also occur in invertible maps, such as homoclinic tangencies. Second, we find bifurcations specific to nonivertible maps: interactions of the stable and unstable manifolds with the critical set, which also cause changes (such as self-intersections) of the topology of these global invariant sets. Overall, a consistent sequence of both types of bifurcations emerges, which we present as a first attempt towards explaining the geometric nature of wild chaos.

Stability of large- and small-amplitude solitary waves in the generalized KdV and Euler-Korteweg / Boussinesq equations

Johannes Höwing
Universität Konstanz, Germany

We show that solitary waves for the generalized Korteweg-de Vries equation and for the generalized Boussinesq equation (the $p-$system endowed with capillarity) are stable if the flux function p satisfies

$$p'' > 0 \qquad \text{and} \qquad p''' \leq 0.$$

While $p'' > 0$ alone suffices for the stability of waves of sufficiently small amplitude, obvious examples show that $p''' \leq 0$ cannot be omitted in the general case. In particular, the generalized Boussinesq equation with $p(v) = kv^{-\gamma}$ $\text{with}\gamma \geq 1$, $k > 0$ describes the flow of an inviscid isothermal ideal (barotropic) fluid with capillarity. In this talk, we present the following new stability results:

Theorem 1 Consider the generalized Korteweg-de Vries (gKdV) equation with a smooth function p satisfying $p'' > 0$ and $p''' \leq 0$. Then any solitary wave is stable.

Theorem 2 Consider the generalized Boussinesq equation with $p : \mathbb{R} \to \mathbb{R}$ or $p : (0, \infty) \to \mathbb{R}$ satisfying $p' < 0$, $p'' > 0$ and $p''' \leq 0$. Then any solitary wave is stable.

These results complement the findings of Bona, Souganidis and Strauss (1987) and Bona and Sachs (1988), respectively; the only overlap of Theorems 1 and 2 with those consisting exactly of the quadratic nonlinearity $p''' \equiv 0$. Note, however, that Theorems 1 and 2 are not restricted to pure power laws.

Comparing different ODE modelling approaches for gene regulatory networks

John Hogan
University of Bristol, UK

A fundamental step in synthetic biology and systems biology is to derive appropriate mathematical models for the purposes of analysis and design. For example, to synthesize a gene regulatory network, the derivation of a mathematical model is important in order to carry out in silico investigations of the network dynamics and to investigate parameter variations and robustness issues. Different mathematical frameworks have been proposed to derive such models. In particular, the use of sets of nonlinear ordinary differential equations has been proposed to model the dynamics of the concentrations of mRNAs and proteins. These models are usually characterized by the presence of highly nonlinear Hill function terms. A typical simplification is to reduce the number of equations by means of a steady-state assumption on the mRNA concentrations. This yields a class of simplified ODE models. A radically different approach is to replace the Hill functions by piecewise-linear approximations. Recently, a further modelling approach has been proposed: discrete-time maps where the evolution of the system is modelled in discrete, rather than continuous, time. The aim of this talk is to discuss and compare these different modelling approaches, using a representative gene regulatory network. We will show that different models often lead to conflicting conclusions concerning the existence and stability of equilibria and stable oscillatory behaviours. Moreover, we shall discuss, where possible, the viability of making certain modelling approximations (e.g. steady-state mRNA dynamics or piecewise-linear approximations of Hill functions) and their effects on the overall system dynamics.

On the collapsing behaviour of the logarithmic diffusion equation

Kin Ming Hui
Institute of Mathematics, Academia Sinica, Taiwan

Let $0 \leq u_0(x) \in L^1(R^2) \cap L^\infty(R^2)$ be such that $u_0(x) = u_0(|x|)$ for all $|x| \geq r_1$ and is monotone decreasing for all $|x| \geq r_1$ for some constant $r_1 > 0$. Then under some mild decay conditions at infinity on the initial value u_0 we will extend the result of P.Daskalopoulos, M.A.del Pino and N.Sesum and prove the collapsing behaviour of the maximal solution of the logarithmic diffusion equation in $\mathbb{R}^2 \times (0,T)$, $u(x,0) = u_0(x)$ in $\mathbb{R}^2$, near its extinction time T without using the Hamilton-Yau Harnack inequality.

Heteroclinic cycles unfolded by nilpotent singularities.

Santiago Ibáñez
University of Oviedo, Spain

We study the existence of heteroclinic cycles in generic unfoldings of nilpotent singularities. Namely, we prove that any nilpotent singularity of codimension four in $\mathbb{R}^4$ unfolds generically a bifurcation hypersurface of bifocal homoclinic orbits, that is, homoclinic orbits to equilibrium points with two pairs of complex eigenvalues. We also prove that any nilpotent singularity of codimension three in $\mathbb{R}^3$ unfolds generically a bifurcation curve of heteroclinic cycles between two saddle-focus equilibrium points with different stability indexes. Under generic assumptions these cycles imply the existence of homoclinic bifurcations. Homoclinic orbits to equilibrium points with complex eigenvalues are the simplest configurations which can explain the existence of complex dynamics. Therefore, since singularities are easily detectable objects in a given family, our results should be useful in applications.

A filtering problem for SDE's associated with parameterized backward parabolic equations

Daniela Ijacu
Bucharest Academy of Economic Studies, Romania

We study a filtering problem for non Markovian SDE's where the drift vector fields comute with diffusion vector fields. The evolution of the conditioned mean value will be described using a backward parabolic equation with parameters.

Existence of non-radial positive solutions for the generalized Hénon equation

Ryuji Kajikiya
Saga University, Japan

We study the existence of non-radial positive solutions of the generalized Hénon equation

$$-\Delta u = h(|x|)u^p, \quad u > 0 \quad \text{in } B, \qquad u = 0, \quad \text{on } \partial B,$$

where B is a unit ball of $\mathbb{R}^N$ with $N \geq 2$, $h \in L^\infty(B)$, $h(|x|)$ is radially symmetric, nonnegative, nontrivial and $1 < p < \infty$ if $N = 2$ and $1 < p < (N+2)/(N-2)$ if $N \geq 3$. We define the Rayleigh quotient

$$R(u) := \left(\int_B |\nabla u|^2 dx \right) \left(\int_B h(|x|)|u|^{p+1} dx \right)^{-2/(p+1)}.$$

A solution u is called a least energy solution if it minimizes $R(u)$ among nontrivial solutions.

Theorem 1. *If the ratio of the the density of $h(|x|)$ in $|x| < a$ to that in $a < |x| < 1$ is small enough and a is sufficiently close to 1, then a least energy solution is not radially symmetric. Therefore there exist at least two positive solutions: one is a radial solution and another is a non-radial least energy solution.*

Corollary 2. *Put $h(r) = g(r)^\lambda$ with $r = |x|$, where $g \in C[0,1]$ and $0 \leq g(r) < g(1)$ for $r < 1$. If $\lambda > 0$ is large enough, then a least energy solution is not radially symmetric.*

Example 1. The above corollary covers a wide class of $h(|x|)$, e.g., $h(|x|) = |x|^\lambda$, which is the original Hénon equation, and $h(|x|) = e^{\lambda|x|}$, $(|x|/(1+|x|))^\lambda$ and $|\sin(\pi|x|/2)|^\lambda$, etc. For such an $h(|x|)$ with $\lambda > 0$ large enough, a least energy solution is not radially symmetric.

Theorem 2. *Put $h(r) = g(r)^\lambda$, where $g \in L^\infty(0,1)$ and $g(r) > 0$ almost everywhere in $(0,1)$. If $\lambda > 0$ is small enough, then a least energy solution is radially symmetric. Moreover, if $g \in C[0,1]$, $g(r) \geq c > 0$ with a constant $c > 0$ and if $\lambda > 0$ is small enough, then a positive solution is unique and it is radially symmetric.*

Stationary solutions and connecting orbits for nonlinear parabolic differential equations at resonance

Piotr Kokocki
Nicolaus Copernicus University, Poland

For an open bounded set $\Omega \subset R^n$ with the boundary $\partial\Omega$ of class C^∞, we study the nonlinear parabolic partial differential equations of the form

$$\begin{aligned} &u_t(t,x) = -\mathcal{A}(x,D)\,u(t,x) + \lambda\, u(t,x) + f(x, u(t,x), \nabla u(t,x)), \qquad t > 0,\ x \in \Omega, \\ &\mathcal{B}(x,D)\,u(t,x) = 0, \qquad t \geq 0,\ x \in \partial\Omega \end{aligned}$$

where λ is a real number, $\mathcal{A}(x,D)$ is a uniformly elliptic differential operator of degree $2m$, $m \geq 1$, with a set of boundary operators $\mathcal{B}(x,D) := \{\mathcal{B}_j(x,D)\}_{j=1}^m$ and $f\colon \Omega \times \mathbb{R} \times \mathbb{R}^n \to \mathbb{R}$

is a mapping of class C^1. We consider the case when the equation is at resonance, i.e., λ is an eigenvalue of $(\mathcal{A}(x,D),\mathcal{B}(x,D))$ and f is bounded. Imposing appropriate Landesman–Lazer type conditions we use the infinite dimensional extension of Conley index to derive a criterion determining the existence of multiple stationary solutions and trajectories connecting them.

Several options for multiscale methods for bacterial chemotaxis with internal dynamics

Annelies Lejon
Katholieke Universiteit Leuven, Belgium

We study velocity-jump processes for bacterial chemotaxis with internal dynamics. The goal is to examine the difference with respect to a simpler kinetic description as the particle velocity approaches zero. We report on initial efforts to construct an asymptotic-preserving scheme, based on the framework of equation free methods. We study (coarse) projective integration. Several options for restriction, lifting and extrapolation have been explored, and point out where additional research is needed.

Multiple positive solutions of semilinear elliptic equations involving concave and convex nonlinearities in $\mathbb{R}^N$

Huei-li Lin
Chang Gung University, Taiwan

For $N \geq 3$ and $2 < p < 2^* = 2N/(N-2)$, we consider the multiplicity of positive solutions of the semilinear elliptic equations

$$\begin{cases} -\Delta u + u = a(z)u^{p-1} + \lambda h(z)u^{q-1} \text{ in } \mathbb{R}^N; \\ u \in H^1\left(\mathbb{R}^N\right), \end{cases} \tag{1}$$

where $\lambda > 0$. Let $a \in C\left(\mathbb{R}^N\right)$, $a > 0$ and $h \in L^{\frac{p}{p-q}}\left(\mathbb{R}^N\right) \cap L^\infty(\mathbb{R}^N)$, $h \gneqq 0$.

