Thursday plenary lectures

Christl Donnelly

MRC Centre for Outbreak Analysis and Modelling, Department of Infectious Disease Epidemiology, Imperial College London

An epidemiologist's life on the edge (of the science-policy interface)
Ebola, MERS, pandemic influenza and SARS have all posed serious threats to our health and economic wellbeing in recent years. In each of these cases, statistical (and more broadly mathematical) epidemiologists contributed to top-level policy discussions of diseases control policy development, implementation and contingency planning. The methods build upon foundations of epidemiological modelling and analysis of both human and animal diseases (HIV/AIDS, BSE, vCJD and foot-and-mouth disease, among others). The potential impact of such analysis is enormous, but it can be challenging to provide robust answers to key scientific and policy questions. In the midst of an epidemic response effort, it really does feel like living on the edge.

Miranda Mowbray

HP Labs

Big Data: drinking from the firehose
The data scientists who use maths to find useful patterns in large data sets have been described as the new rock stars of the technology world. One particularly promising application area for big data analysis is computer network security. Miranda will talk about some general issues with analyzing big data to discover security problems in enterprise computer networks, and some specific techniques that have been successful.

Caroline Series

University of Warwick

Mirzakhani's starting point
In 2014, Maryam Mirzakhani of Stanford University became the first woman to be awarded the Fields medal. The starting point of her work was a remarkable relationship called McShane's identity, about the lengths of simple closed curves on certain hyperbolic surfaces. The proof of this identity, including the Birman-Series theorem about simple curves on surfaces, uses only quite basic ideas in hyperbolic geometry which I will try to explain. We will then look briefly at Mirzakhani's ingenious way of exploiting the identity and where it led.

Friday plenary lectures

Kristin Lauter

Microsoft Research

How to keep your secrets in a post-quantum world
This talk will give an overview of the history of various hard problems in number theory which are used as the basis for cryptosystems. I will survey the evolution of attacks on them and improvements to the algorithms which enabled their attacks. Then I will present some current proposals for post-quantum systems using lattice-based cryptosystems in cyclotomic number fields and give the ideas behind some recent attacks.

Nathalie Vriend

University of Cambridge

Research in deserts and mountains ... with mathematics on my mind!
In this presentation, I will show you how applied mathematics plays an important role in the understanding of our natural environment. My research expertise covers granular materials and I have traveled to various places on this earth to investigate the behavior of snow avalanches in mountains and sand dunes in deserts. Our research group combines field experiments with laboratory experiments (in the GK Batchelor laboratory underneath the courtyard of the Centre for Mathematical Sciences in Cambridge) and uses mathematical tools to model these observations. Our goal is to understand the dynamic behavior of granular flows and potentially even predict some outcomes of avalanches.

Thursday Parallel session 1

1430--1500 Natasha Morrison

University of Oxford

Saturation in the Hypercube

The hypercube of dimension d, denoted Q_d, is the graph with vertex set $\{0,1\}^d$ where two vertices are joined if they differ in exactly one co-ordinate. Given $d \geq m$, a spanning subgraph G of Q_d is said to be (Q_d, Q_m)-*saturated* if it does not contain Q_m as a subgraph but adding any edge of $E(Q_d) \setminus E(G)$ creates a copy of Q_m in G. We say G is *weakly* (Q_d, Q_m)-*saturated* if the edges of $E(Q_d) \setminus E(G)$ can be added to G one at a time so that each additional edge creates a new copy of Q_m.

In this talk we answer two questions of Johnson and Pinto. First we show that for fixed $m \geq 2$ the minimum number of edges in a (Q_d, Q_m)-saturated graph is $\Theta(2^d)$. We also determine the minimum number of edges in a weakly (Q_d, Q_m)-saturated graph for all $d \geq m \geq 1$. This is joint work with Jon Noel and Alex Scott.

