SIAM National Student Chapter Conference 2018 - Bath
Conference Programme

18th & 19th June 2018

Introduction

The SIAM UKIE National Student Chapter Conference is an annual conference organised by one of the SIAM Student chapters in the UK and Ireland. The 2018 edition is the 7th such event, and the first hosted by the University of Bath, and also the first two be over two days.
The aim of this conference is to bring together students working in all areas of applied and industrial mathematics, and related fields, from across the UK and Ireland. There are opportunities to showcase their research through a talk or a poster, and to hear talks by distinguished plenary speakers.
There are 4 plenary talks, 30 student talks, 22 student posters, and 104 registered attendees from 24 different institutions, and multiple different departments.
The conference follows both the SIAM Statement on Inclusiveness and the IMA Diversity Statements, and we endeavour to create a welcoming and inclusive atmosphere at the conference, with a diverse range of participants.
In this program you will find the conference schedule, and the abstracts of all talks and posters.
We hope you enjoy your time in Bath, and look forward to seeing you again soon.

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This conference is kindly supported by grants from:

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Department of Mathematical Sciences, University of Bath

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The 2018 SIAM National Student Chapter Conference is organised by the Bath SIAM-IMA Student Chapter committee:
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Amy Middleton (Vice President)
Dan Green (Secretary)
Benjamin Robinson (Treasurer)
Owen Pembery
Malena Sabaté Landman.

Conference Code of Conduct

We invite you to the SIAM-UKIE National Student chapter conference in a spirit of curiosity, friendliness, open-mindedness and respect. We value your participation and want to ensure a welcoming and safe environment for all. In line with University of Bath policy, we will not tolerate harassment in any form. All participants at our event are required to agree to the following code of conduct.

Need Help?

If you are being harassed, notice that someone else is being harassed, or have any other concerns, please speak to one of the organisers or email siamsc@lists.bath.ac.uk.

Summary

- Our conference is dedicated to providing a harassment-free experience for everyone, regardless of gender, gender identity and expression, sexual orientation, age, disability, appearance, race, ethnicity or religion.
- We do not tolerate harassment of participants in any form.
- Participants asked to stop any harassing behaviour are expected to comply immediately.
- Participants violating these rules may, at the discretion of the organisers, be asked to leave the conference.

Be aware

Harassment includes the following:

- Offensive verbal comments related to gender, gender identity and expression, age, sexual orientation, disability, physical appearance, race, ethnicity or religion.
- Deliberate intimidation, stalking, persistent invasion of personal space, persistent harassing photography or recording, sustained disruption of talks or other events.
- Inappropriate physical contact, persistent and unwelcome sexual attention.
- Solicitation of emotional or physical intimacy accompanied by real or implied threat of professional harm, and/or offering professional favours for compliance.

This list is not exhaustive; see below for links giving further details.

Conference organisers and department staff will be happy to help participants experiencing harassment to feel safe for the duration of the conference, this may include contacting security, contacting local police, or providing an escort. We expect participants to follow these rules at the conference venues and related social events.

More information

- University of Bath policy:
  `http://www.bath.ac.uk/equalities/policiesandpractices/dignityandrespectpolicy.pdf`
- University of Bath guide:
  `http://www.bath.ac.uk/guides/sexual-assault-or-harassment`

Conference Schedule

Monday
18th Jun

10:00 AM - 10:30 AM
Coffee & Registration
4 West Atrium

10:35 AM - 10:45 AM
Welcoming Remarks
University Hall

10:45 AM - 11:45 AM
Plenary Talk 1
University Hall
Domain Decomposition Methods with Adaptive Multipreconditioning
Nicole Spillane, École Polytechnique

11:45 AM - 1:00 PM
Student Talks 1A
4 West 1.2

11:45 - 12:10 Circulant preconditioners for functions of Toeplitz matrices
Sean Hon, University of Oxford

12:10 - 12:35 (P,w)-Partition and alternating sign matrices
Hassan Izanloo, Cardiff University

12:35 - 1:00 Training memory one strategies for the Prisoner's Dilemma
Nikoleta E. Glynatsi, Cardiff University

11:45 AM - 1:00 PM
Student Talks 1B
4 West 1.7 (Wolfson)

11:45 - 12:10 Noise and Bistability in the Square Root Map
Eoghan Staunton, NUI, Galway

12:10 - 12:35 Finite or infinite predictability horizon?
Tsz Yan Leung, University of Reading

12:35 - 1:00 The geometric influence of domain-size on the dynamics of reaction-diffusion systems with applications in pattern formation
Wakil Sarfaraz, University of Sussex

1:00 PM - 2:00 PM
Lunch
4 West Atrium

2:00 PM - 3:15 PM
Student Talks 2A
4 West 1.2

2:00 - 2:25 On the computation and application of M-estimators and its bootstrapped version in GARCH models
Hang Liu, Lancaster University

2:25 - 2:50 Sparse Principal Component Analysis for Exponential Family Data
Luke Smallman, Cardiff University

2:50 - 3:15 Transience and Recurrence of Markov Processes with Constrained Local Time
Adam Barker, University of Reading

2:00 PM - 3:15 PM
Student Talks 2B
4 West 1.7 (Wolfson)

2:00 - 2:25 Droplet Spreading, Chemically Treated Surfaces and Mathematics
Danny Groves, Cardiff University

2:25 - 2:50 Linear stability and transient behaviour of viscoelastic fluids in boundary layers
Martina Cracco, Cardiff University

2:50 - 3:15 The Effect of Surface Stress on Interfacial Solitary Waves
Dane Grundy, University of East Anglia

3:15 PM - 3:45 PM
Coffee
4 West Atrium

3:45 PM - 4:45 PM
Plenary Talk 2
University Hall
Modelling spatio-temporal data: methods, examples and challenges
Marta Blangiardo, Imperial College London

4:45 PM - 4:55 PM
Conference Photo
4 West Atrium

4:55 PM - 6:30 PM
Poster Session & Wine Reception
4 West Atrium

7:00 PM
Conference Dinner
Wessex Restaurant

Tuesday 19th Jun

8:30 AM - 9:00 AM
Coffee & Registration
4 West Atrium

9:00 AM - 10:15 PM
Student Talks 3A
4 West 1.2
9:00 - 9:25 A Convex Variational Segmentation Model and It's Fast Multilevel Algorithm
Abdul Jumaat, University of Liverpool
9:25 - 9:50 What Lies Beneath?
Oliver Dunbar, University of Warwick
9:50 - 10:15 Variational Diffeomorphic Models for Image Registration
Daoping Zhang, University of Liverpool

9:00 AM - 10:15 PM
Student Talks 3B
4 West 1.7 (Wolfson)
9:00 - 9:25 Modelling the evolving ductility of biodegradable polymers
Aoife Hill, NUI, Galway
9:25 - 9:50 Wrinkling in soft dielectric plates
Hannah Conroy Broderick, NUI, Galway
9:50 - 10:15 Inhomogeneous Thinning and Breakdown of Thin Dielectric Elastomers
Paul Greaney, NUI, Galway

10:15 AM - 10:45 AM
Coffee
4 West Atrium

10:45 AM - 11:45 AM
Plenary Talk 3
University Hall
iPhones and Dysons: using fluid dynamics to tailor technology
Ian Griffiths, University of Oxford

11:45 AM - 1:00 PM
Student Talks 4A
4 West 1.2

11:45 - 12:10 Adaptive a posteriori meshes for differential equations
Róisín Hill, NUI, Galway

12:10 - 12:35 Numerical solution of Isaacs equation
Bartosz Jaroszkowski, University of Sussex

12:35 - 1:00 An efficient adaptive algorithm for elliptic problems with random input data
Leonardo Rocchi, University of Birmingham

11:45 AM - 1:00 PM
Student Talks 4B
4 West 1.7 (Wolfson)

11:45 - 12:10 The invasion speed of cell migration models with a multi-stage cell-cycle representation
Enrico Gavagnin, University of Bath