It is well-known that Equation (1) admits infinitely many solutions in a bounded domain. Because of the lack of compactness, it is difficult to deal with this problem in an unbounded domain.

In this paper, we investigate how the shape of the graph of $a(z)$ affects the number of positive solutions of Equation (1) in $\mathbb{R}^N$. We use the argument of Tarantello to divide the Nehari manifold $\mathbf{M}_\lambda(\mathbf{M}_\lambda$ contains all nonzero solutions of Equation(1)) into the two parts $\mathbf{M}_\lambda^+$ and $\mathbf{M}_\lambda^-$ for sufficiently small λ. If a satisfies the suitable conditions, we study the idea of category and Bahri-Li minimax method to get the results of multiple solutions.

Diffusion equations subject to concave-convex absorption

José Sabina de Lis
University of La Laguna, Spain

In this talk we consider a class of reaction–diffusion equations $\Delta u = f(u)$ in a spatial domain Ω, complemented with the flux type boundary condition $\partial u/\partial \nu = \lambda u$, where ν is the outward unit field on $\partial\Omega$. As the main feature, nonlinearity f representing absorption, combines the simultaneous presence of concave and convex terms. On the other hand, flux intensity λ has the status of bifurcation parameter.

We present recent results concerning existence, uniqueness and multiplicity of positive solutions, together with dead–core formation and asymptotic profiles as λ becomes large. Thus, this study is a continuation of previous works where the effect of a convex or a concave absorption was separately analyzed.

Existence of positive solutions for a nonlinear second-order m-point boundary value problem

Rodica Luca-Tudorache
Technical University of Iasi, Romania

We investigate the existence of positive solutions with respect to a cone for the second-order nonlinear differential system

$$(S) \qquad \begin{cases} u''(t) + \lambda c(t) f(u(t), v(t)) = 0, & t \in (0, T), \\ v''(t) + \mu d(t) g(u(t), v(t)) = 0, & t \in (0, T), \end{cases}$$

with the m-point boundary conditions

$$(BC) \qquad \begin{cases} \alpha u(0) - \beta u'(0) = 0, \;\; u(T) = \displaystyle\sum_{i=1}^{m-2} a_i u(\xi_i), \;\; m \geq 3, \\ \gamma v(0) - \delta v'(0) = 0, \;\; v(T) = \displaystyle\sum_{i=1}^{n-2} b_i v(\eta_i), \;\; n \geq 3. \end{cases}$$

The proofs of our results are based on the Krasnoselskii fixed point theorem and on a vector version of this theorem.

Local minimizers of average distance functional in dynamic minimizing movement problem: regularity and topology changing.

XinYang Lu
Scuola Normale Superiore, Italy

Our focus is on the geometrical and analytical properties of the locally optimal sets during an evolution, and our main goal is to analyze their regularity and topology, in particular whether and when they will change topology.

Let be Ω in $\mathbb{R}^2$ a locally convex domain, a Hausdorff one-dimensional subset $\Sigma \subset \Omega$, and 2 functionals: an "energy" F, and a "dissipation" D, and consider the following minimizing movement problem

$$\begin{cases} \Sigma_0 & \text{(initial datum)} \\ \Sigma_n \in \operatorname{argmin}_{\Sigma_{n-1} \subset \Sigma'} F(\Sigma') + D(\Sigma_{n-1}, \Sigma'). \end{cases}$$

Letting the incremental length go to 0 we have the continuous (rate-independent) case, in which the evolution is "continuous". We will investigate the case F having the form

$$\int_\Omega \phi(\mathrm{dist}(x, \Sigma))\mathrm{d}x$$

with ϕ satysfing certain properties.

First, we will estimate the speed of this evolution. Then, with direct estimates on the "branching time" (time t in the evolution at which the minimizing set Σ_t changes topology) upperbounds, we will show that very similar initial data can lead to totally different behaviors, and we will show that significant difference exists even as the dissipation exponent is above or below 3/2, as for the first case the evolution countinues for any time, but for the second case the configuration may reach a stable equilibrium from which every further evolution is not permitted. Finally, we analyze the regularity during the rate-independent evolution, i.e. if and when the tangent vector varies with regularity, showing that in general very little can be guaranteed even with extremely regular domain and initial data.

A one-dimensional optimal design problem: numerical analysis

Manuel Luna-Laynez
University of Seville, Spain

It is known that optimal design problems for two phase materials have no solution in general and to guarantee the existence it is necessary to introduce relaxations. Hence, for the numerical approximation of these problems, we can consider discretized versions of the original problems or of the relaxed ones. In this work we are interested in studying and comparing both approaches in the one-dimensional setting. We prove the convergence of both discretizations and obtain convergence rates. Our results show a faster convergence with a lower computational cost for the discretization based on the relaxations. In particular it is worth emphasizing that, even when the original problem has a solution and the relaxation is not necessary, the algorithms converge faster when they are implemented on the relaxed version.

Systems of partial differential inclusions under constraints

Mateusz Maciejewski
Nicolaus Copernicus University, Poland

The existence of solutions of vector partial differential inclusions under constraints will be established. Topological approach will be presented. The theorem will be applied to show the existence of positive solutions of systems of elliptic PDEs with noncontinuous right-hand side.

Homogenization of the wave equation with non-smooth coefficients in time

Faustino Maestre
Universidad de Sevilla, Spain

In this talk we present a recent result about the homogenization of the wave equation. We can find in the literature some classical results for the homogenization for hyperbolic system with coefficients which do not depend on the time variable or assuming Lipschitz-continuity in time. We analize the case for discontinuous coefficients, we generalize the classical results assuming BV coefficients in the time variable. Finally we show a result of corrector for strong convergence.

Maximum principle results for higher order PDE's

Anita Mareno
The Pennsylvania State University, USA

We consider a variety of semilinear partial differential equations of order greater than two. We show that functionals defined on the solutions of these equations are subharmonic and deduce maximum prinicple results for such equations. Then various apriori bounds are deduced.

Reversible stochastic flows associated with nonlinear SPDE's

Marinela Marinescu
Bucharest Academy of Economic Studies, Romania

In this paper we study the reversibility of a stochastic flow based its integral representation when the difusion vector field commutes with drift vector fields. The unique solution satisfies a nonlinear SPDE.

Generalized synchronization of non-autonomous coupled oscillators

Rogério Martins
FCTUNL-Lisbon, Portugal

We consider the problem of proving generalized synchronization of a system of not necessarily identical oscillators. We give a method for proving the existence of certain type of invariant manifolds (synchronization manifolds) that attracts all the bounded orbits of a system of coupled oscillators. This method is based in some results developed by R. Smith and gives a practical way to compute estimations on the parameters for which generalized synchronization occurs.

Several examples of application with several kinds of coupling schemes will be presented.

Strong solutions of doubly nonlinear parabolic equations

Aleo Matas
West Bohemia University, Czech Republic

The aim of the talk is to discuss strong solutions of doubly nonlinear parabolic equations $\frac{\partial Bu}{\partial t} + Au = f$, where $A : X \to X^*$ and $B : Y \to Y^*$ are operators satisfying standard assumptions on boundedness, coercivity and monotonicity. Six different situations are identified which allow to prove the existence of a solution $u \in L^\infty(0, T; X \cap Y)$ to an initial value $u_0 \in X \cap Y$, but only in some of these situations the equation is valid in a stronger space than $(X \cap Y)^*$.

Semicommutative differential operators associated with the Dirac operator and a new formulation of the mKdV hierarchy

Masatomo Matsushima
Doshisha University, Japan

In this paper, we clarify a class of differential operators which are semicommutative with the 1-dimensional Dirac operator L defined by$L = i\sigma_2(\mathrm{d}/\mathrm{d}x) + \sigma_1 v(x)$, where σ_1, σ_2 are Pauli matrices. The differential operators A, B are said to be semicommutative, if the commutator $[A, B] = AB - BA$ is the multiplicative operator.

Similar results are already known for the 1-dimensional Schrödinger operator $H = -(\mathrm{d}/\mathrm{d}x)^2 + u(x)$. In fact, it is known that there exist $2n + 1$ th order differential opetarors A_n such that $Z_n(u) = [H, A]$ are the multiplicative operators by the differential polynomials in $u(x)$. The system of nonlinear ODEs $(\mathrm{d}/\mathrm{d}x)\left(Z_{n+1}(u) + \sum_{j=1}^{n} c_j Z_(u)\right) = 0$ is called the stationary KdV hierarchy.

On the other hand, concered with the Dirac operator, we have the following results. There exist the $(2n + 1)$th order 2×2 matrix differential operators B such that the commutator $K_n\sigma_0 = [L, B]$ are the multipricative operators by diffrential polynomials in v, where σ_0 is the unit matrix. Moreover, the relations$K_n = 1/2(Z_{n+1}(u^-) - Z_{n+1}(u^+))$ hold, where $u^\pm$ are defined by the Miura transformations $u^\pm = \pm v' + v^2$.

The system of the nonlinear ODEs $K_n + \sum_{j=0}^{n-1} c_j K_j = 0$ is the stationary mKdV hierarchy. So our theorem gives new formulation of the stationary mKdV hierarchy.

Well-posedness of non-Lipschitz reaction-diffusion Cauchy problems

John Meyer
University of Birmingham, UK

Reaction-Diffusion systems fall into the class of semi-linear parabolic partial differential equations and occur numerously in mathematical models of physical phenomena ranging from population dynamics to combustion. Throughout the 20th century these systems were largely studied with a condition (often assumed but not explicitly stated) on the reaction functions, namely Lipschitz continuity on any closed bounded interval.

My work has primarily been concerned with the question of well-posedness regarding a model of an auto-catalytic chemical reaction scheme and its various approximation models, which all share the key feature of non-Lipschitz reaction terms.

Asymptotic behaviour of nonlocal reaction-diffusion equations

Maria Anguiano Moreno
Universidad de Sevilla, Spain

Global attractors for nonlocal evolution equations have been investigated recently for the globally modified Navier-Stokes equations by Caraballo et al., for m-Laplacian parabolic equations with a nonlocal nonlinearity by Chen and by Hilhorst et al. for a nonlocal Kuramoto-Sivashinsky equation. Several aspects of reaction-diffusion equations are being analyzed over the last years, particularly, their asymptotic behaviour.

