LMS Prospects in Mathematics Meeting – Warwick
7/8 September 2018

All talks are in MS.02 (Zeeman Building)

Friday

12:00-13:00h	**Registration and lunch**
13:00-13:15h	**Welcome, followed by a few words from LMS**
13:15-14:00h	**Felix Schulze (UCL London)** *Recent Advances in Geometric Analysis*
14:00-14:45h	**Nina Snaith (Bristol)** *Discovering random matrices here, there and everywhere*
14:45-15:30h	**Benedict Leimkuhler (Edinburgh)** *A random walk from molecular dynamics to data science*
15:30-16:00h	**Coffee/Tea break**
16:00-16:45h	**Julia Böttcher (LSE London)** *Discrete Mathematics*
16:45-17:30h	**Ivan Graham (Bath)** *Modern Topics in Numerical Analysis and Scientific Computing*
17:30-18:15h	**Federica Dragoni (Cardiff)** *Sub-Riemannian manifolds and geometric properties of sub-elliptic PDEs*
18:15-18:30h	**Student Talk by Iliana Peneva (MathSys CDT Warwick)**
18:30-19:15h	**Reception (wine & nibbles in the street)**
19:15-22:00h	**Dinner (Mathematics Common Room)**
19:30-20:30h	**Break-out session: women in maths (Mathematics Common Room)**

Saturday

09:00-09:45h	**Chandrasekhar Venkataraman (Sussex)** *Research in Mathematical Biology*

09:45-10:30h **Rachel Newton (Reading)**
Diophantine equations

10:30-11:00h **Coffee/Tea break**

11:00-11:45h **Andras Juhasz (Oxford)**
Low-dimensional topology: knots and surfaces

11:45-12:30h **Christina Goldschmidt (Oxford)**
Scaling limits in probability

12:30-13:00h **Lunch in the street**

13:00-13:15h **Student Talk by Trish Gunaratnam (MASDOC CDT Warwick)**

13:30-14:15h **Jason Miller (Cambridge)**
Random planar geometry

14:15-15:00h **Darren Wilkinson (Newcastle)**
Bayesian inference for big data

List of abstracts

1.) Felix Schulze (UCL)

Title: Recent Advances in Geometric Analysis
Abstract: We will survey some recent advances in Ricci flow, the min-max theory of minimal surfaces and mean curvature flow.

2.) Nina Snaith (Bristol)

Title: Discovering random matrices here, there and everywhere
Abstract: Points on a line can be perfectly periodically spaced, completely random, or demonstrate distinctive correlations in their positions. The study of the eigenvalues of Hermitian or unitary random matrices involves investigating the distribution of points on a line. Their distinctive distribution appears to be universal and occurs in many places in the wider world, having been observed in the vibrational frequencies of aircraft, communication networks, zeros of famous number theoretical functions such as the Riemann zeta function,

eigenenergies of classically-chaotic quantum systems, biologically-important events on chromosomes and more. This talk will introduce random matrix theory and discuss some of the many places it surfaces.

3.) Benedict Leimkuhler (Edinburgh)

Title: A random walk from molecular dynamics to data science

Abstract: Models of biological molecules and neural networks both lead to `extended dynamical systems.' In the case of the molecule the key variables are the positions of the atoms; for the neural network, the states are parameters that describe the way the network processes information. In either case, due to the complexity of the interactions involved, one needs to take a probabilistic perspective to understand the system. In the talk, I will describe the mathematical formulation of such systems and I will discuss the design of Markov chains that efficiently explore the most likely states. I will show that surprisingly similar mathematical procedures can be used for each application.

4.) Julia Böttcher (LSE London)

Title: Discrete Mathematics

Abstract: Discrete Mathematics is the study of discrete structures, such as graphs, hypergraphs, permutations or partially ordered sets, but also the integers, or discrete geometric objects. In the last decades, the field gained in importance through its strong connections to computer science and operations research. Moreover, powerful proof frameworks were developed, such as the probabilistic method or the regularity method, leading to a significant advance in our understanding. The UK has a strong field of researchers in Discrete Mathematics, and the area offers a variety of interesting and challenging directions of research.

5.) Ivan Graham (Bath)

Title: Modern Topics in Numerical Analysis and Scientific Computing

Abstract: In this talk I'll present some current exciting directions for PhD research in Numerical Analysis and Scientific Computing. The areas I will present will have strong practical and technological motivation but will also provide ample opportunity for elegant mathematical theory. As such they will be suitable for students with strong undergraduate Mathematics training who are interested in rigorous mathematics motivated by applications. I'll describe some topics from the following list:

* Uncertainty quantification for partial differential equations
* High dimensional problems
* Inverse problems, e.g. Seismology
* Randomised algorithms in linear algebra
* Mathematical approaches in machine learning

6.) Federica Dragoni (Cardiff)

Title: Sub-Riemannian manifolds and geometric properties of sub-elliptic PDEs
Abstract: I will introduce Carnot groups focusing on both their non-commutative Lie groups' structure and their sub-Riemannian manifolds' structure. I will then introduce some geometrical notions such as convexity and star shapedness adapted to the underlying non-Euclidean structure and show that, unlike the Euclidean or Riemannian case, some new, unexpected facts happen. Then I will investigate the connections between these geometrical notions and a large class of PDEs, namely sub-elliptic equations, that naturally generalise the elliptic case.