12:10 - 12:35 An Anisotropic Interaction Model for Simulating Fingerprints
Lisa Maria Kreusser, University of Cambridge

12:35 - 1:00 Kernel Reconstruction for Delayed Neural Field Equations
Jehan Alswaihli, University of Reading

1:00 PM - 2:00 PM
Lunch
4 West Atrium

2:00 PM - 3:15 PM
Student Talks 5A
4 West 1.2

2:00 - 2:25 FEniCS.jl, solving PDE's using Julia
Yiannis Simillides, UCL

2:25 - 2:50 Eliminating Gibbs Phenomenon: A non-linear Petrov-Galerkin method for convection-dominated problems
Sarah Roggendorf, University of Nottingham

2:50 - 3:15 Light scattering by complex ice crystals using the Boundary Element Method
Antigoni Kleanthous, UCL

2:00 PM - 3:15 PM
Student Talks 5B
4 West 1.7 (Wolfson)

2:00 - 2:25 (2,2) -Tight Surface Graphs
Qays Shakir, NUI, Galway

2:25 - 2:50 Anomalous metapopulation dynamics on scale-free networks
Helena Stage, The University of Manchester

2:50 - 3:15 Phase transitions of multistable dynamical networks
Roberto Galizia, NUI, Galway

3:15 PM - 4:15 PM
Plenary Talk 4
University Hall
Coercivity of second kind boundary integral equations on Lipschitz domains
Simon Chandler-Wilde, University of Reading

4:15 PM - 4:30 PM
Closing Remarks
University Hall

Abstracts of Plenary Talks

Plenary Talk 1 *Monday 10:45 - 11:45, University Hall*

Domain Decomposition Methods with Adaptive Multipreconditioning

Domain decomposition methods are a family of parallel solvers for large linear systems. They all share the idea of approximating the inverse of some matrix by a sum of local inverses (in the so-called subdomains). I will present some classical domain decomposition methods, their limitations and some recent efforts to improve their robustness and scalability so that they can be applied to problems arising from real life simulations. More precisely, I will present the method of adaptive multipreconditioning. This is a modification of the iterative solver (the preconditioned conjugate gradient algorithm). Instead of one single preconditioner, a family of preconditioners is applied at each iteration, each corresponding to one of the subdomains. This significantly increases the size of the minimization space and consequently accelerates convergence. I will introduce the method, discuss its analysis and show numerical results obtained in collaboration with C. Bovet, P. Gosselet and A. Parret-Fréaud.

Nicole Spillane, École Polytechnique

Plenary Talk 2 *Monday 3:45 - 4:45, University Hall*

Modelling spatio-temporal data: methods, examples and challenges

In this talk I will present how the Bayesian hierarchical framework is commonly used to model spatial and spatio-temporal data. I will first consider the space as discrete (small area framework) and introduce autoregressive structures, which can be used to account for spatial and temporal dependency. I will focus on different examples drawn from the epidemiological field.
Then I will move to the case when space is continuous and introduce the geostatistics framework. Here I will present two examples drawn from epidemiology and environmental science.
I will finish the talk presenting some of the (methodological and non) challenges which researchers face in this context.

Marta Blangiardo, Imperial College London

Plenary Talk 3 *Tuesday 10:45 - 11:45, University Hall*

iPhones and Dysons: using fluid dynamics to tailor technology

As technology continues to advance, new strategies involving a range of scientific disciplines are required. Mathematicians can provide frameworks to predict operating regimes and manufacture techniques. In this talk we present two case studies: the fabrication of precision glass, for smartphones and new flexible devices; and the development of superior filters for vacuum cleaners. In each case we use asymptotic analysis to derive a model that determines the fabrication protocol required to produce a desired final product.

Ian Griffiths, University of Oxford

Plenary Talk 4 *Tuesday 3:15 - 4:15, University Hall*

Coercivity of second kind boundary integral equations on Lipschitz domains

Boundary integral equation methods are a well-established technique for solving linear elliptic partial differential equations. Second kind integral equation formulations, taking the form $\phi + K\phi = g$, where K is a boundary integral operator, are attractive because they are well-conditioned. However, even in the simplest case (Laplace's equation on a bounded domain D with Dirichlet boundary conditions), it is not known whether standard Galerkin numerical methods, for example so-called boundary element methods based on finite-element-type approximations, are stable and convergent for these formulations for general Lipschitz domains.
When D is smooth and convex the standard second kind formulation for this simplest case can be written in this form where K, related to the standard double-layer potential operator, is a contraction, i.e. $\|K\| < 1$. Indeed, this observation was the basis of one of the first rigorous proofs of existence of solution for elliptic PDEs by Carl Neumann, already in the 19th century. The condition $\|K\| < 1$, for K as an operator on $L^2(\Gamma)$, guarantees convergence of Galerkin approximation methods, and in fact convergence holds under the weaker condition that $K = L + C$ where $\|L\| < 1$ and C is compact, or the weaker condition still that $I + K = L + C$ with L coercive and C compact. (An operator L on $L^2(\partial D)$ is said to be coercive if, for some $c > 0$, $|(L\psi, \psi)| \ \geq c\|\psi\|^2$, for all $\psi \in L^2(\partial D)$, where $(\cdot, \cdot)$ is the inner product and $\| \cdot \|$ the norm on $L^2(\partial D)$). It is known that $K = L + C$, with $\|L\| < 1$ and C compact, if D is C^1; if it is curvilinear polygon in 2D; if it is Lipschitz and convex; and if it is a general Lipschitz domain with sufficiently small Lipschitz constant; and it is a long-standing conjecture that this holds for all Lipschitz D.
But in this talk we exhibit examples of Lipschitz domains in 2D for which it does not hold that K is a compact perturbation of a contraction; in fact the so-called essential norm may be arbitrarily large. These domains are also examples where $I + K$ is not a compact perturbation of a coercive operator; in fact the so-called essential numerical range of K can contain arbitrarily large discs. On the other hand, in a positive direction, we also exhibit new, modified versions of the standard second kind integral equation formulation which have the attractive property that the associated operators are coercive (rather than the weaker coercive plus compact) for all Lipschitz D, so that every Galerkin method is convergent. The proof of this is an application of Rellich-identity technology, an elementary but ubiquitous method of argument based on applications of the divergence theorem.
Joint work with Euan Spence (Bath)

Simon Chandler-Wilde, University of Reading

Abstracts of Student Talks

Student Talks 1A *Monday 11:45 - 1:00, 4 West 1.2*

Circulant preconditioners for functions of Toeplitz matrices *11:45 - 12:10*
Circulant based preconditioning for symmetric Toeplitz systems has been well developed over the past few decades. For a large class of such systems, descriptive bounds on the convergence of the conjugate gradient method can be obtained. For nonsymmetric Toeplitz systems, much work had been focused on normalising the original systems until [J. Pestana and A. J. Wathen. SIAM J. MATRIX ANAL. APPL. Vol. 36, No. 1, pp. 273-288, 2015] recently showed that theoretic guarantees on the convergence of the minimal residual method can be established via a simple trick of reordering. The authors further proved that a suitable absolute value circulant preconditioner can be used to ensure rapid convergence. In this talk, we show that the related ideas can also be applied to systems defined by functions of Toeplitz matrices. Numerical examples are given to support our results.

Sean Hon, University of Oxford

(P,w)-Partition and alternating sign matrices *12:10 - 12:35*
An alternating sign matrix of order n, ASM for short, is an n by n matrix with entries from the set -1,0,1 in which its rows/columns sum equal to 1 and non-zero entries in each row/column alternate in sign. In this talk, I will briefly discuss (P,w)-partition theory where P is a given finite poset and w is a labeling for P. Then its application to ASMs will be investigated.