We consider general nonlinear nonlocal terms in autonomous reaction-diffusion equations, which generate strict multivalued semiflows.

In particular, we establish the existence of a global attractor after first proving weak solutions and the compactness of attainability sets of the multivalued semiflow. For this we use estimates obtained as limits of Galerkin approximations which hold for every time instant and not just for almost all time instants.

Finally, we present an explicit example.

Finite element approximation for microstructure formation and evolution

Richard Norton
University of Oxford, UK

A possible model for microstructure formation and evolution is an H1 gradient flow of an energy integral where the energy density is the sum of a double-well potential and a bending energy term. This model can be rewritten as a semilinear parabolic equation with a nonlocal nonlinear source term. Existing finite element approximation theory does not completely cover this situation because our problem is posed in H1 (instead of the more usual L2), our nonlinear term is a nonlocal operator, and we want to know how the error bounds depend on the relative size of the bending energy. We successfully adapt existing finite element approximation theory for all of these difficulties.

On blow-up phenomena for the weakly dissipative Camassa-Holm equation

Emil Novruzov
Hacettepe University, Turkey

The Camassa-Holm equation is a model for wave motion on shallow water which was derived physically by Camassa and Holm by approximating the Hamiltonian for Euler's equation directly in the shallow water regime, where a solution of the equation represents the fluid's free surface above a flat bottom. The equation has bi-Hamiltonian structure and is completely integrable. The talk is devoted to investigation of the weakly dissipative Camassa-Holm equation. A new blow-up result for positive strong solutions of the equation with certain profiles will be presented.

Bifurcation analysis to Lugiato-Lefever equations

Isamu Ohnishi
Hiroshima University, Japan

We study the stability and bifurcation of steady states for a certain kind of damped driven nonlinear Schrödinger equation with cubic nonlinearity and a detuning term in one space dimension, mathematically in a rigorous sense. It is known by numerical simulations that the system shows lots of coexisting spatially localized structures as a result of subcritical bifurcation. Since the equation does not have a variational structure, unlike the conservative case, we cannot apply a variational method for capturing the ground state. Hence, we analyze the equation from a viewpoint of bifurcation theory. In the case of a finite interval, we prove the fold bifurcation of nontrivial stationary solutions around the codimension two bifurcation point of the trivial equilibrium by exact computation of a fifth-order expansion on a center manifold reduction. In addition, we analyze the steady-state mode interaction and prove the bifurcation of mixed-mode solutions, which will be a germ of localized structures on a finite interval. Finally, we study the corresponding problem on the entire real line by use of spatial dynamics. We obtain a small dissipative soliton bifurcated adequately from the trivial equilibrium.

Massera type theorems for linear functional equations with infinite delay in hyperfunctions

Yasunori Okada
Chiba University, Japan

In this talk, we introduce a notion of bounded hyperfunctions at infinity, and give Massera type theorems in hyperfunctions, i.e., show that the existence of a bounded hyperfunction solution at infinity implies the existence of a periodic hyperfunction solution, for some classes of periodic linear functional equations. After discussing the case of functional equations with finite delay, we study a class of equations with infinite delay, containing linear Volterra integral equations as typical examples.

Theorem of reduction in the theory of stability of impulsive differential systems

Andrejs Reinfelds
University of Latvia, Latvia

We consider the system of impulsive differential equations in Banach space that satisfies the conditions of integral separation. We prove the theorem of asymptotic phase. Using this result and the centre manifold theorem we reduce the investigation of stability of the trivial solution of initial impulsive differential system to investigation of stability of simpler impulsive differential system.

Determining functionals for cocycles with application to the microwave heating problem

Volker Reitmann
Saint Petersburg State University, Russia

Determining functionals are often used to describe the asymptotic behaviour of an evolution process. We develop some elements of the theory of determining functionals for cocycles. Cocycles on infinite-dimensional space are often generated by non-autonomous PDEs. We apply the cocycle theory to the microwave heating problem, proving the existence of a finite system of determining functionals. The microwave heating problem is described by a coupled system consisting of Maxwell's equations and a heat equation. Non-autonomous perturbations which are assumed to be bounded are included into the boundary conditions of the Maxwell's equations. The theory of determining functionals is applied to this problem taking into account its coupled structure. Numerical results are presented which illustrate the dissipativity of the system and show the properties of the determining functionals.

Multiple solutions in various quasi-linear boundary value problems

Felix Sadyrbaev
University of Latvia, Latvia

We consider the second order equations of the form

$$(l_2 x) = \varphi(t, x, x') \tag{1}$$

together with two-point boundary conditions, for instance, the Dirichlet ones

$$x(a) = A, \quad x(b) = B. \tag{2}$$

The expression $(l_2 x)$ is either the linear form

$$x''(t) + p(t)x'(t) + q(t)x(t) \tag{3}$$

or asymmetric expression

$$x''(t) + p(t)x^+(t) + q(t)x^-(t), \quad x^+ = \max\{0, x\},\ x^- = \max\{0, -x\}. \tag{4}$$

We show that the problem (1), (2) has a solution (solutions) which locally has (have) the same oscillatory property as the "linear" part $(l_2 x)$ does. The oscillatory properties of solutions can be characterized in terms of the respective equation of variations if the function φ is differentiable.

If equation (1) can be rewritten in a quasi-linear form with another "linear" part then another type solutions exist for a given BVP. Therefore multiple solutions.

Generalizations are proposed for the third order problems with some monotonicity restrictions.

Persistence of embedded eigenvalues

Sara Maad Sasane
Stockholm University, Sweden

We consider conditions under which an embedded eigenvalue of a self-adjoint operator remains embedded under small perturbations. In the case of a simple eigenvalue embedded in continuous spectrum of multiplicity $m < \infty$ we show that in favorable situations, the set of small perturbations of a suitable Banach space which do not remove the eigenvalue form a smooth submanifold of co-dimension m. We also have results regarding the cases when the eigenvalue is degenerate or when the multiplicity of the continuous spectrum is infinite.

Damping in hyperbolic equations with parabolic degeneracy

Katarzyna Saxton
Loyola University, USA

We examine the effect of damping on a nonstrictly hyperbolic 2 2 system. It is shown that the growth of singularities is not restricted as in the strictly hyperbolic case where dissipation can be strong enough to preserve the smooth- ness of small solutions globally in time. Here, irrespective of the stabilizing properties of damping, solutions are found to break down in finite time on a line where two eigenvalues coincide in state space.

Generalizations of the Proudman Johnson equation

Ralph Saxton
University of New Orleans, USA

The inviscid Proudman Johnson equation provides, by means of an ansatz, exact solutions to the incompressible, two-dimensional Euler equations. Its generalizations allow classes of solutions to be constructed in higher dimensions and lead to applications in several different areas. In this talk, we will discuss background and current findings for the problem.

Well-posedness of a class of semilinear reaction-diffusion equations with singular initial data

Nicholas Sharples
University of Warwick, UK

It is known that for vector fields f with sufficient regularity (typically some Sobolev regularity) there exists a unique generalised flow solution to the ordinary differential equation $\dot{x} = f(x)$. This generalised flow is an aggregate of trajectories of the ordinary differential equation, one for almost every initial condition.

We provide an example of a vector field with arbitrary Sobolev regularity for which there is a unique generalised flow but non-unique trajectories for each initial condition. Consequently there is no condition of the integrability of a vector field which guarantees almost-everywhere uniqueness of trajectories.

Well-posedness of a class of semilinear reaction-diffusion equations with singular initial data

Mikolaj Sierzega
University of Warwick, UK

We present a method of establishing existence of solutions for a class of scalar semilinear reaction-diffusion equations with initial data in L^q. We then test the procedure against classical results and discuss possible extensions.

A solution operator of one-dimensional p-Laplacian for strong singular weight and its application

Inbo Sim
University of Ulsan, South Korea

We establish a solution operator of one-dimensional p-Laplacian for strong singular weight. Employing the global continuation theorem we show the existence of non-trivial solutions for one-dimensional p-Laplacian with strong singular weight and nonlinear term.

Characterization of hyperbolicity and generalized shadowing lemma

Sinisa Slijepcevic
University of Zagreb, Croatia

J. Mather characterized uniform hyperbolicity of a discrete dynamical system as equivalent to invertibility of an operator on the set of all sequences bounded in norm in the tangent bundle of an orbit. We develop a similar characterization of nonuniform hyperbolicity and show that it is equivalent to invertibility of the same operator on a larger, Frechet space. Finally we show that something weaker than hyperbolicity is required to obtain hyperbolic-like behavior such as the shadowing property: it is enough if the same operator is invertible on an even larger Banach space.

Eigenvalues for third order nonlinear boundary value problems with nonlocal conditions

Sergey Smirnov
Daugavpils University, Latvia

The second order nonlocal boundary value problems are intensively studied due to their importance in applications. At the same time there are few investigations of higher order boundary value problems with nonlocal boundary conditions.

We are concerned with the third order Emden-Fowler type eqution

$$x''' = -|x|^p \mathrm{sign} x \tag{5}$$

together with the nonlocal boundary conditions

$$x(0) = x'(0) = 0, \int_0^1 x(s)ds = 0, \; x(1) = 0. \tag{6}$$

The problem is not overdetermined since $p > 1$ is treated as a parameter. We show that there exists an increasing sequence of eigenvalues $\{p_i\}$ such that the problem (5), (6) has a nontrivial solution. The interesting fact about eigenvalues is that this sequence is bounded.

Existence of positive solutions to nonlinear periodic problems with concave terms

Vasile Staicu
Aveiro University, Portugal

We consider the following parametric periodic problem driven by the scalar p-Laplacian

$$(P_\lambda) \qquad \begin{cases} -\left(|u'(t)|^{p-2} u'(t)\right)' = \lambda |u(t)|^{q-2} u(t) + f(t, u(t)) \text{ a.e. on } [0,b] \\ u(0) = u(b), \; u'(0) = u'(b), \; 1 < q < p < \infty, \; \lambda > 0, \; u > 0. \end{cases}$$

where $\lambda |x|^{q-2} x$ is a parametric term which is $(p-1)-$ sublinear (since $1 < q < p$), and is usually called a *concave term,* and $f(t,x)$ is a Carathéodory perturbation. We assume that $x \to f(t,x)$ exhibits a $(p-1)-$superlinear growth near $+\infty$, but we do not employ the usual in such cases Ambrosetti-Rabinowitz condition. Instead, we use a more general condition, which incorporates in our framework of analysis, functions with much slower growth near $+\infty$. So, we see that in problem (P_λ) we have the combined effects of *concave* and *convex* terms (the latter being the $(p-1)-$superlinear perturbation).