1500--1530 Anne Hillebrand

University of Oxford

Colour degree matrices of graphs with at most one cycle

Colour degree matrix problems, also known as edge-disjoint realisation and edge packing problems, have connections for example to discrete tomography. Necessary and sufficient conditions are known for a demand matrix to be the colour degree matrix of an edge-coloured forest. We will give necessary and sufficient conditions for a demand matrix to be realisable by a graph with at most one cycle, and a polynomial time algorithm to find a such a realisation, or a violating set if no realisation exists.

Thursday Parallel session 2

1430--1500 Victoria Allan

University College London

Making the most out of the mismatched, messy, and missing Electronic Health Records (EHR)

Electronic health records (EHR) contain valuable clinical information (such as symptoms, diagnoses, and medications), and are collected routinely, each time patients interact with health care services across the United Kingdom (UK). These data hold the potential to transform how health-related research is conducted and in turn influence clinical practice and patient care, however there are a number of concomitant challenges in the way of achieving this. Data are 'mismatched'; information collected from general practices (GP), are not linked up with information collected from hospitals. Data are 'messy'; the amount, type and quality of the information captured can vary considerably. Data are also frequently 'missing', but not necessarily missing by chance. Mismatched, messy and missing data can bias study findings, but fortunately there are a number of mathematical approaches (such probabilistic matching and multiple imputation) to combat this. This presentation will consider how these methods are applied to GP and hospital data, using specific examples in cardiovascular disease.

1500--1530 Alina Peluso

Brunel University

Pay for Performance incentives lead to better patient health outcomes

The ``Pay-for-Performance'' (P4P) approach has been widely adopted in health care systems. By supplying incentives to health care providers in order to achieve an improved performance, an increasing quality of care or reduction in costs is expected. In this paper, we evaluate the effectiveness of this approach, using data from the Italian Lombardy region where a rewarding program was introduced in 2012. Data are available over four years, two years prior and two years post implementation of the program. Mixed effects models at a ward, hospital and patient level and over multiple outcomes are used to test for improvements on the performance of the wards that received the reimbursement bonus (nine specialities) after the policy intervention and in comparison with the wards used as control group. Our analysis shows that the policy introduction has overall an effect on the hospital performance, with certain wards benefiting from the policy more than others. Furthermore, we observe a significant improvement for those hospital outcomes that could be more influenced by a managerial action rather than those more affected by the patients' condition. Finally, radar plots are used at a hospital-ward level to summarise the results and provide an easy-to-read visualization of the results for stakeholders.

Thursday Parallel session 3

1430--1500 Rachael Bonnebaigt

University of Cambridge

The effect of phase change material on reducing fluctuations in building temperatures
Modern, lightweight buildings provide little buffering of daily temperature variations. Phase change materials (PCMs), such as wax, can provide such buffering -- they melt when it's hot, storing heat, and solidify when it's cold, releasing heat. We use the appropriate nonlinear diffusion equation modelling the varying thermal diffusivity of phase change material, due to Richardson and Woods [Proc. R. Soc. A 464 (2008) 1029 -- 1056]. We first use the model to optimise PCM properties: the amount of PCM and how it is distributed through the wall. Next, we explore how PCM thermal mass interacts with its surroundings. In particular, we look at a naturally ventilated space with a ceiling that contains PCM, at a hot period and at a period where the hot days are longer than the cool nights. We find that PCM is beneficial when used in appropriate quantities and locations.

1500--1530 Tania Khaleque

University of Oxford

Mantle convection with strongly temperature and pressure dependent viscosity
The convection in the Earth's mantle is a complicated phenomenon that causes various tectonic activities and makes the mantle evolve on geologic time scale (billions of years). The complicated behaviour of mantle convection all comes from the complicated nature of the convecting mantle materials. Our focus is on the influence of variable viscosity on the mantle convection. We propose a mathematical model for a basally heated mantle that incorporates temperature and pressure-dependent viscosity defined in an Arrhenius form. The mathematical model is solved numerically for large viscosity variations across the mantle in a unit aspect-ratio cell and steady solutions for temperature, isotherms and streamlines are obtained. In order to improve the efficiency of numerical computation, we use a modified form of viscosity with a low temperature cut-off. The results are in good agreement with the previous results. And continued numerical experiments suggest that narrow cells are preferred at extreme viscosity contrasts which is supported by the linear stability analysis.