Hassan Izanloo, Cardiff University

Training memory one strategies for the Prisoner's Dilemma *12:35 - 1:00*
According to Charles Darwin's theory of evolution, natural selection is ruled by the survival of the fittest. However, in spite of all the 'selfish genes' animal communities seem to altruistically help each other and cooperate. Vampire bats share part of their meal with members of the community that failed to find prey; similarly humans collaborate which leads to the creation of governments.
The question remains: why and how does cooperation emerge? In the field of game theory a game called the prisoner's dilemma has been used for decades to explain the emergence of altruistic behaviour. In the 1980s, a political scientist called Robert Axelrod carried out a computer tournament. A number of strategies playing the iterated prisoner's dilemma, clashed in a round robin tournament.
Some recent work explored the effects of how good a strategy's memory is. The results stated that in the prisoner's dilemma interactions memory is not advantageous. As a game theorist I disagree with the above statement. I am proposing to talk about my work which focuses on proving that memory size can be advantageous in multi agent interactions.

Nikoleta E. Glynatsi, Cardiff University

Student Talks 1B *Monday 11:45 - 1:00, 4 West 1.7 (Wolfson)*

Noise and Bistability in the Square Root Map *11:45 - 12:10*
Recurrent mechanical real-world systems with impacts are often modelled using impact oscillators. Examples of such systems include rattling gears, a moored ship impacting a dock, Braille printers, percussive drilling and atomic force microscopes.
Near low-velocity impacts the dynamics of impact oscillators can be described by a one-dimensional nonsmooth map known as the square root map. Here we will describe the complex structure of the basins of attraction of the map's stable periodic orbits and how this produces sensitivity to the addition of small-amplitude white noise. In particular, we will focus on the effects of noise of varying amplitudes on the square root map close to parameter values that lead to bistability.
We will show that on intervals of bistability there is a nonmonotonic relationship between noise amplitude and the proportion of time spent in each periodic behaviour. We will explain how these relationships can be understood by comparing approximations of steady-state distributions of trajectory deviations due to noise and the deterministic structures of the map. We will also show that bistability can be induced by the addition of noise of an appropriate amplitude and present the mechanisms of noise-induced transitions in this case.

Eoghan Staunton, NUI, Galway

Finite or infinite predictability horizon? *12:10 - 12:35*
It is well-accepted that the chaotic nature of atmospheric dynamics imposes an inherent finite limit of predictability. The idea originated from a paper by Edward Lorenz in 1969, in which he presented a theoretical argument suggesting that the predictability horizon cannot be indefinitely extended by reducing the initial error to anything above zero. In his derivation the 2D barotropic vorticity model was used, and the error growth behaviours with kinetic energy spectral slopes of $-5/3$ and $-7/3$ were compared. Extrapolating from his results, Lorenz hypothesised that the predictability would become infinite if the spectral slope steepened to -3 without providing any direct numerical or theoretical evidence.
We have performed direct numerical simulation of a forced-dissipative version of the spectral 2D barotropic vorticity model with a -3 spectral slope. Contrary to Lorenz's hypothesis, our results suggest finite predictability. Repeating Lorenz's derivation for the case of a -3 spectral slope, we will study the possible reasons leading to the disagreement.

Tsz Yan Leung, University of Reading

The geometric influence of domain-size on the dynamics of reaction-diffusion systems with applications in pattern formation *12:35 - 1:00*
This talk presents the theory and application of a self-contained and robust methodology for exploring models of patterns formation from the perspective of a dynamical system. The contents of this work applies the methodology to investigate the geometric influence of the domain size on the evolution of the dynamics modelled by reaction-diffusion systems (RDSs). We focus on a particular RDS of *activator-depleted* class and apply the detailed framework consisting of the application of linear stability theory, domain-dependent harmonic analysis and the numerical solution by the finite element method to predict and verify the theoretically proposed behaviour in the evolving dynamics. This is achieved by employing the analytical results of domain-dependent harmonic analysis on three different types of two-dimensional domains consisting of rectangular, circular and a non-compact annular type regions. The bulk of the talk is restricted to an *activator-depleted* class reaction-diffusion model where we explores the model on a rectangular compact geometry and relates the side-lengths of a rectangular geometry to the magnitude of reaction-diffusion constants, where the numerical verification through the formulation, implementation and the results of finite element is provided. We also present a detailed study of the model on circular two dimensional compact geometry, in which the radius of a disk-shape domain is related to the magnitude of reaction-diffusion parameters in the context of bifurcation analysis. Finally a similar study is conducted on a non-compact domain that consists of annular region, in which the thickness of a two dimensional flat ring is used to explore the admissibility of different types of bifurcations subject to the choice of thickness of a shell with respect to the choice of reaction-diffusion parameters.

Wakil Sarfaraz, University of Sussex

Student Talks 2A *Monday 2:00 - 3:15, 4 West 1.2*

On the computation and application of M-estimators and its bootstrapped version in GARCH models *2:00 - 2:25*

In this paper, we use a new algorithm for computing M-estimators and its weighted bootstrap version for the parameters of the GARCH (p, q) model. Since the algorithm for the computation of M-estimates is at the same time software-friendly to compute bootstrap replicates from the given data, we provide extensive simulation results regarding the bootstrap approximation of the distribution of M-estimators. We demonstrated high coverage probability of various weighted bootstrap schemes and analyse some real financial data to demonstrate the usefulness of M-estimators. Finally, we analyse data which can be modelled by higher order GARCH that has attracted attention in recent literature.

Hang Liu, Lancaster University

Sparse Principal Component Analysis for Exponential Family Data *2:25 - 2:50*

Principal Component Analysis (PCA) is one of the most widely used dimension reduction tools, but it is largely unsuitable for data which is not normally distributed. In this talk, I will briefly summarise efforts in the literature to extend PCA to exponential family data, then explain my work extending these methods to produce sparse loadings. I will also illustrate why such loadings are desirable.

Luke Smallman, Cardiff University

Transience and Recurrence of Markov Processes with Constrained Local Time *2:50 - 3:15*

We study Markov processes conditioned so that their local time must grow slower than a prescribed function. Building upon recent work on Brownian motion with constrained local time in [BB11, KS16], we study transience and recurrence for a broad class of Markov processes.

Main results include necessary and sufficient conditions for transience/recurrence of the conditioned Markov process. We explicitly determine the distribution of the inverse local time for the conditioned process, and in the transient case, we explicitly determine the law of the conditioned Markov process. In the recurrent case, we explicitly determine the "entropic repulsion envelope" of the process, which formally characterises the effects of entropic forces on the system.

This work is theoretical, but relates to problems in polymer physics. Constraining the local time imposes self-repellence on the process, and so our results complement various models for long polymer chains, in which the asymptotic properties of long polymers are modelled via self-repelling processes [HK01].

References:

[BB11] Benjamini, I. Berestycki, N. An Integral Test for the Transience of a Brownian Path with Limited Local Time, Ann. Inst. H. Poincar Probab. Statist. (2011)

[HK01] van der Hofstad, R. KÃűnig, W. A survey of One-Dimensional Random Polymers, J. Stat. Phys. (2001)

[KS16] Kolb, M. Savov, M. Transience and Recurrence of a Brownian Path with Limited Local Time, Ann. Probab. (2016)

Adam Barker, University of Reading

Student Talks 2B *Monday 2:00 - 3:15, 4 West 1.7 (Wolfson)*

Droplet Spreading, Chemically Treated Surfaces and Mathematics *2:00 - 2:25*
Whether it's the raindrops on your car's windshield, or the water running off a plant leaf, we frequently encounter the rich physics behind droplet motion and yet remain unaware of its impact on the modern world. For many decades this class of phenomena has fascinated academics from all areas of science and engineering, furthermore, this interest has brought the development of new technologies such as ink-jet printers, and the design of self cleaning surfaces. From a mathematical point of view this area leads to some interesting and yet complex equations, where solutions rely on powerful computers with long simulation times. In many configurations where large amounts of simulations are required we cannot afford these high computing costs, therefore emphasis must also be placed on powerful mathematical methods, such as matched asymptotic analysis, to develop simpler models that retain key physical mechanisms. Using these methods we can determine solutions to the complicated equations at much faster rates, with an example simulation being 250,000 times faster than a supercomputer simulation. This simpler model can potentially assist in the design of surface features for experimental study, help us further understand the key physics behind droplet motion, and advance the development of new technologies.