The goal in this talk is to present a bifurcation-type result concerning the nonexistence, existence and multiplicity of positive solutions for problem (P_λ) as the parameter λ varies, establishing the existence of a critical parameter value $\lambda^* > 0$ such that for all $\lambda \in (0, \lambda^*)$, the problem (P_λ) has at least two positive solutions, for $\lambda = \lambda^*$, it has at least one positive solution and for all $\lambda > \lambda^*$ the problem (P_λ) has no positive solutions.

Our approach is variational, based on the critical point theory, and also uses suitable truncation techniques.

Bifurcations of transition states

Dayal Christopher Strub
University of Warwick, UK

A transition state for a Hamiltonian system is a codimension-2 submanifold of an energy-level that can be spanned by two surfaces of unidirectional flux with no local recrossings, such that their union locally divides the energy-level into two components. This union is therefore called a dividing surface. Originally, these were considered in molecular reaction dynamics, where an estimate of the equilibrium reaction rate constant can be obtained by computing the flux of energy-surface volume across the dividing surface. They are now also used to study the rate at which systems evolve in a number of other applications. Transition states diffeomorphic to S^{2n-3} are known to exist for energies just above any index-1 critical point of a Hamiltonian of n degrees of freedom. The question to be examined here is what qualitative changes in the transition state, and consequently the dividing surface, may occur as the energy is increased further. We will introduce reaction-like dynamical systems and recall the local picture for energies just above the critical one, before moving on to consider the various possible bifurcation scenarios. This is joint work with Robert MacKay.

Reynolds equation for a viscous fluid in a slightly rough thin domain

Francisco Javier Suárez-Grau
Universidad de Huelva, Spain

Usually the Stokes equations that govern a flow in a smooth thin domain, with height of order ε, is related to the Reynolds equation for the pressure. In this paper, we consider a slightly rough thin domain with height of order ε and rugosities of period and amplitude of order r_ε and δ_ε, respectively. We show that the limit behaviour when $varepsilon$ tends to zero depends on the limit λ of $(\delta_\varepsilon \varepsilon^{1/2})/r_\varepsilon^{3/2}$. More precisely, we prove that the flow is governed by a modified Reynolds equation for the limit pressure depending on the value of λ.

Nonuniqueness of positive solutions of two-point boundary value problems for superlinear equations

Satoshi Tanaka
Okayama University of Science, Japan

The two-point boundary problem

$$u'' + h(x)f(u) = 0, \quad u(-1) = u(1) = 0$$

is considered, where $h \in C^1([-1,0) \cup (0,1]) \cup C[-1,1]$, $h(x) > 0$ for $x \in [-1,0) \cup (0,1]$, $f \in C^1[0,\infty)$, $f(s) > s$ for $s > 0$ and f satisfies some superlinear property. A typical example is one-dimensional Hénon equation

$$u'' + |x|^l u^p = 0, \quad u(-1) = u(1) = 0,$$

where $l > 0$ and $p > 1$. When f is superlinear, a number of uniqueness results of positive solutions have been obtained, but there are only a few nonuniqueness results. In this talk, new nonuniqueness results of positive solutions are presented.

Fractional differential evolution equations

Nasser-eddine Tatar
King Fahd University of Petroleum and Minerals, Saudi Arabia

We consider a non-local differential problem involving non-integer order derivatives. This problem does not generate a semi-group and therefore the standard methods usually used to study ordinary differential equations (and even partial differential equations) are not valid. In this talk we show how the Gamma function can be used to transform the "hereditary" problem to a "non-hereditary" one. That is we transform the non-local problem to an augmented system of "local" differential equations for which the semi-group theory applies. This works well for linear problems, however, things are not clear in the nonlinear case. For non-linear problems we consider second order evolution problems and show how the cosine family can be used to solve the question of well-posedness.

Support splitting phenomena in some nonlinear initial-boundary value problem

Kenji Tomoeda
Osaka Institute of Technology, Japan

Let us consider the following nonlinear initial-boundary value problem

$$\begin{cases} v_t(t,x) = (v^m)_{xx} - cv^p \text{ on } (0,\infty)\times(-L,L), \\ v(t,-L) = f(t), v(t,L) = g(t) \text{ for } t \geq 0, \\ v(0,x) = v^0(x) \text{ on } [-L,L], \end{cases}$$

where v denotes the density of the liquids, $m > 1$, $0 < p < 1$, $c > 0$, $m + p = 2$ and $v^0(x)(\geq 0)$. According Kersner's result, there appear the support splitting phenomena which the effect of the absorption $-cv^p$ causes. We tried the numerical computation by using our scheme, and found that the appearance of such phenomena depends on the relation between the length of interval $2L$ and the boundary conditions $f(t)$ and $g(t)$.

In this talk, we show some results concerned with the profile of the support of the stationary solution and the dynamical behaviour of the support.

Chirality issues with distance based protein folding simulations

Andrew Toon
SIM University, Singapore.

Differential equations can be exploited to solve molecular or protein geometric distance problems using a class of distance based energy potentials. We show that energy potentials based on local distance information have dynamical solutions satisfying all distance constraints but can have the wrong local chirality.

Dynamics around periodic minimals

Antonio Urena
University of Granada, Spain

We study the dynamics of Euler-Lagrange systems in the vicinity of a periodic, globally minimizing solution. An elementary proof showing that such a solution must be unstable is provided. If the system is reversible, nondegenerate minimizers must be hyperbolic. Applications are given for autonomous systems with a discrete symmetry.

Global asymptotic stability in a two-species nonautonomous competition system

Hiroyuki Usami
Gifu University, Japan

Let us consider the following differential system

$$\begin{aligned} x' &= x(a_1(t) - b_1(t)F_1(x) - c_1(t)G_1(y)) \\ y' &= y(a_2(t) - b_2(t)F_2(x) - c_2(t)G_2(y)) \end{aligned} \tag{S}$$

under the following conditions:

(A$_1$) $F_i, G_i \in C([0,\infty);[0,\infty)), i = 1,2,$ are strictly increasing functions satisfying $F_i(0) = G_i(0) = 0, F_i(\infty) = G_i(\infty) = \infty$;

(A$_2$) $a_i, b_i, c_i \in C([0,\infty);(0,\infty)), i = 1,2;$

(A$_3$) $a_1(t)/b_1(t), c_1(t)/b_1(t), a_2(t)/c_2(t), b_2(t)/c_2(t), i = 1,2,$ are bounded and the inferior limits at the infinity of them are all positive;

(A$_4$) $\int^\infty b_1 = \int^\infty c_2 = \infty.$

We can regard system (S) as a generalisation of the famous Lotka-Volterra competition system. When $a_1(t)/b_1(t), c_1(t)/b_1(t), a_2(t)/c_2(t), b_2(t)/c_2(t), i = 1,2,$ behave like positive constants at the infinity, we can show that all positive solutions of (S) tend to only one " stationary point" in some sense under several additional assumptions. When (S) reduces to the classical Lotka-Volterra competition system (with constant coefficients), our results also reduce to well-known classical results which can be proved via phase plane analysis.

A weak comparison principle for reaction-diffusion systems

José Valero
Universidad Miguel Hernández, Spain

In this work we prove a weak comparison principle for a reaction-diffusion system without uniqueness of the Cauchy problem. We assume for this system growth and dissipative conditions ensuring existence of solutions. But such conditions are not enough to have uniqueness. Roughly speaking the weak comparison principle says that if two initial conditions are ordered, then there exist at least two solutions (corresponding respectively to each initial data) which are ordered for every future moment of time. We apply the abstract results to the Lotka-Volterra system with diffusion, a generalized logistic equation and to a model of fractional-order chemical autocatalysis with decay. Morever, in the case of the Lotka-Volterra system a weak maximum principle is given, and a suitable estimate in the space of essentially bounded functions is proved for at least one solution of the problem.

Periodic solutions of quaternionic ODEs

Pawel Wilczynski
Jagiellonian University, Poland

We provide some results on the existence of the periodic solutions of quaternionic-valued first order differential equations. We present some results concerning the equation of the form

$$\dot{q} = q^3 + a(t), \tag{1}$$

where $a \in \mathcal{C}(\mathbb{R}, \mathbb{H})$ is T-periodic. Unlikely the Riccati equation

$$\dot{q} = q^2 + a(t),$$

it does not generate a dynamical system on the sphere $\mathbb{H} \cup \{\infty\}$. This makes finding periodic solutions more complicated e.g. presented method cannot describe the dynamics on the whole space $\mathbb{H}$. Moreover, unlike the complex case the theory of quaternionic regular functions is not enough developed to determine all possible types of dynamics of the equation (1).

Discretized method of characteristics for McKendrick-von Foerster equation

Piotr Zwierkowski
University of Gdansk, Poland

Consider a population with death process described by McKendrick-von Foerster equation with maturity of individuals dependent on time and size of the whole population. The initial condition is described by an initial distribution of density of the population. The birth process is governed by the boundary condition, given by a prescribed function. Solutions of the model are approximated be means of a discretized method of characteristics. Some properties of solution of the difference scheme, i.e. nonnegativeness of solutions, boundedness in l^1, l^∞ will be given as well as convergence of the difference method. Theoretical results will be illustrated with a numerical example.

Equadiff 2011

Posters

POSTERS

Authors will attend their posters during the wine reception in the EHB Atrium on Monday evening between 18.30 and 19.30.

3D model for compressible viscous heat conducting micropolar fluid with symmetry and free boundary

Ivan Drazic
University of Rijeka, Croatia

We consider 3D compressible viscous micropolar fluid model with spherically symmetric initial data of large oscillations between a static solid core and a free boundary connected to a surrounding vacuum state. The fluid is thermodynamically perfect and polytropic.

The model is described in Eulerian description and transformed in Lagrangian form. There is also given an effective difference scheme which is used to construct approximate solutions to the problem.

Multiple positive solutions for a critical elliptic system with concave-convex nonlinearities and sign-changing weight functions

Tsing-San Hsu
Chang Gung University, Taiwan

In this poster, we consider a quasilinear elliptic system with both concave-convex nonlinearities and critical growth terms in the entire space. By means of variational methods, the existence and multiplicity results of positive solutions to the system are obtained.