Friday Parallel session 1

1000--1030 Anja Komatar

University of Leeds

An Introduction to Structural Ramsey Theory

Suppose we invite 6 people to a party - even if that were random six people we saw in a local supermarket, either three of them will be friends or three will be strangers. Representing those people as vertices and a red edge between strangers, we claim that we can find a monochromatic triangle in any complete graph on six vertices with two-coloured edges. Instead of colouring complete graphs and its edges, we could colour bigger subgraphs of various graphs and looking for a one with all subgraphs of a certain colours. Similarly, in structural Ramsey theory, given any substructure A of B, we want to find a structure C, such that whenever we colour substructures A of C, we can find a monochromatic B. I will state the kind of problems structural Ramsey theory considers and discuss examples.

Friday Parallel session 2

0930--1000 Magdalini Flari

University of Sheffield

Lie algebroids and Poisson geometry, together again

Lie algebra duals are one of the key examples of Poisson manifolds; indeed any linear Poisson structure is the dual of a Lie algebra structure. The standard symplectic structure on a cotangent bundle can be seen as arising from the bracket of vector fields in the same way.

This correspondence between Lie theory and Poisson geometry is encompassed by the duality of Lie algebroids. Once we describe this relation, we will give several enlightening examples, and reach the next level, Lie bialgebroids.

1000--1030 Jolanta Marzec

University of Bristol

A dance on the edge of number theory

In the last few decades the interest in the theory of (classical and Siegel) modular forms has experienced a significant growth. One of the reasons for that is their relation, through L-functions, with central objects of algebraic geometry such as elliptic curves or abelian surfaces. During the talk we will gently expose this connection and reveal some surprising properties on both sides. At the end we will focus on the building blocks of Siegel modular forms - their Fourier coefficients, and investigate their intimate relation with central values of L-functions.

1030--1100 Lubna Shaheen

University of Oxford

A geometric model of representations of $\mathbb{Z}$

The aim of this project is to attach a geometric structure to the ring of integers. It is generally assumed that the spectrum Spec($\mathbb{Z}$) defined by Grothendieck serves this purpose. However, it is still not clear what geometry this object carries. E.g. Y I. Manin discusses what the dimension of Spec($\mathbb{Z}$) could be, speculating that it may be 1,3 or infinity. A.Connes and C.Consani published recently an important paper in which they introduces a much more complicated structure called the arithmetic site on the basis of Spec($\mathbb{Z}$).

Our approach is based on the generalisation of constructions applied by Boris Zilber for similar purposes in non-commutative (and commutative) algebraic geometry.

The aim of this work is two folded. Firstly, we want to connect the study of Zariski geometries to the schemes of arithmetic types, in particular to the schemes of Spec($\mathbb{Z}$), by considering it as a coordinate ring or a set of representation of $\mathbb{Z}$. The set of representations of ($\mathbb{Z}$) is related to Spectrum of ($\mathbb{Z}$) but still very different as we will explain it later.

Secondly, we are anticipating to answer the questions of dimension of Spec($\mathbb{Z}$) asked by Manin in a more reasonable way.