Danny Groves, Cardiff University

Linear stability and transient behaviour of viscoelastic fluids in boundary layers *2:25 - 2:50*
The behaviour of many real fluids is well described by Navier-Stokes theory. This theory is based on the assumption of a Newtonian constitutive equation. Many rheological complex fluids such as polymer solutions, blood, paints and shampoo are not adequately described by a Newtonian constitutive equation. Viscoelastic fluids are examples of non-Newtonian fluids, they exhibit both viscous and elastic properties when undergoing deformation. The aim of my research is to understand the stability behaviour of such fluids in boundary layers, thin layers of fluid close to a surface. Results based on two-dimensional linear stability analysis for a fluid of second grade demonstrate the stabilising effects of elasticity. The analysis is expanded to three-dimensional disturbances and a nonmodal approach is adopted in order to have a more complete idea of the short-term behaviour of disturbances. It is shown that elasticity generally increases the energy of the perturbations over short-time periods. The stability analysis is extended to more complicated models of viscoelastic fluids.

Martina Cracco, Cardiff University

The Effect of Surface Stress on Interfacial Solitary Waves *2:50 - 3:15*
The theory of solitary waves is well developed when normal stress is applied at a fluid surface, leading to the KdV equation. However, when a fluid of finite depth is subjected to an electric field, or a surfactant is present, then a tangential stress arises at the free surface. Taking a large Reynolds Number limit leads to a boundary layer at the free surface and imposing a no-slip condition on the solid bottom leads to a viscous boundary layer at the bottom of the fluid. In this talk I will introduce each scenario and discuss recent numerical and analytical results describing a solitary wave in the presence of an electric field, and a uniform surfactant at the free surface.

Dane Grundy, University of East Anglia

Student Talks 3A *Tuesday 9:00 - 10:15, 4 West 1.2*

A Convex Variational Segmentation Model and It's Fast Multilevel Algorithm *9:00 - 9:25*
Selective image segmentation is a task of extracting one object of interest among many others in an image based on minimal user input. In this talk, a convex selective segmentation model is proposed. A fast optimisation based multilevel method for solving the model is introduced in order to achieve fast convergence especially for images with large size. Numerical results show that the model produces quality segmentation in an optimal computational time.

Abdul Jumaat, University of Liverpool

What Lies Beneath? *9:25 - 9:50*
Seismic Tomography is a technique in subsurface imaging where one uses the paths of pressure waves in the earth to reveal the underlying structure. In this talk we discuss first traveltime tomography, where only the first hitting time of waves on detectors is used in this reconstruction. One may formulate this as an inverse problem, with associated forward problem modeled by the Eikonal equation. We will introduce the model and discuss well posedness, regularisation and implementation.

Oliver Dunbar, University of Warwick

Variational Diffeomorphic Models for Image Registration *9:50 - 10:15*
Image registration is to find a transformation to map the corresponding image data. But in large deformation registration problems, it is very difficult to obtain a solution that has no folding. Lam and Lui (2014) has used Beltrami coefficient to control the transformation and avoid the twist. In this talk, I will propose novel diffeomorphic models based quasi-conformal theory for image registration. Numerical experiments demonstrate that the proposed models can get accurate and diffeomorphic transformations.

Daoping Zhang, University of Liverpool

Student Talks 3B *Tuesday 9:00 - 10:15, 4 West 1.7 (Wolfson)*

Modelling the evolving ductility of biodegradable polymers *9:00 - 9:25*

Drug-eluting stents have become desirable due to the reduction in restenosis that they offer following stenting [1]. A biodegradable polymer coating, often PLGA [2], containing drug, coats a stent, and the drug is released as the polymer degrades. To help combat issues relating to delamination and breakages during deployment, it is vital to investigate the failure mechanisms of biodegradable polymers. A non-linear relationship was seen between the molecular weight, M_n, and failure strain, ϵf, for polypropylene [3]. A significant decrease in ductility was previously found for polylactide as degradation proceeded [4] (Fig.1b). Here, we explore the relationship between ductility and molecular weight distributions of degrading PLGA. A microscale model of polymer chain scissions was developed in MATLAB, motivated by Shirazi et al. [5]. Representative polymer chain distributions were generated and subjected to randomly assigned sequences of end-scissions and chain-scissions (Fig.1a). The evolving distribution of chain length was tracked and failure criteria were then explored based on the ratio of free chain length to fully extended chain length as the chain length decreases with each scission. The evolution of the predicted modulus, E^-, based on the number of chains above a critical M_n, is compared to experimental data in Fig.1c; a steep decrease in E^- is observed for smaller M_n. Two criteria for ϵf are presented in Fig.1d: ϵf^α is based on M_n of the ensemble of chains and ϵf^b is based on the number of chains above a critical length. Both criteria show a substantial decrease in ductility with decreasing M_n; however, ϵf^α shows this decrease earlier. This computational investigation of ϵf of an evolving biodegradable polymer and its dependence on M_n will aid in designing biodegradable drug-eluting medical devices with suitable degradation rates and sufficient mechanical integrity for their purpose. Work is ongoing to include higher order kinetics and link this to continuum finite element models.

REFERENCES

[1] C. Shanshan, T. Lili, T. Yingxue, Z. Bingchun, Y. Ke, Study of drug-eluting coating on metal coronary stent., Materials Science & Engineering. C, 33, pp. 1476-80 (2013)

[2] H.K. Makadia, S.J. Siegel, Poly Lactic-co-Glycolic Acid (PLGA) as Biodegradable Controlled Drug Delivery Carrier, Polymers, 3, pp. 1377-1397 (2011)

[3] B. Fayolle, L. Audouin, J. Verdu, A critical molar mass separating the ductile and brittle regimes as revealed by thermal oxidation in polypropylene, Polymer, 45, pp. 4324-4330 (2004)

[4] K.S. Bezela, Examination of biodegradable materials for medical devices, RWTH Aachen University, NUI, Galway, Unpublished ME Thesis (2017)

[5] R.N. Shirazi, W. Ronan, Y. Rochev, P.E. McHugh, Modelling the degradation and elastic properties of poly(lactic-co-glycolic acid) films and regular open-cell tissue engineering scaffolds, Journal of the Mechanical Behavior of Biomedical Materials, 54, pp. 48-59 (2016)

Aoife Hill, NUI, Galway

Wrinkling in soft dielectric plates *9:25 - 9:50*

Dielectric materials are smart materials that deform in the presence of an electric field. Soft dielectrics have potential applications in devices such as artificial muscles and soft robotics, where there is demand for materials that can undergo repeated large deformations. Large actuation can be achieved by soft dielectrics, by using the snap-through behaviour of the material. However, it is difficult to achieve this large stretch as soft dielectrics are prone to electric breakdown. When a voltage is applied across the thickness of a soft dielectric plate it expands in the planar directions, increasing its surface area, but it gradually becomes thinner, causing electric breakdown. We show that a smooth giant voltage actuation of soft dielectric plates is not easily obtained in practice. In principle one can exploit, through pre-deformation, the snap-through behaviour of their loading curve to deliver a large stretch prior to electric breakdown. However, we demonstrate that even in this favourable scenario, the soft dielectric is likely to first encounter the plate wrinkling phenomenon, as modelled by the onset of small-amplitude sinusoidal perturbations on its faces.