A discretized nonlocal diffusion equation in unbounded domain

Francisco Morillas Jurado
Universitat de València, Spain

In this work we consider a discrete evolution problem with non-local diffusion in unbounded domain. This non-local diffusion equation is obtained in a similar way that the continuous case, the diffusion term is constructed using an auxiliary function that can be interpreted as a density function of probability. For the equation considered we prove the existence and uniqueness of the solution and a principle of comparison. Also, we propose an application to graduate dynamical life's tables.

Boundary regularity of flows under perfect slip boundary conditions

Jakub Tichy
Charles University in Prague, Czech Republic

We investigate boundary regularity of solutions of generalized Stokes equations describing stationary flow. The problem is complemented with perfect slip boundary conditions. The nonlinear elliptic operator, which is related to the stress tensor, has p-potential structure.

At first we focus on the case $p = 2$. For this case we obtain solution belonging to the space $W^{2,2}$. Then for the case $p > 1$ we approximate the stress tensor quadratically, show uniform estimates and pass to the limit. Perfect slip boundary conditions let us use second normal derivatives of solution (up to some corrections) as a test function.

Traveling wave solutions in diffusive predator-prey type model

Chi-Ru Yang
National Tsing Hua University, Taiwan

In this work we investigate the existence of the traveling wave so- lution connecting two equilibria in the following nonlinear diffusive predator-prey type model:

$$\begin{aligned} u_t(x;t) &= d1u_xx(x;t) - h(u)[g(w) - p(u)], \\ w_t(x;t) &= d2w_xx(x;t) - l(w)q(u), \end{aligned}$$

where p, g, h, l, q are smooth functions with some monotonic conditions. The traveling front solutions are equivalent to the heteroclinic orbits of the system in $\mathbb{R}^4$. The methods used to prove the result are Wazewski's theorem and LaSalle's invariance principle.

Picone-type inequality and Sturmian comparison theorems for quasilinear elliptic operators with $p(x)$-Laplacians

Norio Yoshida
University of Toyama, Japan

In this work Picone-type inequalities for quasilinear elliptic operators with $p(x)$-Laplacians and mixed nonlinearities are established, and Sturmian comparison theorems are presented on the basis of the Picone-type inequality by comparing with half-linear elliptic operators with $p(x)$-Laplacians.

Periodic orbits of radially symmetric on relativistic mechanic model

Manuel Zamora
Universidad de Granada, Spain

By the use of topological degree theory we study the existence of positive periodic solutions to the following radially symmetric system

$$\left(\frac{x'}{\sqrt{1 - {x'}^2}}\right)' = f(t, |x|)\frac{x}{|x|} \qquad x \in \mathbb{R}^2 \backslash \{0\}$$

where f belongs to Caratheodory class on $[0,T] \times (0,+\infty)$.

We will pay special attention to the model

$$\left(\frac{x'}{\sqrt{1-{x'}^2}}\right)' = -\frac{c(t)}{|x|^\alpha}x + e(t)\frac{x}{|x|} \qquad x \in \mathbb{R}^2 \backslash \{0\},$$

being α a positive constant, and c and e integrable functions on $[0,T]$. This model may be proposed to study relativistic effects on classical mechanical models.

Equadiff 2011

Programme

Monday 1 August 2011

7.30	Elvyn Richards Dining Room	Breakfast for residential delegates
9.15	Lecture theatre J.1.10	Opening remarks
9.30	Lecture theatre J.1.10	Plenary talk: Ray Goldstein (University of Cambridge, UK) *Stirring tails of evolution*
10.15	EHB Atrium	Coffee
10.45	Lecture theatre J.1.10	Plenary talk: Thierry Gallay (Université de Grenoble I, France) *Interaction of vortices in viscous planar flows*
11.30	Lecture theatre J.1.10	Plenary talk: Vassili Gelfreich (University of Warwick, UK) *Dynamics of slow-fast Hamiltonian systems*
12.15	EHB Atrium and Lounge	Lunch for all delegates
14.00	EHB and James France building	Parallel sessions A
16.00	EHB Atrium and James France exhibition area	Coffee
16.30	EHB and James France building	Parallel sessions B
18.30	EHB Atrium	Poster Session Wine Reception
19.30	Elvyn Richards Dining Room	Dinner for residential delegates

Tuesday 2 August 2011

7.30	Elvyn Richards Dining Room	Breakfast for residential delegates
9.30	Lecture theatre J.1.10	Plenary talk: Simon Brendle (Stanford University, USA) *Recent progress on the Yamabe problem*
10.15	EHB Atrium	Coffee
10.45	Lecture theatre J.1.10	Plenary talk: David Damanik (Rice University, USA) *The Hofstadter butterfly, uniform hyperbolicity, and gap labeling*
11.30	Lecture theatre J.1.10	Plenary talk: George Papanicoulaou (Stanford University, USA) *Large deviation problems for partial differential equations and applications to uncertainty quantification*
12.15	EHB Atrium and Lounge	Lunch for all delegates
14.00	EHB and James France building	Parallel sessions C
16.00	EHB Atrium and James France exhibition area	Coffee
16.30	EHB and James France building	Parallel sessions D
19.00	EHB Atrium and Lounge	Gala dinner for all delegates

Wednesday 3 August 2011

7.30	Elvyn Richards Dining Room	Breakfast for residential delegates
9.00	Lecture theatre J.1.10	Plenary talk: Barbara Niethammer (University of Oxford, UK) *Self-similarity in Smoluchowski's coagulation equations*
9.45	EHB Atrium	Coffee
10.15	Lecture theatre J.1.10	Plenary talk: Georg Weiss (Heinrich-Heine-Universität Düsseldorf, Germany) *Singularities of water waves with vorticity*
11.00	Lecture theatre J.1.10	Plenary talk: Sue Ann Campbell (Waterloo) *Delay-induced behaviour*
12.00	EHB Atrium and Lounge	Lunch for all delegates
13.00	Depart outside EHB	Excursion to Chatsworth House and Gardens
19.00	Elvyn Richards Dining Room	Dinner for residential delegates

Thursday 4 August 2011

7.30	Elvyn Richards Dining Room	Breakfast for residential delegates
9.30	Lecture theatre J.1.10	Plenary talk: Andrea Malchiodi (SISSA, Italy) *Improved Moser-Trudinger inequalities and Liouville equations on compact surfaces*
10.15	EHB Atrium	Coffee
10.45	Lecture theatre J.1.10	Plenary talk: Sergei Kuksin (École Polytechnique, France) *Damped-driven Hamiltonian PDE*
11.30	Lecture theatre J.1.10	Plenary talk: Mary Silber (Northwestern University, USA) *Spatio-temporal feedback control of unstable wave patterns*
12.15	EHB Atrium and Lounge	Lunch for all delegates
14.00	EHB and James France building	Parallel sessions E
16.00	EHB Atrium and James France exhibition area	Coffee
16.30	EHB and James France building	Parallel sessions F
19.00	Elvyn Richards Dining Room	Dinner for residential delegates

Friday 5 August 2011

7.30	Elvyn Richards Dining Room	Breakfast for residential delegates
9.30	Lecture theatre J.1.10	lenary talk: Jesús María Sanz-Serna (Universidad de Valladolid, Spain) *Numerical mathematics and the method of averaging*
10.15	EHB Atrium	Coffee
10.45	Lecture theatre J.1.10	Plenary talk: Jonathan Mattingly (Duke University, USA) *A menagerie of stochastic stabilization*
11.30	Lecture theatre J.1.10	Plenary talk: Yann Brenier (Northwestern) *Université de Nice, France* *How can we modify the least action principle for conservative dynamical systems, in order to handle dissipative phenomena?*
12.15	EHB Atrium and Lounge	Lunch for all delegates
14.00	EHB and James France building	Parallel sessions G

Parallel sessions A (Monday 1 August 2011, 14:00-16:00)

Session 1 (Room J.1.10) **Exponentially small phenomena 1**	**Session 2 (Room J.0.02)** **Statistical properties of dynamical systems 1**	**Session 3 (Room J.0.01)** **Infinite-dimensional dynamical systems 1**	**Session 4 (Room CC.00.11)** **Conservation laws 1**	**Session 5 (Room CC.00.12)** **Pattern formation 1**
14:00 *Normal forms, invariant manifolds and exponentially small phenomena* Eric Lombardi **14:30** *The asymptotic wavenumber in point-defect solutions of the complex Ginzburg-Landau equation* Maria Aguareles **15:00** *Splitting of invariant manifolds near a Hamiltonian-Hopf bifurcation* Jose Pedro Gaivao **15:30** *Breakdown of heteroclinic orbits for analytic unfoldings of the Hopf-zero singularity: The singular case* Oriol Castejón	**14:00** *Transience in dynamical systems* Mike Todd **14:30** *Equilibrium measures for beta-shifts and their factors* Dan Thompson **15:00** *Recent results on the statistical properties of non-uniformly expanding maps in any dimension* Sandro Vaienti **15:30** *Limit laws for iterated function systems that contract-on-average* Charles Walkden	**14:00** *Nonlinear stability of defects* Kevin Zumbrun **14:30** *True invariant manifolds from approximations* Peter Bates **15:00** *A centre-stable manifold for Schrödinger's equation* Marius Beceanu **15:30** *Metastability and global invariant manifolds for Burgers equation* Margaret Beck	**14:00** *A priori estimates for 3D incompressible current-vortex sheets* Paolo Secchi **14:30** *Algebraic vortex spirals and non-uniqueness of inviscid flow* Volker Elling **15:00** *Existence and stability of relativistic plasma-vacuum interfaces* Yuri Trakhinin **15:30** *Ill-posedness issues for first-order quasi-linear systems* Benjamin Texier	**14:00** *Quasipatterns in a parametrically forced fluid film* Gérard Iooss **14:30** *Resonant triad interactions and spatio-temporal chaos* Anne Skeldon **15:00** *Approximate quasipattern solutions of PDEs* Alastair Rucklidge **15:30** *Pattern formation in the hyperbolic plane* Pascal Chossat