Saturday:

7.) Chandrasekhar Venkataraman (Sussex)

Title: Research in Mathematical Biology
Abstract: Mathematical biologists use mathematical methods to help understand biological problems. This can take the form of applied studies where they work together with biologists on real biological systems or more theoretical works where biology provides the motivation for the development of new mathematics. Postgraduate study in math biology is therefore very diverse and modern math biologists can be found across all fields of mathematics from Pure to Applied. In this talk, I will discuss the mathematical modelling of cell biological problems and I will attempt to illustrate the different strands of research math biologists carry out. We will see how mathematical methodologies can help cell biologists interpret experimental imaging data and how problems from cell biology provide the motivation for the development of new results in the analysis of PDEs.

8.) Rachel Newton (Reading)

Title: Diophantine equations
Abstract: I will introduce a modern approach to the ancient study of integer solutions to polynomial equations. I will demonstrate some methods for proving the existence and non-existence of solutions, using local-global principles. I will discuss current research directions in this area of number theory and will end by listing some universities in the UK which are active in number theory research.

9.) Andras Juhasz (Oxford)

Title: Low-dimensional topology: knots and surfaces
Abstract: An n-manifold is a topological space that locally looks like n-dimensional coordinate space. Surprisingly, the most difficult dimensions to understand are 3 and 4. Low-dimensional topology is an important area of mathematics that studies manifolds in exactly these dimensions. Knots play a central role in low-dimensional topology as they can be used to construct all 3- and 4-manifolds and they also appear in physics, biology, and chemistry. Knot Floer homology is a powerful, computable, and geometrically rich invariant

of knots defined by Ozsvath-Szabo and Rasmussen in 2002. It is a fundamental question of low-dimensional topology to understand the surfaces a knot can bound in the 4-ball. In this talk, I will explain how knot Floer homology can be used to distinguish disks bounded by a knot in the 4-ball.

4.) Christina Goldschmidt (Oxford)

Title: Scaling limits in probability

Abstract: One of the first things we learn in undergraduate probability courses is that there are different senses in which a sequence of random variables can converge. The term "scaling limit" usually refers to the situation where we have some sequence of random objects (S_n)_{n \ge 1} which are, roughly speaking, getting bigger as n increases, in such a way that when we rescale by the right function of n, there is a limit \emph{in distribution}, S. A familiar example is given by the central limit theorem: let X_1, X_2, \ldots be independent and identically distributed real-valued random variables with mean 0 and finite variance \sigma^2 > 0. Then if we take S_n = \sum_{i=1}^n X_i we get that \frac{1}{\sigma \sqrt{n}} S_n converges in distribution as n \to \infty to S which has N(0,1) distribution. Notice that the limit only depends on the distribution of the X_i's through a scaling constant given by the variance! In this example, the random objects are real-valued, but we are often interested in random versions of much more complicated mathematical structures. I will spend some time talking about random walks (which we may think of as random functions) and their scaling limit, Brownian motion, which is one of the fundamental processes of probability theory. Finally, I will turn to scaling limits of random trees, which is one of the topics of my own research.

5.) Jason Miller (Cambridge)

Title: Random planar geometry
Abstract: In the last several decades, there have been enormous breakthroughs in understanding random geometric phenomena in two dimensions. Much of this has been made possible due to the invention of the Schramm-Loewner evolution (SLE) by Oded Schramm in 1999. SLE is a random, fractal curve which turns out to describe the large-scale behavior of the geometric structures which arise in many two-dimensional models from statistical mechanics (e.g., percolation, loop-erased random walk, the uniform spanning tree). In this talk, I will discuss some of these models and SLE as well as describe some more recent work in the field.

6.) Darren Wilkinson (Newcastle)

Title: Bayesian inference for big data
Abstract: Now is a great time to be a statistician. The data revolution is transforming every aspect of our lives, and there is a critical shortage of people with the expertise necessary to transform large and varied sources of data into actionable knowledge and insight. The mathematical discipline of statistics provides the necessary foundation underpinning the

principled analysis of data, and it is currently thriving due to advances in theory, methodology, computational power, and data availability.

This talk will focus on one small aspect of this much bigger picture. We will look at how technology improvements in molecular biology are leading to the generation of large data sets requiring sophisticated statistical models for analysis and interpretation. Here, as in many other applications, the combination of Bayesian modelling and advanced computationally intensive algorithms enables the generation of new scientific knowledge.