Hannah Conroy Broderick, NUI, Galway

Inhomogeneous Thinning and Breakdown of Thin Dielectric Elastomers *9:50 - 10:15*
Thin dielectric elastomers with compliant electrodes have diverse applications in areas such as energy harvesting and microfluidics. The application of a voltage across the thickness direction of an incompressible dielectric elastomer results in an in-plane expansion, which can be large enough to produce areal strains of 500%. When the voltage applied is increased to a critical threshold, the elastomer thins catastrophically in localised regions, ultimately leading to the formation of holes and cracks. Modelling the electric breakdown associated with this catastrophic thinning phenomenon is a major challenge associated with the practical implementation of dielectric elastomers. We present some recent work which extends a theoretical model for catastrophic thinning in homogeneous systems to the case of inhomogenously deformed systems. We compare our results with recent experimental findings on out-of-plane inhomogeneous deformations of dielectric elastomer actuators and find a good match between theory and experiment.

Paul Greaney, NUI, Galway

Student Talks 4A *Tuesday 11:45 - 1:00, 4 West 1.2*

Adaptive a posteriori meshes for differential equations *11:45 - 12:10*
We consider the numerical solution of differential equations by finite element methods (FEMs), implemented in FEniCS, a open-source platform for solving partial differential equations [5]. Our model one-dimensional problem is the singularly perturbed reaction-diffusion problem: $\epsilon^2 u''(x) + b(x)u(x) = f(x)$ on $\Omega = (0, 1)$ with the boundary conditions $u(0) = u(1) = 0$: It is singularly perturbed in the sense that the positive real parameter epsilon may be arbitrarily small, but, if we formally set $\epsilon = 0$, then it is ill-posed. When epsilon is small, the solution may exhibit boundary layers (and, perhaps, also interior layers, depending on the smoothness of b and f). The numerical solution of (1) presents numerous mathematical and computational challenges, particularly as epsilon tends to 0. Much of the research published over the past 20 years focuses on the solution of these problems on fitted meshes, which are constructed based on detailed a priori knowledge on the location and asymptotic properties of layers. This is somewhat artificial since, for many problems (particularly nonlinear ones) the location or width of layers may be unknown. This motivates us to develop algorithms that iteratively generate adaptive meshes, based on a posteriori information. This leads to three problems that must be addressed: (i) how to estimate errors in computed solutions; (ii) how to quantify that error locally, to provide information to drive the mesh adaption; (iii) how to solve the non-linear adaptivity problem. In this presentation, we will describe approaches for each of these when computing the numerical solution of (1) and its generalisations, by FEMs in FEniCS. Taking inspiration from [3], for (i), we construct a hierarchical error estimator, based on comparing solutions computed in polynomials spaces of different degree. For (iii), we investigate both de Boor-type and MMPDE (mesh moving PDE) algorithms for generating the adaptive mesh, which is, itself, a nonlinear problem [1]. The key novelty in this presentation is how we address (ii). We compare results obtained by quantifying the error with different functionals including ones based on the usual energy norm, a special "balanced" norm [2], a weighted L2 norm [4], and the Hessian of the error estimate [2]. We analyse the efficiency of the algorithms and their ability to resolve the layers in the solutions to (1) and, therefore, the appropriateness of the resulting mesh. We also consider their application to other problems, including a Helmholtz-type problem whose solution exhibits an interior layer.
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Róisín Hill, NUI, Galway

Numerical solution of Isaacs equation *12:10 - 12:35*
Isaacs equations form a family of fully nonlinear PDEs arising naturally from stochastic zero-sum two player games. We consider the problem of the following form:

$$-\partial_t + \inf_{\beta} \sup_{\alpha} (L^{(\alpha,\beta)} v - f^{(\alpha,\beta)}) = 0,$$

where $L^{(\alpha,\beta)}$ are first- or second-order linear operators. One can think of them as a generalisation of Hamilton-Jacobi-Bellman equations from optimal control theory. The aim of the talk is to present a novel finite element method for these Isaacs equations. The main difficulty arises from the non-convex structure of the underlying inf-sup operator. The presented numerical method permits fully implicit, semi-explicit and explicit time discretizations, with the fully implicit one being unconditionally stable. We discuss monotonicity, L-infinity stability and consistency, even for unstructured meshes. Based on this we obtain uniform convergence of numerical solutions to the viscosity solution of Isaacs problem. We illustrate the theoretical findings with numerical experiments.

Bartosz Jaroszkowski, University of Sussex

An efficient adaptive algorithm for elliptic problems with random input data *12:35 - 1:00*
We consider elliptic PDEs whose coefficients have an affine dependence on a large (possibly infinite) number of random parameters. For example, coefficients given in terms of polynomial chaos or Karhunen-Lòeve expansions of random fields can be considered. For the discretisation of such problems, the adaptive algorithm that we present in this talk uses the stochastic Galerkin Finite Element Method (sGFEM). This method generates numerical approximations of the solution in tensor product spaces composed of classical finite element spaces (for spatial discretisations) and finite-dimensional spaces of multivariate polynomials in the parameters.
The global discretisation error is controlled by a hierarchical a posteriori error estimator which leads to two distinct estimators associated either with the spatial or parametric components of the discretisation. At the same time, such estimators provide precise estimates of the error reduction achieved if different enhanced approximations are computed. In particular, at each iteration, the algorithm performs either a local refinement of the underlying mesh or a polynomial enrichment on the parameter domain according to which enhancement provides a larger error reduction. In both cases, Dörfler marking is employed in the "mark" step of the adaptive loop.
We show the performance and the efficiency of our algorithm on some bechmark problems with (spatially) regular and singular solutions.

Leonardo Rocchi, University of Birmingham

Student Talks 4B *Tuesday 11:45 - 1:00, 4 West 1.7 (Wolfson)*

The invasion speed of cell migration models with a multi-stage cell-cycle representation *11:45 - 12:10*
Cell proliferation is crucial in many developmental and pathological processes. Proliferation is commonly incorporated into stochastic mathematical models of cell migration by assuming that cell divisions occur after an exponentially distributed waiting time. Experimental observations, however, show that this assumption is often far from the real cell-cycle time distribution (CCTD). Recent studies have suggested an alternative approach of modelling cell proliferation based on a multi-stage representation of the CCTD. These models are appealing because they provide an accurate description of CCTD while maintaining the efficiency of simulating independent exponentially distributed waiting times. In order to validate and parametrise these models, it is important to connect their formulation to experimentally measurable quantities. In this paper we consider a stochastic, on-lattice agent-based model of cell invasion and we investigate how the incorporation of a general multi-stage proliferation mechanism at the individual-cell level affects the speed of the collective invasion. By deriving a set of reaction-diffusion equations for the average agents' density and studying the corresponding travelling wave solutions, we obtain the analytical expression of the speed of invasion for a general N-stage model with identical transitional rates, in which case the resulting CCTD is known as Erlang distribution. We discuss the extension of the formula to more general cases, such as the exponentially-modified Erlang distribution, and we suggest an efficient numerical approach which allows us to explain the contribution to the speed in different limiting cases.

Enrico Gavagnin, University of Bath

An Anisotropic Interaction Model for Simulating Fingerprints *12:10 - 12:35*
Motivated by the formation of fingerprint patterns we consider a class of interaction models with anisotropic interaction forces whose orientations depend on an underlying tensor field. This class of models can be regarded as a generalization of a gradient flow of a nonlocal interaction potential which has a local repulsion and a long-range attraction structure. In contrast to isotropic interaction models the anisotropic forces in our class of models cannot be derived from a potential. The underlying tensor field introduces an anisotropy leading to complex patterns which do not occur in isotropic models. This anisotropy is characterized by one parameter in the model. We study the variation of this parameter, describing the transition between the isotropic and the anisotropic model, analytically and numerically. We analyze the steady states and their stability by considering the particle model and the associated mean-field equations. Besides, we propose a bio-inspired model to simulate fingerprint patterns (and more general any desired pattern) as stationary solutions by choosing the underlying tensor field appropriately.