Session 6 (Room CC.00.13) **Water waves 1**	Session 7 (Room CC.00.29a) **Large scale numerical bifurcation problems 1**	Session 8 (Room CC.00.14) **Mathematical biology (contributed talks)**	Session 9 (Room CC.1.09) **Differential inclusions and fractional partial differential equations (contributed talks)**	Session 10 (Room CC.1.10) **Boundary-value problems (contributed talks)**
14:00 *Existence and stability of fully localised three-dimensional gravity-capillary solitary water waves* Mark Groves	**14:00** *Numerical methods for large scale bifurcation problems* Andrew Cliffe	**14:00** *Comparing different ODE modelling approaches for gene regulatory networks* John Hogan	**14:00** *Fractional differential evolution equations* Nasser-eddine Tatar	**14:00** *Support splitting phenomena in some nonlinear initial-boundary value problem* Kenji Tomoeda
14:30 *Regularity of two dimensional steady capillary gravity water waves* Guanghui Zhang	**14:30** *The role of exact solutions in the non-linear behaviour of the Navier-Stokes equations* Andrew Hazel	**14:30** *Periodic solutions of neural network models* Inese Bula	**14:30** *Semilinear differential Inclusions without compactness* Irene Benedetti	**14:30** *Multiple solutions in various quasi-linear boundary value problems* Felix Sadyrbaev
15:00 *On estimates for slopes for steady gravtiy water waves in a channel of finite depth* Vladimir Kozlov	**15:00** *Bifurcations in data assimilation for 2D Navier-Stokes* Kody Law	**15:00** *Global asymptotic stability in a two-species nonautonomous competition system* Hiroyuki Usami	**15:00** *On the solution set of a class of fractional differential inclusions* Aurelian Cernea	**15:00** *Eigenvalues for third order nonlinear boundary value problems with nonlocal conditions* Sergey Smirnov
15:30 *Turning waves and breakdown for incompressible flows* Angel Castro	**15:30** *Discontinuous Galerkin methods for bifurcation phenomena in the flow through open systems* Edward Hall	**15:30** *Discretized method of characteristics for McKendrick-von Foerster equation* Piotr Zwierkowski	**15:30** *Systems of partial differential inclusions under constraints* Mateusz Maciejewski	**15:30** *Maximum principle results for higher order PDEs* Anita Mareno

Parallel sessions B (Monday 1 August 2011, 16:30-18:30)

Session 1 (Room J.1.10) **Exponentially small phenomena 2**	**Session 2 (Room J.0.02)** **Statistical properties of dynamical systems 2**	**Session 3 (Room J.0.01)** **Infinite-dimensional dynamical systems 2**	**Session 4 (Room CC.00.11)** **Conservation laws 2**	**Session 5 (Room CC.00.12)** **Pattern formation 2**
16:30 *Resonant chaotic zones: Dynamical consequences of the difference between the inner/outer splittings of separatrices* Arturo Vieiro **17:00** *Exponential homogenisation of elliptic PDE* Karsten Matthies **17:30** *Exponentially small splitting of separatrices for the pendulum with fast periodic or quasiperiodic perturbation* Marcel Guardia **18:00** *Multi-site breathers in Klein-Gordon lattices: Bifurcations, stability, and resonances* Dmitry Pelinovsky	**16:30** *Statistical problems and phenomena in some models of asynchronous dynamics* Michael Field **17:00** *Robustness of extremes for chaotic dynamical systems* Mark Holland **17:30** *First and higher order limit theorems for dynamical systems with infinite measure* Dalia Terhesiu **18:00** *Fluctuation theorems, large deviations and shrinking intervals* Richard Sharp	**16:30** *Multiple-spike solutions in singularly perturbed reaction-diffusion equations with nonlocal interaction* Oleh Omelchenko **17:00** *Convergence theorems for asymptotically autonomous parabolic equations on* R^N Peter Polacik **17:30** *Topology and dynamics of finite-dimensional attractors* James Robinson **18:00** *Pulse solutions of some hydrodynamic problems and reversible Takens-Bogdanov bifurcation without parameter* Andrei Afendikov	**16:30** *Vanishing viscosity for nonlinear systems of conservation laws* Gui-Qiang Chen **17:00** *Kinetic shock profiles for nonlinear hyperbolic conservation laws* Carlota Cuesta **17:30** *Asymptotic stability of boundary layers to the Euler-Poisson equation in plasma physics* Shinya Nishibata **18:00** *Modulation and large time asymptotic profiles near periodic traveling waves* Miguel Rodrigues	**16:30** *Pattern formation in colloidal explosions: Theory and experiments* Arthur Straube **17:00** *Exponential asymptotics of homoclinic snaking in two-dimensional lattices* Andrew Dean **17:30** *Variational approximations to homoclinic snakings* Hadi Susanto **18:00** *Pattern formation on small world networks* Thomas Wagenknecht

Session 6 (Room CC.00.13) **Water waves 2**	Session 7 (Room CC.00.29a) **Large scale numerical bifurcation problems 2**	Session 8 (Room CC.00.14) **Singular perturbation theory 1**	Session 9 (Room CC.1.09) **Finite-dimensional dynamical systems (contributed talks)**	Session 10 (Room CC.1.10) **Dynamics of partial differential equations 1 (contributed talks)**
16:30 *Transverse instability of line solitary waves* Frédéric Rousset	**16:30** *The ocean circulation as a complex dynamical system* Henk Dijkstra	**16:30** *True slow surfaces and dynamical bifurcations* Yulij Ilyashenko	**16:30** *Interacting global manifolds in a 2D noninvertible map model of wild chaos* Stefanie Hittmeyer	**16:30** *On the collapsing behaviour of the logarithmic diffusion equation* Kin Ming Hui
17:00 *A variational approach to a class of nonlocal evolution equations and existence of solitary waves of the Whitham equation* Mats Ehrnström	**17:00** *Numerical continuation of oscillons in reaction-diffusion equations* Daniele Avitabile	**17:00** *The singular limit of a Hopf bifurcation* Hinke Osinga	**17:00** *Family of Julia sets as orbits of differential equations* Yi-Chiuan Chen	**17:00** *A weak comparison principle for reaction-diffusion systems* José Valero
17:30 *Surface waves on steady perfect-fluid flows with vorticity* John Toland	**17:30** *On the use of approximate macroscopic models in equation-free coarse bifurcation analysis* Giovanni Samaey	**17:30** *Periodic orbits near common slow-fast cycles in planar slow-fast systems* Peter De Maesschalck	**17:30** *Characterization of hyperbolicity and generalized shadowing lemma* Sinisa Slijepcevic	**17:30** *Local minimizers of average distance functional in dynamic minimizing movement problem: regularity and topology changing* Xin Yang Lu
18:00 *Dynamical behaviour near solitary waves obtained by minimax methods* Boris Buffoni	**18:00** *Continuation in physical experiments* Jan Sieber	**18.00** *Invariant cones in 3D piecewise linear systems via Melnikov function* Soledad Fernandez-Garcia	**18:00** *Integrability of polynomial fields in the plane by means of Picard-Vessiot theory: Statements and examples* Primitivo Acosta-Humanez	**18:00** *Persistence of embedded eigenvalues* Sara Maad Sasane

Parallel sessions C (Tuesday 2 August 2011, 14:00-16:00)

Session 1 (Room J.1.10) **Mathematical neuroscience 1**	Session 2 (Room J.0.02) **Statistical properties of dynamical systems 3**	Session 3 (Room J.0.01) **Delay differential equations 1**	Session 4 (Room CC.00.11) **Dynamical systems techniques for fluids 1**	Session 5 (Room CC.00.12) **Pattern formation 3**
14:00 *Dynamics of nonlinear integrate-and-fire neurons* Jonathan Touboul **14:30** *Global bifurcation diagrams for models of two coupled class 1 neurons* Claude Baesens **15:00** *Continuation-based computation of global isochrons* Hinke Osinga **15:30** *Macroscopic entrainment of neuronal ensembles with application in medicine* Oleksandr Popovych	**14:00** *Statistical properties for interval maps with critical points and singularities* Ian Melbourne **14:30** *A mechanism for producing SRB measures in certain evolution PDEs* William Ott **15:00** *Robustness and synchronisation of non-autonomous oscillators* Robert MacKay **15:30** *Multifractal analysis and frequency of digits for countable branch expanding maps* Thomas Jordan	**14:00** *Positive operators, tensor products and differential-delay equations* Roger Nussbaum **14:30** *Non-linear oscillations of differential equations with two time lags* Gabor Kiss **15:00** *Analysis of synchronisation in networks with time-delayed coupling* Yuliya Kyrychko **15:30** *Existence and estimation of solutions of a class of time-delay dynamical systems* Lotfi Boudjenah	**14:00** *Large time beahvior decay and growth for a viscous Boussinesq system* Lorenzo Brandolese **14:30** *Uniqueness and blow-up for a noisy viscous dyadic model of turbulence* Marco Romito **15:00** *Global existence and long-time asymptotics for rotating fluids in a 3D layer* Volaine Roussier-Michol **15:30** *Dynamical systems and vortex methods* David Uminsky	**14:00** *Energy-driven pattern formation via competing long- and short-range interactions* Mark Peletier **14:30** *Multimode localized structures far from equilibirum* Ehud Meron **15:00** *Self-assembly, defect motion and rheology of mesophases* Jorge Vinals **15:30** *Pattern formation in chemotaxis-like systems* Angela Stevens

Session 6 (Room CC.00.13) **Celestial mechanics 1**	Session 7 (Room CC.00.29a) **Nonlinear waves in lattices 1**	Session 8 (Room CC.00.14) **Singular perturbation theory 2**	Session 9 (Room CC.1.09) **Functional-differential equations with rescaling 1**	Session 10 (Room CC.1.10) **Numerical analysis and homogenisation (contributed talks)**
14:00 *Minimum time trajectories of the circular restricted three-body problem* Jean-Baptiste Caillau **14:30** *Non-integrability of N-body problems via variational equations* Juan Morales-Ruiz **15:00** *Cyclic central configurations in the four-body problem* Gareth Roberts **15:30** *Two approaches to Smale's 6th problem* Alain Albouy	**14:00** *Continuum limits for localised patterns in lattices* Jonathan Dawes **14:30** *Dynamics of breathing in DNA* Jonathan Wattis **15:00** *Periodic traveling waves in the Burridge-Knopoff model* Marion Lebellego **15:30** *Oscillatory waves in discrete scalar conservation laws* Michael Herrmann	**14:00** *Geometric singular perturbation theory beyond the standard form* Peter Szmolyan **14:30** *Canards and inflection* Martin Krupa **15:00** *Exponentially slow solutions in viscous balance laws* Julia Ehrt **15:30** *Canards in the dynamics of aircraft as ground vehicles* Bernd Krauskopf	**14:00** *Balanced pantograph equation revisited* Leonid Bogachev **14:30** *A functional linear operator arising from a model of dynamo growth* Ben Mestel **15:00** *Asymptotic behavior of solutions for the Poincaré equation* Gregory Derfel **15:30** *The germination of the pantograph equation* John Ockendon	**14:00** *Several options for multiscale methods for bacterial chemotaxis with internal dynamics* Annelies Lejon **14:30** *Finite element approximation for microstructure formation and evolution* Richard Norton **15:00** *Homogenization of the wave equation with non-smooth coefficients in time* Faustino Maestre **15:30** *A one-dimensional optimal design problem: Numerical analysis* Manuel Luna-Laynez