Friday Parallel session 3

0930--1000 Katie Gittins

University of Bristol

The Heat Content of a Polygon
Take an open, bounded set $\emptyset \neq D \subset \mathbb{R}^2$ with initial temperature 1 inside D, while the complement of D has initial temperature 0. Allow the heat to flow out of D. A natural question is: how much heat is left inside D at time $t > 0$? Formally, this quantity is called the *heat content of D in $\mathbb{R}^2$ at t*. It is defined via the solution of the heat equation on $\mathbb{R}^2$ subject to the aforementioned initial conditions, and has an asymptotic expansion in powers of $t^{\frac{1}{2}}$. For small time, the coefficients of powers of $t^{\frac{1}{2}}$ rely heavily upon the geometry of D. Supposing D has polygonal boundary, we will discuss the interplay between the geometry of D and its heat content for small time. In addition, we will use these results to obtain the heat content (for small time) of a fractal polyhedron.

1000--1030 Ma Elena Hernández-Hernández

University of Warwick

Probabilistic approach to solve fractional differential equations
Fractional differential equations have become a matter of interest for modelling a variety of phenomena which behave as anomalous diffusions. Different methods have been used to study this type of equations. In this talk we focus on a new probabilistic approach to solve them. This method makes use of the (recently introduced) probabilistic interpretation of fractional operators as generators of certain Feller processes.

1030--1100 Meena Kotecha

London School of Economics

Addressing Mathematics and statistics anxiety in undergraduates
Communicating mathematics and statistics, especially to non-specialist undergraduates, is a challenge all academics involved with delivering courses related to these disciplines face to a certain degree. ``Mathematics and statistics anxiety'' is one of the main issues in these student cohorts, which obstructs their engagement with the subjects.

This interactive and lively presentation aims to share some of the features of a teaching model developed during a longitudinal study conducted to understand and address this challenge. ``Mathematics and statistics anxiety'' is a highly complex issue and requires extremely delicate handling. It may be due to a variety of reasons and can be successfully addressed by carefully designed course material and delivery.

Applicability of these features is not limited to teaching mathematics and statistics; educators from all related disciplines should be able to apply the proposed techniques to their respective areas. Further, it should be of interest to educators from all disciplines, as well as researchers and all interested in the theme.

Friday Parallel session 4

1000--1030 Alexis Kaminski

University of Cambridge

Evolution of Linear Optimal Perturbations in Stratified Shear Layers
Stratified shear flows are ubiquitous features in the oceans and atmosphere, and the study of such flows is a canonical problem in fluid dynamics. Classical normal-mode stability analysis has given rise to many results for such flows; one of the most famous is the Miles-Howard stability theorem, which states that a necessary condition for normal-mode instability in parallel, inviscid, steady stratified shear flows is that the gradient Richardson number, Ri_g is less than $1/4$ somewhere in the flow. However, non-normal modes may undergo substantial transient growth at finite times even when $Ri_g > 1/4$ everywhere in the flow. We have calculated the ``optimal perturbations'' which maximize linear perturbation energy gain for a stably-stratified shear layer. We then give these optimal perturbations a small but finite initial amplitude and use them to initialize direct numerical simulations. The optimal perturbation are observed to grow at the predicted linear rate initially, but in some cases experience sufficient transient growth to become nonlinear and susceptible to secondary instabilities which break down into turbulence. We will describe the nonlinear evolution of the optimal perturbations, as well as the resulting turbulence and mixing.

1030--1100 Srisivane Sivanesan

Oxford Brookes University

Non-iterative three-dimensional image reconstruction algorithm for Electrical Impedance Mammography
The forward problem for complex electrical impedance tomography (EIT) is solved using a meshless method, namely the method of fundamental solutions (MFS). The MFS for the 3D complex EIT direct problem is numerically implemented and its efficiency, accuracy and numerical convergence of the MFS-based solution are analysed when assuming the presence in the medium (background) of one or two inclusions with the physical properties (i.e., conductivity and permittivity) different from those of background. Numerical examples for various convex and non-convex smooth shapes (e.g. spherical, ellipsoidal, peanut-shaped and acorn-shaped) and sizes of the inclusion(s) are presented and thoroughly investigated.