Lisa Maria Kreusser, University of Cambridge

Kernel Reconstruction for Delayed Neural Field Equations *12:35 - 1:00*
Understanding the neural field activity for realistic living systems is a challenging task in contemporary neuroscience. Neural fields have been studied and developed theoretically and numerically with considerable success over the past four decades. However, to make effective use of such models, we need to identify their constituents in practical systems. This includes the determination of model parameters and in particular the reconstruction of the underlying effective connectivity in biological tissues.
In this talk, we introduce an integral equation approach to the reconstruction of the neural connectivity in the case where the neural activity is governed by a delay neural field equation. To support our idea, we use numerical examples to show the feasibility of the approach for kernel reconstruction, including numerical sensitivity tests, which show that the integral equation approach is a very stable and promising approach for practical computational neuroscience.

Jehan Alswaihli, University of Reading

Student Talks 5A *Tuesday 2:00 - 3:15, 4 West 1.2*

FEniCS.jl, solving PDE's using Julia *2:00 - 2:25*
In this talk we will demonstrate our Julia Package for solving PDE's using the Finite Element Method, initially funded by Google (Open Source Programs). We will initially walkthrough the package, demonstrating the mesh generation and related functionality. We will then examine how mathematical problems can be efficiently described and solved using the code, before proceeding to demonstrate some worked examples, such as 2D-wave problems.

Yiannis Simillides, UCL

Eliminating Gibbs Phenomenon: A non-linear Petrov-Galerkin method for convection-dominated problems *2:25 - 2:50*
We consider the numerical approximation of partial differential equations whose solutions may contain sharp features, such as interior and boundary layers. One of the main challenges of designing a numerical method for these types of problems is that these sharp features can lead to non-physical oscillations in the numerical approximation, often referred to as Gibbs phenomena.
The idea we are pursuing is to consider the approximation problem as a residual minimization in dual norms in Lq-type Sobolev spaces, with 1=<q<2. We then apply a non-standard, non-linear Petrov-Galerkin discretization that is applicable to reflexive Banach spaces, such that the space itself and its dual are strictly convex. Similar to discontinuous Petrov-Galerkin methods, this method is based on employing optimal test functions. Replacing the intractable optimal test space by a suitable computable approximation gives rise to a non-linear inexact mixed method for which optimal a priori estimates hold. This generalizes the Petrov-Galerkin framework developed in the context of discontinuous Petrov-Galerkin methods to more general Banach spaces.
A key advantage of considering a more general Banach space setting is that the oscillations in the numerical approximation vanish as q tends to 1, as we will demonstrate using a few simple numerical examples. This is joint work with Paul Houston, Ignacio Muga and Kris van der Zee.

Sarah Roggendorf, University of Nottingham

Light scattering by complex ice crystals using the Boundary Element Method *2:50 - 3:15*
The Boundary Element Method (BEM), has recently been shown to be a competitive computational method for simulating light scattering problems. BEM is a flexible tool offering accurate simulations even for complex scatterer configurations. It involves reformulating the Maxwell's equations into integral equations on the boundary of the scatterer(s). This requires the solution of large linear systems on the boundary and then extension of the solution to the interior and exterior of the scatterer via the Stratton-Chu representation formulae.
In recent years, certain strategies have been investigated to try to speed up the iterative solution of such large linear systems, including CalderÃšn preconditioning and the use of novel basis functions. In this talk, we will discuss recent developments in the solution of dielectric scattering problems using BEM, the extension of these ideas to scattering by multiple dielectric objects, and their implementation in the software library Bempp. Bempp is an open source library offering fast and accurate simulation of electrostatic, acoustic and electromagnetic scattering problems.
Of particular interest to us are cases of light scattering by ice crystals found in cirrus clouds. We will demonstrate how one can use the above theory and the Bempp library to efficiently solve examples of light scattering by single and multiple ice crystals of complex shape.

Antigoni Kleanthous, UCL

Student Talks 5B *Tuesday 2:00 - 3:15, 4 West 1.7 (Wolfson)*

(2,2) -Tight Surface Graphs *2:00 - 2:25*
For integers $k \geq l$, a graph is (k, l)-sparse if any subset X of the vertex set V spans no more than $k|X| - l$ edges. It is (k, l)-tight if it has $k|V| - l$ edges in total. Sparsity and tightness of graphs have been subject much research. For example (k, k)-tight graphs are exactly those that can be decomposed into edge-disjoint spanning trees by a well-known theorem of Nash-Williams and Tuttle. In geometric rigidity theory, Laman has shown that $(2, 3)$-tight graphs are precisely those for give rise to rigid generic bar and joint frameworks in the plane. In geometric graph theory, certain families of tight graphs arise as contact graphs associated to configurations of geometric objects. In this project, we study inductive constructions for graphs that are embedded in surfaces without edge crossings. In particular, for $(2, 2)$-tight graphs on a torus we exhibit a complete inductive construction theorem for such graphs. We also give a geometric application of this result to representations of graphs as contact graphs of configurations of circular arcs.
Joint work with James Cruickshank, Derek Kitson and Stephen Power

Qays Shakir, NUI, Galway

Anomalous metapopulation dynamics on scale-free networks *2:25 - 2:50*
We model transport of individuals across a heterogeneous scale-free network where a few weakly connected nodes exhibit heavy-tailed residence times. Using the empirical law Axiom of Cumulative Inertia and fractional analysis we show that 'anomalous cumulative inertia' overpowers highly connected nodes in attracting network individuals. This fundamentally challenges the classical result that individuals tend to accumulate in high-order nodes. The derived residence time distribution has a non-trivial U-shape which we encounter empirically across human residence and employment times.

Helena Stage, The University of Manchester

Phase transitions of multistable dynamical networks *2:50 - 3:15*
In this talk we will analyse the dynamic behaviour of multistable networks, i.e. networks with coexisting attractors. We will show that connecting bistable nodes is a simple and effective way to construct multistable networks with any topology. Furthermore, we present a control paradigm for the triggering of phase transition from one stable attractor to another, while only acting on a subset of the nodes. The solution of an optimization problem shows which nodes have to be controlled and how strong the control action has to be. We will show that the feasibility of the task is strongly dependent on the topology of the network and the coupling strength. Numerical examples highlighting different aspects of the dynamics and control will be shown.

Roberto Galizia, NUI, Galway

Abstracts of Posters

Kernel Reconstruction for Delayed Neural Field Equations *Monday 4:45 - 6:30, Poster Session*
See talk of the same title in Student Talks 4B.

Jehan Alswaihli, University of Reading

The stability of embbedded eigenvaluees of Laplace operator *Monday 4:45 - 6:30, Poster Session*
Most mathematical problems that require partial differential equations are generally challenging. The theory of partial differential equations impacts on the development of physical science and is considered as the outstanding creation of the human mind. There are many applications of this theory, making it possible to find the solutions for many problems. In this report, our interest is on spectral theory which is an extremely rich field and which contains many techniques, for example; separation of variables, Fourier transform, Laplace operators, perturbation theory, eigenfunction with its eigenvalue, and variational methods. Our focus will be on mathematical problems involving the stability of "trapped modes" or eigenvalues embedded within continuous spectra for Schrödinger operator or Laplace operator with a relatively compact perturbation. It is known that the perturbation problems for these operators with embedded eigenvalues are generally challenging, since the embedded eigenvalues can not be separated from the rest of the spectra. The existence of embedded eigenvalue occurs in many applications arising in physics, in quantum mechanics for instance, eigenvalues of the energy operator correspond to the energy bonds states. In this paper, we will highlight the idea of existence of embedded eigenvalues for the laplacian with an added potential function, when the underlying domain is a cylinder. There have been several studies on existence of trapped modes which is related to an eigenvalue of laplace operator in mathematics, in (1991), Evans and Linton used some techniques of Ursell method (1951) to prove the existence of trapped modes in the case of an abstraction of shape which is described by two long parallel lines or walls of the channel and showed to separate the problem into solutions (symmetric or antisymmetric) with respect to the centreline. In addition, they identified a trapped mode frequency as an eigenvalue of the Laplace operator on unbounded domain which established the existence of the smallest eigenvalue by using Rayleigh quotient (see, Evans et al.,1993). Furthermore, this research focuses on the development of aspects of the theory of partial differential equations with operator by concentrating on some particular examples of trapped modes; these include the stability of embedded eigenvalues within spectrum for the operator $\Delta - V$ on cylindrical domain for a positive symmetric potential function V. Common threads will be taken from these problems to subsequently develop a more general existence of embedded eigenvalue.