Session 11 (Woodhouse Room) **Well-posedness of partial differential equations (contributed talks)**
14:00 *Damping in hyperbolic equations with parabolic degeneracy* Katarzyna Saxton **14:30** *Strong solutions of doubly nonlinear parabolic equations* Aleš Matas **15:00** *Well-posedness of non-Lipschitz reaction-diffusion Cauchy problems* John Meyer **15:30** *Well-posedness of a class of semilinear reaction-diffusion equations with singular initial data* Mikolaj Sierzega

Parallel sessions D (Tuesday 2 August 2011, 16:30-18:30)

Session 1 (Room J.1.10) **Mathematical neuroscience 2**	**Session 2 (Room J.0.02)** **EPDiff@Equadiff 1**	**Session 3 (Room J.0.01)** **Delay differential equations 2**	**Session 4 (Room CC.00.11)** **Dynamical systems techniques for fluids 2**	**Session 5 (Room CC.00.12)** **Front propagation in heterogenous media 1**
16:30 *Propagation of spike sequences in neural networks* Arnaud Tonnelier	**16:30** *EPDiff momentum maps for image analysis* Darryl Holm	**16:30** *Unique periodic orbits of a DDE with piecewise linear feedback function* Ábel Garab	**16:30** *The structure of phase flow and nonlocal stabilization for semilinear parabolic equations of normal type* Andrei Fursikov	**16:30** *Travelling waves in reaction-diffusion equations with nonlinear boundary conditions* Vitaly Volpert
17:00 *Propagation to chaos and information processing in large assemblies of neurons* Olivier Faugeras	**17:00** *Fractional Sobolev metrics on diffeomorphism groups* Martin Bauer	**17:00** *Existence and stability of periodic solutions of a state-dependent delay equation* Benjamin Kennedy	**17:00** *Uniqeness of particle trajectories for weak solutions of the 3D Navier-Stokes equations* James Robinson	**17:00** *Pulsating traveling wave in nonlocal reaction diffusion equation* Jerome Coville
17:30 *Analysis of a geometric model for visual edges and textures perception* Gregory Faye	**17:30** *Singular solutions of cross-coupled EPDiff equations: Waltzing peakons and compacton pairs* Rossen Ivanov	**17:30** *Slowly oscillating periodic solutions of a delay differential equation* Eugen Stumpf	**17:30** *On the box-counting dimension of a singular set for 3D Navier-Stokes equations* Witold Sadowski	**17:30** *Asymptotic spreading for general heterogeneous Fisher-KPP equations* Grégoire Nadin
18:00 *Limit theorems for stochastic spatio-temporal models* Martin Riedler	**18:00** *Numerical solutions of singular cross-coupled EPDiff equations* James Percival	**18:00** *Infinite number of stable periodic solutions for an equation with negative feedback* Gabriella Vas	**18:00** *On the problem of moments for 3D Navier-Stokes equations* Alejandro Vidal-Lopez	**18:00** *Reversing invasion in bistable competition models* Fordyce Davidson

Session 6 (Room CC.00.13) **Celestial mechanics 2**	Session 7 (Room CC.00.29a) **Nonlinear waves in lattices 2**	Session 8 (Room CC.00.14) **Singular perturbation theory 3**	Session 9 (Room CC.1.09) **Functional-differential equations with rescaling 2**	Session 10 (Room CC.1.10) **Positive solutions of differential equations (contributed talks)**
16:30 *Topology and stability of integrable Hamiltonian systems* Alexey Bolsinov **17:00** *Higher variational equation integrability conditions and applications to the n body problem* Thierry Combot **17:30** *Platonic polyhedra, topological constraints and periodic soutions of the N-body problem* Giovanni Gronchi **18:00** *Complexity of collisions in Newtonian 3-body problems* Jean-Pierre Marco	**16:30** *Localised patterns in an urban crime model* David Lloyd **17:00** *Crossings of global minimizers for finite-range variational monotone recurrence relations* Blaz Mramor **17:30** *Shilnikov chaos in parametrically-driven coupled nonlinear lattices: Application in two coupled rc-SQUIDs* Vassilis Rothos **18:00** *Spontaneous symmetry breaking phenomenon in nonlinear Schrödinger equations with double well potential* Andrea Sacchetti	**16:30** *Hunting French ducks in a noisy environment* Christian Kuehn **17:00** *Delayed exchange of stability and relaxation oscillations of a new type in an enzyme reaction* Ilona Kosiuk **17:30** *Time-periodic perturbation of a Liénard equation with an unbounded homoclinic loop* Marcelo Messias **18:00** *Slow-fast dynamics of a charged particle interacting with an oblique electromagnetic field* Anatoly Neishtadt	**16:30** *Orthogonal polynomials on the unit circle and functional differential equations* Maria-Jose Cantero **17:00** *The best constant of Sobolev-type inequality corresponding to higher-order heat operator* Yoshinori Kametaka **17:30** *The best constant of a Sobolev-type inequality which corresponds to Heaviside and Thomson cable with periodic boundary condition* Kazuo Takemura **18:00** *Stability properties of equilibria and periodic solutions in systems with large delay* Matthias Wolfrum	**16:30** *Non-existence of one-signed solutions of evolutionary differential equations* Leopold Herrmann **17:00** *Existence of positive solutions for a nonlinear second-order m-point boundary value problem* Rodica Luca-Tudorache **17:30** *Existence of positive solutions to nonlinear periodic problems with concave terms* Vasile Staicu **18:00** *Nonuniqueness of positive solutions of two-point boundary value problems for superlinear equations* Satoshi Tanaka

Session 11 (Woodhouse Room) **Dynamics of partial differential equations 2 (contributed talks)**
16:30 *Reynolds equation for a viscous fluid in a slightly rough thin domain* Francisco Javier Suárez-Grau **17:00** *Stationary solutions and connecting orbits for nonlinear parabolic differential equations at resonance* Piotr Kokocki **17:30** *Determining functionals for cocycles with application to the microwave heating problem* Volker Reitmann **18:00** *Asymptotic behaviour of nonlocal reaction-diffusion equations* María Anguiano Moreno

Parallel sessions E (Thursday 4 August 2011, 14:00-16:00)

Session 1 (Room J.1.10) **Mathematical neuroscience 3**	**Session 2 (Room J.0.02)** **EPDiff@Equadiff 2**	**Session 3 (Room J.0.01)** **Delay differential equations 3**	**Session 4 (Room CC.00.11)** **Homogenisation 1**	**Session 5 (Room CC.00.12)** **Front propagation in heterogenous media 2**
14:00 *Homogenization of neural field models* John Wyller **14:30** *Towards a new computational framework for studying the role of gap junctions on neural network dyanmics* Yulia Timofeeva **15:00** *Nonlinear synchrony dynamics of coupled neuronal bursters* Abul Kalam al Azad **15:30** *Possible role for coherence in neuronal communication* Magteld Zeitler	**14:00** *EPDiff and computational anatomy* Laurent Younes **14:30** *Multiresolution diffeomorphic matching methods using EPDiff* Martins Bruveris **15:00** *On the well-posedness of some EPDiff type equations* Francois Gay-Balmaz **15:30** *Euler-Poincaré equations on automorphism groups of principal bundles and dual pairs* Cornelia Vizman	**14:00** *Quiescent phases and delay equations* Karl-Peter Hadeler **14:30** *On permanence of a class of delayed Lotka-Volterra systems with variable growth rates* Zhanyuan Hou **15:00** *Bifurcations of a differential equation with linearly state dependent delays* Tony Humphries **15:30** *A local Hopf bifurcation theorem for differential equations with state-dependent delays* Tibor Krisztin	**14:00** *Homogenisation in finite elasticity for composites with a high contrast in the vicinity of rigid-body motions* Mikhail Cherdantsev **14:30** *Two-scale homogenisation of a periodic elastic composite with partial degeneracies* Shane Cooper **15:00** *Radial symmetry of point defects in nematic liquid crystals* Apala Majumdar **16:30** *Multi-scale homogenization of degenerating PDEs and applications* Valery Smyshlyaev	**14:00** *Spreading and vanishing in nonlinear diffusion problems with free boundaries* Bendong Lou **14:30** *Propagation phenomena for time heterogeneous KPP equations* Luca Rossi **15:00** *Continuous dependence in front propagation for convective reaction-diffusion models with aggregative movements* Luisa Malaguti **15:30** *Front-like entire solutions for reaction-diffusion equations with convection* Elaine Crooks

Session 6 (Room CC.00.13) **Water waves 3**	Session 7 (Room CC.00.29a) **Limit cycles 1**	Session 8 (Room CC.00.14) **Kinetic equations 1**	Session 9 (Room CC.1.09) **Spectral theory and dynamics of cocycles 1**	Session 10 (Room CC.1.10) **Fluids 1 (contributed talks)**
14:00 *On the Cauchy problem for water gravity waves in a channel* Thomas Alazard **14:30** *Non-symmetric periodic three-dimensional water waves* Gérard Iooss **15:00** *Existence of steady free-surface waves with corners of 120 degrees at their crests in the presence of vorticity* Eugen Varvaruca **15:30** *Exact theory on asymptotic linear stability of solitary gravity waves* Shu-Ming Sun	**14:00** *Darboux theory of integrability for nonautonomous systems* Chara Pantazi **14:30** *Remarkable values of Darboux first integrals: The infinity and the inverse integrating factor* Antoni Ferragut **15:00** *Local integrability of three dimensional Lotka-Volterra systems* Waleed Aziz **15:30** *Eventual stability properties of a non-autonomous Lotka-Volterra equation* Attila Dénes	**14:00** *A nonautonomous predator-prey system arising from coagulation theory* Fernando da Costa **14:30** *A 1D inelastic collision model arising from biology* Gael Raoul **15:00** *Selfsimilar solutions of the second kind representing gelation in finite time for the Smoluchowski equation* Giancarlo Breschi **15:30** *Post-gelation behavior of Smoluchowski's equation* Raoul Normand	**14:00** *The Atkinson spectral problem and applications* Russell Johnson **14:30** *Typical properties within special classes of smooth SL(2,R) valued cocycles* Mahesh Nerurkar **15:00** *Perturbative reducibility results for quasi-periodic cocycles without diophantine conditions* Claire Chavaudret **15:30** *Genericity of exponential dichotomy for SL(2,R)-valued cycles* Roberta Fabbri	**14:00** *Local strong solutions to non-stationary channel flows of heat-conducting viscous Incompressible fluids* Michal Benes **14:30** *Semicommutative differential operators associated with the Dirac operator and a new formulation of the mKdV hierarchy* Masatomo Matsushima **15:00** *The probabilistic method and large initial conditions for the Navier-Stokes equation* Jean C. Cortissoz **15:30** *On blow-up phenomena for the weakly dissipative Camassa-Holm equation* Emil Novruzov