Friday Parallel session 5

1000--1030 Katy Gaythorpe

University of Bath

Minimising infectious disease outbreaks after natural disasters
In a crisis situation, what is the best way to use limited time, money and resources to minimise the spread of infectious diseases? We consider the threat of environmentally transmitted pathogens to a developing world city after severe flooding. Our methodology abstracts the problem into a mathematical model in which epidemiological dynamics occur through a metapopulation structure. This metapopulation incorporates heterogeneous attributes such as population density, sanitation provision and connectivity. We apply sensitivity techniques, including impact, influence and resilience analyses, to the disease free and endemic states of this system to identify the most effective implementations of several transmission control strategies. The outcome depends on the nature of the heterogeneities in the system and the target criteria. Our results offer specific and general insights into how heterogeneities in a community influence the effectiveness of disease control strategies. These insights provide a framework in which to make better informed decisions about the most efficient deployment of limited resources to contain infectious outbreaks in the aftermath of a natural disaster.

1030--1100 Chloe Spalding

University of Birmingham

Mathematical Modelling of the population dynamics of Pseudomonas aeruginosa with a view to developing novel antimicrobials
Antibiotic resistance is fast becoming one of the largest global health concerns of the 21st century and understanding how resistance develops is fundamental in establishing new therapies to cure bacterial infections. Here, we introduce a differential equation model that can describe the population dynamics of P. aeurginosa treated with the antibiotic meropenem. P. aeurginosa is a nosocomial opportunistic pathogen which is especially dangerous for those that are immunocompromised due to its versatility. Various data fitting techniques are used to fit the model to experimental data. These shed light on the mode of action of meropenem on P. aeruginosa and suggest a novel model formulation that should be used to capture the mechanistic interactions between the drug and pathogen. We discuss possible extensions to the model to aid with the development of novel antimicrobials.

Thursday Panels

Session 1: The gender gap in first class degrees

A panel discussion with Janet Dyson (Oxford), Emma McCoy (Imperial), Elizabeth Morland (Oxford), Ellen Powell (Cambridge).
Chair: Jessica Spencer (Oxford).
Organised by the Mirzakhani Society.

Session 2: Careers: what can I do with a maths PhD?

A panel discussion with Heather Harrington (Oxford), Miranda Mowbray (HP Labs), Jennifer Scott (Rutherford Appleton Laboratory), Heather Tewkesbury (Smith Institute).
Chair: Elizabeth Mansfield (Kent).

Session 3: Obtaining funding for research in maths

Organised by Laura Watkin (EPSRC) and Hannah Maytum (EPSRC), with assistance from the Oxford Mathematical Institute's Research Facilitation Team.
Chair: Peter Clarkson (Kent).

Session 4: To me success means ...

A panel discussion with Eugenie Hunsicker (Loughborough), Kristin Lauter (Microsoft Research), Ulrike Tillmann (Oxford), Ruth Williams (Cambridge).
Chair: Marta Mazzocco (Loughborough)

Friday Panels

Session 1: Diversity in maths

A panel discussion with Jennifer Balakrishnan (Oxford), Peter Clarkson (Kent), Cathy Hobbs (UWE), Kristin Lauter (Microsoft Research).
Chair: Alison Etheridge (Oxford).

Session 2: Combining career and family

A panel discussion with Janet Dyson (Oxford), Rosie Robison (Anglia Ruskin), Gwyneth Stallard (Open), Nathalie Vriend (Cambridge).
Chair: Frances Kirwan (Oxford).

Session 3: Careers: what can I do with a maths degree?

A panel discussion with Rebecca Cotton-Barratt (Oxford), Ceri Fiddes (Millfield School), Nancy Nichols (Reading), Rachel Thomas (PLUS).
Chair: Ursula Martin (Oxford).

Session 4: PhDs from the perspectives of students and supervisors

A panel discussion with Rachael Bonnebaigt (Cambridge), Helen Byrne (Oxford), Diana Maclagan (Warwick).
Chair: Julia Gog (Cambridge).