Nifeen Altaweel, Lancaster University

Discretisation of Wasserstein Gradient Flows for Solving Higher Order Nonlinear Partial Differential Equations *Monday 4:45 - 6:30, Poster Session*
Nowadays, as demonstrated in recent articles, there is growing interest and breakthroughs in terms of studying evolution equations with underlying gradient flow structures.
Starting with a basic introduction to the Optimal Transport Problem, this poster shows how we can then expand on existing work carried out, that concerns the variational discretisations of nonlinear partial differential equations which constitutes gradient flows in the Wasserstein metric. The problem focuses on the Derrida-Leibowitz-Speer-Spohn Equation.
We extend the work, where the Minimising Movement Schemes are adapted from the Implicit Euler Scheme (BDF1) (already published) to higher order/steps schemes i.e. Backward Difference Formulas (BDF) of orders 2 to 6 (BDF2 to BDF6) and Diagonally Implicit Runge Kutta (DIRK) Methods up to stage 4, and analyse whether the Numerical convergence L^2-error plots provide better rates of convergence.

Blake Ashworth, University of Sussex

Finding and verifying the nucleolus of cooperative games *Monday 4:45 - 6:30, Poster Session*
In cooperative games players allowed to form coalitions with other players. The nucleolus offers a stable payoff allocation for these games by lexicographically minimising the regret of all possible coalitions. Computing it is desired, however very challenging. The Kohlberg criterion verifies whether a solution is the nucleolus in relatively small games. As opposed to Kohlbergs exponential, we develop a simplified criteria that involves checking linear many sets of coalitions, also reducing the size of these sets. Moreover, we propose a new constructive algorithm computing the nucleolus. Numerical results show that our algorithm outperforms classical and state-of-the-art algorithms.

Marton Benedek, University of Southampton

Machine Learning for Image Analysis *Monday 4:45 - 6:30, Poster Session*
The movement of cells may be described in two forms, pseudopoda and blebbing. The poster will outline a method in which a Hidden Markov Model may be applied to images of a cell blebbing, to gain an insight into the underlying processes behind bleb formation.

Hanson Bharth, University of Warwick

Navier-Stokes-Korteweg Simulations of Dynamic Wetting using the PeTS Equation of State *Monday 4:45 - 6:30, Poster Session*
For a variety of engineering processes, a numerical simulation of dynamic wetting of component surfaces becomes important. Such simulations can be done using finite element phase field models.
Commonly, phase field models use a double-well potential to define the energy density at a point of the computational domain. However, the double-well potential does not adequately represent the free energy density within the small but finite transition zone between the liquid and the gas (vapor) phase. In order to address this issue, the energy density function of the PeTS molecular equation of state [1], which corresponds to molecular dynamics simulations of the Lennard-Jones truncated and shifted (LJTS) fluid and is based on perturbation theory (PeTS), is incorporated into the phase field model. This results in phase field liquid-vapor interfaces that conform to the physical density gradient between the two phases. The model is extended to the dynamic case by a coupling with the compressible Navier-Stokes equations. This coupling requires a tensorial pressure term that complies with the surface tension of the liquid-vapor interface resulting from the PeTS equation of state (comparable to the so-called Korteweg tensor). The contact angle to a (possibly structured) solid surface is not prescribed by a boundary constraint but obtained by considering the energy contributions from the surface tensions of the solid-liquid as well as the solid-vapor interfaces [2].
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[2] M. Ben Said, M. Selzer, B. Nestler, D. Braun, C. Greiner, H. Garcke: A Phase-Field Approach for Wetting Phenomena of Multiphase Droplets on Solid Surfaces, Langmuir 30(14) (2014) 4033-4039.

Felix Diewald, University of Nottingham

An Introduction to Horizontal Mean Curvature Flow *Monday 4:45 - 6:30, Poster Session*
The horizontal mean curvature flow equation is a particular nonlinear degenerate elliptic PDE defined in a sub-Riemmanian geometry, which describes the motion of an hypersurface evolving with normal velocity proportional to its horizontal mean curvature. This equation has interesting applications in biology, such as the Citti-Sarti model for visual cortex, and in computer science. I will give a brief introduction about sub-Riemmanian geometries, with a focus on Carnot groups, and about viscosity solutions. Finally I will present the level sets formulation for the, so called, generalised evolution by horizontal mean curvature flow.

Raffaele Grande, Cardiff University

Droplet Spreading, Chemically Treated Surfaces and Mathematics *Monday 4:45 - 6:30, Poster Session*
See talk of the same title in Student Talks 2B.

Danny Groves, Cardiff University

Decay of Solitary Waves *Monday 4:45 - 6:30, Poster Session*
The relevance of perturbed forms of the Korteweg-de Vries equation to a range of physical problems is discussed. Solutions which are perturbations of solitary travelling wave solutions are considered, focussing predominantly on the Burgers-KdV equation. Asymptotic analysis demonstrates the appearance of a slowly decaying tail behind a core soliton-like solution. Asymptotic results are fully validated by comparison with numerical results.

Dane Grundy, University of East Anglia

Biased Consensus Games *Monday 4:45 - 6:30, Poster Session*
Consider a consensus game played in a cycle with odd length. This game progresses such that, at each round, each node chooses one neighbour at random with equal probability and copy its colour. All changes are made synchronously. We say that the game ends when there is only one colour left. The celebrated results from Hassin and Peleg provide a solution not only for cycles of odd length, but for all non-bipartite undirected graphs. In this poster presentation, we consider the problem above but with a twist. Assume that a given game ended in, say, blue consensus. We assume this game will be played again. However, this time, all nodes will have an equal bias towards blue. This bias can be understood as a weight on each neighbour's colour. For the case with two colours, we derive a formula for the probability of consensus in each of the two colours given the initial configuration of this game played in a cycle of odd length and the bias for each colour. Furthermore, we explore the scenario in which this game is played successively, with an increase of bias towards the winning colours at the end of each iteration. We model this as a random walk on a line in which each direction represents the increase of bias of one of the two colours. We say the game ends when this walk reaches either M or $(-M)$, for a natural number M.

David Kohan Marzagão, King's College London

Topology optimization of frame structures *Monday 4:45 - 6:30, Poster Session*
Interest in doubly-curved frame structures has increased significantly over the past years due to the freedom of design they provide and the continuous development of both design and fabrication tools. The challenge in designing such structures lies in optimizing the layout of their structural grid whilst at the same time incorporating fabrication criteria that will enable their realization in practice. Conway operators are an efficient tool for manipulating the topology of such layouts. Despite the apparent simplicity of their formulation, their consequent application on a structural grid can lead to very complex layouts. Furthermore, the modularity of the resulting geometry lends itself well for application to both single and double layered grid structures whilst at the same time ensures constructability. This research focuses on the development of a computational tool for the layout optimization of double layered grid structures generated using Conway operators. After defining a sequence of Conway operators, the tool optimizes the mass and size of the members in compliance with structural design criteria. Given the low computational cost of the proposed method, it allows for comparative studies to be carried out at an early stage in the design process, and an efficient yet aesthetically desirable layout of members to be determined. Such a study is reported, giving an insight into the relative performance of different materials for a given design problem. The efficiency of the proposed tool is validated through its application on a number of realistic examples as well as on benchmark problems available in literature.