Parallel sessions F (Thursday 4 August 2011, 16:30-18:30)

Session 1 (Room J.1.10) **Geometrical algorithms for partial differential equations 1**	Session 2 (Room J.0.02) **Dynamical systems methods for fluids 3**	Session 3 (Room J.0.01) **Delay differential equations 4**	Session 4 (Room CC.00.11) **Homogenisation 2**	Session 5 (Room CC.00.12) **Front propagation in heterogenous media 3**
16:30 *Microlocal methods in nonlocal quantum theories* Dorothea Bahns **17:00** *Diffeomorphism symmetry, constraints and discretization independence in discrete gravity* Bianca Dittrich **17:30** *Preconditioning techniques for systems of partial differential equations using algebraic tools* Victorita Dolean **18:00** *Noether's second theorem for finite difference Euler Lagrange systems* Elizabeth Mansfield	**16:30** *Invariant measures of the 2D Euler and Navier-Stokes equations* Freddy Bouchet **17:00** *On the existence and regularity of pullback attractors for non-autonomous 2D-Navier-Stokes equations* Julia Garcia-Luengo **17:30** *Counterexamples in the attractors theory* Sergey Zelik **18:00** *Time-periodic solutions to the full Navier-Stokes-Fourier system* Milan Pokorny	**16:30** *Stability of functional differential equations with variable impulsive perturbations via generalized ordinary differential equations* Marcia Federson **17:00** *On differentiability of solutions with respect to parameters in neutral differential equations with state-dependent delays* Ferenc Hartung **17:30** *Well-posedness of initial value problems for functional differential-algebraic equations of mixed type* Hermen Jan Hupkes **18:00** *Unbounded state-dependent delays* Hans-Otto Walther	**16:30** *Diffusion on rapidly varying surfaces* Andrew Duncan **17:00** *Derivation of effective equations for electronkinetic transport* Markus Schmuck **17:30** *Averaging over fast variables in the fluid limit of Markov chains* James Norris **18:00** *Diffusive limits for non Markovian Langevin equations* Grigoris Pavliotis	**16:30** *G-equations in the modeling of the turbulent flame speed* Yifeng Yu **17:00** *Planar traveling waves of reaction diffusion equations in periodic media* Adam Boden **17:30** *Fronts for periodic KPP equations in a two-dimensional cylinder with undulating boundary - virtual pinning case* Steffen Heinze **18:00** *Existence of recurrent traveling waves* Ken-Ichi Nakamura

Session 6 (Room CC.00.13) **Hamiltonian systems (contributed talks)**	**Session 7 (Room CC.00.29a)** **Limit cycles 2**	**Session 8 (Room CC.00.14)** **Kinetic equations 2**	**Session 9 (Room CC.1.09)** **Spectral theory and dynamics of cocycles 2**	**Session 10 (Room CC.1.10)** **Ordinary differential equations 1 (contributed talks)**
16:30 *Chirality issues with distance based protein folding simulations* Andrew Toon **17:00** *Dynamics around periodic minimals* Antonio Urena **17:30** *On the (n, k)-stacked central configurations* Antonio Carlos Fernandes **18:00** *Bifurcations of transition states* Dayal Christopher Strub	**16:30** *The tangential center-focus problem for Darboux centres* Colin Christopher **17:00** *Limit cycles of some perturbations of linear center* Salomon Rebollo Perdomo **17:30** *Hilbert 16th Problem, large amplitude and alien limit cycles* Magdalena Caubergh **18:00** *Persistence of equilibria as periodic solutions of forced systems* Adriana Buica	**16:30** *Hastings-Levitov aggregation in the small-particle limit* James Norris **17:00** *On spacial inhomogeneous coagulation-fragmentation models with diffusion* Klemens Fellner **17:30** *Strong semiclassical approximation of Wigner Functions for the Hartree dynamics* Federica Pezzotti **18:00** *Dispersion and resonances for the Schrödinger flow on the torus* Fabricio Macia	**16:30** *Lyapunov spectrum of nonautonomous linear stochastic differential algebraic equations of index -1* Nguyen Dinh Cong **17:00** *Linearization of hyperbolic finite-time processes* Daniel Karrasch **17:30** *Limit-periodic Verblunsky coefficients for OPUS* Darren Ong **18:00** *Linearization of quasiperiodically forced circle flow beyond Brjuno condition* Qi Zhou	**16:30** *Heteroclinic cycles unfolded by nilpotent singularities* Santiago Ibáñez **17:00** *Periodic solutions of quaternionic ODEs* Pawel Wilczynski **17:30** *Reversible periodic orbits in piecewise linear systems* Elisabeth García-Medina **18:00** *Global bifurcation analysis of planar neural dynamical systems* Valery Gaiko

Parallel sessions G (Friday 5 August 2011, 14:00-16:00)

Session 1 (Room J.1.10) Geometrical algorithms for partial differential equations 2	Session 2 (Room J.0.02) EPDiff@Equadiff 3	Session 3 (Room J.0.01) Problems with moving interfaces	Session 4 (Room CC.00.11) Mathematical biology and stochastic partial differential equations (contributed talks)	Session 5 (Room CC.00.12) Fluids 2 (contributed talks)
14:00 *Matrix geometry for discrete gravity* Dmitry Pavlov **14:30** *Preserving Noether's conservation laws using compatible and incompatible finite element schemes* Tristan Pryer **15:00** *A numerical study of the Maxwell Kelin Gordon equation using lattice guage theory* Claire Scheid **15:30** *Geometric singularities of differential equations* Werner Seiler	**14:00** *Modeling water monolayers as interacting rolling particles: Liquid and gas states, statistical mechanics and geometric Vaslov theory* Vakhtang Putkaradze **14:30** *Euler-Poincaré approach to hybrid Vlasov-fluid models* Cesare Tronci **15:00** *Variational integrators for higher order mechanics on Lie groups* Christopher Burnett **15:30** *Unreduction* David Ellis	**14:00** *On motions of Prandtl-Eyring fluids in 2D* Lars Diening **14:30** *Fluid film equations and other applications of the calculus of moving surfaces* Pavel Grinfeld **15:00** *Some high-order, optimally local schemes for interface problems* Jean-Christophe Nave **15:30** *A projection-less method for the incompressible Navier-Stokes equations on irregular domains* David Shirokoff	**14:00** *Analysis of a dengue disease transmission model with delay* Eric Avila **14:30** *Symmetry and synchronization in models of antigenic variation* Konstantin Blyuss **15:00** *A filtering problem for SDE's associated with parameterized backward parabolic equations* Daniela Ijacu **15:30** *Reversible stochastic flows associated with nonlinear SPDE's* Marinela Marinescu	**14:00** *On types of solutions of nonlinear BVPs and approximation schemes* Maria Dobkevich **14:30** *Generalizations of the Proudman Johnson equation* Ralph Saxton **15:00** *Evolutionary PDE's in perfectly plastic fluid theory* Dominic Breit **15:30** *Stability of large- and small-amplitude solitary waves in the generalized KdV and Euler-Korteweg / Boussinesq equations* Johannes Höwing

Session 6 (Room CC.00.13) **Celestial mechanics 3**	Session 7 (Room CC.00.29a) **Limit cycles 3**	Session 8 (Room CC.00.14) **Nonlinear Schrödinger equations (contributed talks)**	Session 9 (Room CC.1.09) **Elliptic partial differential equations (contributed talks)**	Session 10 (Room CC.1.10) **Ordinary differential equations 2 (contributed talks)**
14:00 *Generic Nekhoroshev theory without small divisors and applications* Laurent Niederman **14:30** *Higher-order variational equations and their application to problems in celestial mechanics* Sergi Simon **15:00** *Constant inclination solutions of the three-body problem* Eldar Straume **15:30** *Euler equations of many body systems* Lars Sydnes	**14:00** *Some new types of attractors* Yulij Ilyashenko **14:30** *Connection between box dimension and cyclicity for planar systems* Maja Resman **15:00** *Fractal analysis of Hopf bifurcation at infinity* Goran Radunovic **15:30** *Polynomial growth of cyclicity for elementary polycycles and Hilbert-Arnold problem* Ilya Schurov	**14:00** *Bifurcation analysis to Lugiato-Lefever equations* Isamu Ohnishi **14:30** *Asymptotic bifurcation for the asymptotically linear NLS* Francois Genoud **15:00** *Conservation laws in the nonlinear Schrödinger equations* Marisela Guzmán-Gómez **15:30** *Energy preserving methods for nonlinear Schrödinger equation* Canan Akkoyunlu	**14:00** *Diffusion equations subject to concave-convex absorption* José Sabina de Lis **14:30** *Existence of non-radial positive solutions for the generalized Hénon equation* Ryuji Kajikiya **15:00** *Nonexistence of positive supersolutions for nonlinear elliptic equations in R^N* Jorge Garcia Melian **15:30** *A solution operator of one-dimensional p-Laplacian for strong singular weight and its application* Inbo Sim	**14:00** *Generalized synchronization of non-autonomous coupled oscillators* Rogério Martins **14:30** *Theorem of reduction in the theory of stability of impulsive differential systems* Andrejs Reinfelds **15:00** *Uniqueness of flows and non-uniqueness of trajectories for ODEs with limited regularity* Nicholas Sharples **15:30** *Massera type theorems for linear functional equations with infinite delay in hyperfunctions* Yasunori Okada

List of speakers

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