Antiopi Koronaki, University of Bath

Discrete to Continuum Modeling of Biological Transport Networks *Monday 4:45 - 6:30, Poster Session*
Network formation and transportation networks are fundamental processes in living systems. A new dynamic modeling approach to describe the formation of biological transport networks has recently been introduced by Hu and Cai. They propose a discrete, purely local, dynamic adaptation model, based on microscopic physical laws. We study the existence and uniqueness of solutions to this model. Besides, we propose a continuum model and prove the continuum limit of the discrete to the macroscopic model. Using methods from mathematical and numerical analysis we study qualitative properties of network structures such as the existence and stability of steady states. As proposed in experimental studies our analytical and numerical results confirm a phase transition behavior with a uniform sheet (i.e. the network is tiled with loops) or a loopless tree, depending on the value of one of the model parameters.

Lisa Maria Kreusser, University of Cambridge

Active Subspaces in Networks *Monday 4:45 - 6:30, Poster Session*
Models in uncertainty quantification, optimisation and sensitivity analysis use a large number of parameters, which can be expensive and time consuming. Often simulations have to be run multiple times to effectively study inputs and outputs. Using an active subspace approach allows us to identify a linear combination of important parameters instead of analysing all of them individually. This can significantly reduce the dimension of the parameter study. In this work, the method of the active subspaces is applied in the setting of identifying key edges in graphs of networks. This is based on evaluating the Katz centrality of network nodes. The active subspace technique requires the calculation of sample gradients, which can be expensive to obtain using finite difference techniques. We, therefore, derive an analytical expression for the gradient of Katz centrality. A well known test problem in network theory, the so-called Zachary's karate club network, is used as an example to showcase the capability of the method.

Tadas Krikstanavicius, University of Strathclyde

Nonisothermal & Compressible Viscoelastic fluid Modelling *Monday 4:45 - 6:30, Poster Session*
Compressible and nonisothermal effects are often ignored when modelling non-Newtonian fluids. However, flows of viscoelastic materials often occur under extreme conditions with large temperature and pressure gradients where the assumption of constant density, viscosity and temperature is no longer suitable. For example, fluid compressibility can determine the stability and load bearing capacity of polymer infused lubricants used in journal bearings. The generalised bracket method for deriving thermodynamically consistent governing equations are presented along with and some numerical results for 2D flow problems.

Alex Mackay, Cardiff University

Stability of Oscillatory Rotating Disk Boundary Layers *Monday 4:45 - 6:30, Poster Session*
Some of the most popular applications of fluid mechanics come in aerodynamics, and methods of laminar flow control have become increasingly important over the past few decades; especially with the global emphasis on emissions reduction. Another reason for the recent development of this field is the availability of high-performance computers, meaning calculations that would have been impossible only a decade ago can now be performed quickly on a workstation.
With instability mechanisms in common with a swept wing, the rotating disk has long been considered an approximation to this flow and is far more amenable to experiments. The experimental setup for a rotating disk study requires a smaller space and less expensive equipment than the wind tunnel required for swept wing experiments. For this reason, there are a wealth of experimental and theoretical studies of the rotating disk boundary layer and this poster will extend these established results.
A recent study by Thomas et. al. [Proc. R. Soc. A (2011) 467, 2643-2662] discusses adding an oscillatory Stokes layer to a channel flow and shows some stabilising results. We present a similar modification to the rotating disk configuration and provide results from both DNS and local analyses showing a stabilising effect.

Scott Morgan, Cardiff University

A Contour Integral Eigensolver for Dense Nonlinear Eigenvalue Problems *Monday 4:45 - 6:30, Poster Session*
Given a nonempty open set $\Omega \subseteq \mathbb{C}$, our aim is to develop an algorithm to compute eigenvalues λ and eigenvectors x of dense matrix-valued functions $F\colon \Omega \to \mathbb{C}^{n\times n}$, i.e., we want to find pairs $(\lambda, v) \in \Omega \times (\mathbb{C}^{n\times n} \setminus \{0\})$ such that $F(\lambda)v = 0$. We use a contour integral approach to replace the nonlinear eigenvalue problem defined by F with a linear eigenvalue problem $\lambda B_0 - B_1$, where B_0, B_1 are block-Hankel matrices with blocks of the form

$$A_p = \int_{\partial\Omega} z^p F(z)^{-1} V \, dz,$$

for some integer p and given probing matrix V. We combine this approach with a Newton refinement scheme and a deflation strategy. We discuss possible improvements.

Gian Maria Negri Porzio, The University of Manchester

Optimising 'First In Human' trials through dynamic programming *Monday 4:45 - 6:30, Poster Session*
'First in Human' (FIH) or Phase I clinical trials aim to find the maximum tolerated dose (MTD) of a potential new treatment. Clinical trials are expensive and time consuming so we are constantly striving to make them quicker and cheaper whilst still ensuring the safety of those participating in the trial. Subjects enter FIH trials one cohort at a time. Typically the dose of the test treatment allocated to the first cohort is low and is increased for subsequent cohorts. The combination of doses tested over the course of the trial is called the dose escalation scheme and is an important aspect of FIH trial design. This poster shows how the optimal dose escalation scheme can be found by employing dynamic programming. In this context, optimal is defined in terms of minimising a loss function that quantifies the trade off between estimating the MTD accurately and maximising safety. We investigate the properties of a FIH trial design using this scheme through simulation and compare it to the Continuous Reassessment Method (CRM) (O'Quigley et al. 1990) which is a commonly used and well researched design. Dynamic programming produces a design that has similar estimation properties to the CRM but favours dosing subjects at lower dose levels, which makes it a safer trial design.

Lizzi Pitt, University of Bath

Tightness of Surface Graphs *Monday 4:45 - 6:43, Poster Session*
See talk of the same title in Student Talks 5B.

Qays Shakir, NUI, Galway

The auxiliary region method: simulating second-order systems *Monday 4:45 - 6:30, Poster Session*
The auxiliary region method is a spatially extended hybrid-method for the efficient and accurate simulation of reaction-diffusion systems. It utilises the coarse PDE representation in regions of space with large particle numbers, and the fine scale individual-based modelling paradigm in areas with small copy numbers or when parts of space need to be resolved on a fine scale. Here, we use this method in order to simulate a second-order reaction system in three dimensions to demonstrate the accuracy and efficiency of the method.

Cameron Smith, University of Bath

Cancer Research using Drop-seq data *Monday 4:45 - 6:45, Poster Session*
According to Cancer Research UK there were 163.444 deaths from cancer in 2014 in the UK alone and 359.960 new cases in 2015.
The recently developed Drop-seq technology enables to analyse the RNA expression genome-wide of thousands of individual cells at once. Application of this technology to primary tumour biopsies and samples taken pre-, mid- and post-chemotherapy provides data that has the potential to answer the following questions: How will the tumour spread and develop? How is it likely to respond to conventional interventions and more targeted therapies?
Finding answers to these questions will lead to more personalised and targeted approaches in cancer treatment. However, the analysis of the data is complex and comes with several mathematical challenges, which my research focusses on.

Annika Stechemesser, University of Warwick

Solving PDEs using Residual Minimization in Discrete Dual Non-Hilbert Norms *Monday 4:45 - 6:30, Poster Session*
In this poster, we present the inexact nonlinear Petrov-Galerkin method for solving linear PDEs in Banach-space settings, which is a general methodology for obtaining stable approximations to PDEs in non-standard low-regular settings, for example first-order PDEs (transport) with discontinuous solutions.

Kris van der Zee, University of Nottingham

Mathematically Modelling indoor wifi propagation. *Monday 4:45 - 6:30, Poster Session*
The method of geometric optics is applied to a simplified domestic environment to simulate the trajectories of wifi waves. Randomness is then used to account for phase change and predict the signal strength distribution over the domain. Weighted sums are then used to characterise the quality of the coverage. This model can then be applied to different source locations to optimise transmitter locations in an environment.

Hayley Wragg, University of Bath

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