The Complexity Cluster Event organisers, Professor Helen Byrne and Professor Gui-Qiang G. Chen, cordially invite you to attend a Complexity Cluster Special Public Lecture and Research Workshop on Wednesday, 12nd February 2025 in the Glen Callater Room, H B Allen Centre, Keble College. The details of the event are given below.

Complexity Cluster Event

Venue: Glen Callater Room, H B Allen Centre, Keble College
Date: Wednesday, 12 February 2025

Programme:

4.10 - 4.30pm: Coffee, Drinks & Refreshments

Complexity Cluster — Special Public Lecture

4.30 – 5:00pm: **Professor Helge Holden, Keble Senior Visiting Scholar**
NTNU Norwegian University of Science and Technology
Chair of the Abel Prize Committee

Title: The Abel Prize --- One of the Most Prestigious Prizes in Mathematics

Abstract: The Abel Prize was introduced in 2003 and has, in a short time, established itself as one of the most prestigious prizes in mathematics. In the talk, we survey the history of the prize and discuss some of its recipients.

5:00-5:20pm: Coffee, Drinks & Refreshments

Complexity Cluster Research Workshop

5:20pm-5:40m: Professor Jose Carrillo, Mathematical Institute, Oxford

Title: ***Aggregation-Diffusion Equations for Collective Behaviour in the Sciences***

Abstract: Many phenomena in the life sciences, ranging from the microscopic to macroscopic level, exhibit surprisingly similar structures. Behaviour at the microscopic level, including ion channel transport, chemotaxis, and angiogenesis, and behaviour at the macroscopic level, including herding of animal populations, motion of human crowds, and bacteria orientation, are both largely driven by long-range attractive forces, due to electrical, chemical or social interactions, and short-range repulsion, due to dissipation or finite size effects. Various modelling approaches at the agent-based level, from cellular automata to Brownian particles, have been used to describe these phenomena. An alternative way to pass from microscopic models to continuum descriptions requires the analysis of the mean-field limit, as the number of agents becomes large. All these approaches lead to a continuum kinematic equation for the evolution of the density of individuals known as the aggregation-diffusion equation. This equation models the evolution of the density of individuals of a population, that move driven by the balances of forces: on one hand, the diffusive term models diffusion of the population, where individuals escape high concentration of individuals, and on the other hand, the aggregation forces due to the drifts modelling attraction/repulsion at a distance. The aggregation-diffusion equation can also be understood as the steepest-descent curve (gradient flow) of free energies coming from statistical physics. Significant effort has been devoted to the subtle mechanism of balance between aggregation and diffusion. In some extreme cases, the minimisation of the free energy leads to partial concentration of the mass. Aggregation-diffusion equations are present in a wealth of applications across science and engineering. Of particular relevance is mathematical biology, with an emphasis on cell population models. The aggregation terms, either in scalar or in system form, is often used to model the motion of cells as they concentrate or separate from a target or interact through chemical cues. The diffusion effects described above are consistent with population pressure effects, whereby groups of cells naturally spread away from areas of high concentration. This talk will give a short overview of the state of the art in the understanding of aggregation-diffusion equations, and their applications in mathematical biology.

5:45pm –6:05pm: François Caron, Tutorial Fellow of Keble College
Department of Statistics, University of Oxford

Title: Frequentist, Assisted by Bayes, Prediction-Powered Inference

Abstract: Prediction-powered inference (PPI) enables valid statistical inference by combining experimental data with machine-learning predictions, without making assumptions about the quality of the machine-learning predictions. When a sufficient number of high-quality predictions is available, PPI results in more accurate estimates and tighter confidence intervals than traditional methods. Here, we propose informing the PPI framework with prior knowledge regarding the quality of the predictions, considering that predictions are (i) usually very good but (ii) sometimes prone to large errors and hallucinations. The resulting method, which we call frequentist, assisted by Bayes, PPI (FAB-PPI), improves over PPI when the observed prediction quality is likely under the prior, while maintaining its frequentist guarantees. Furthermore, when using heavy-tailed priors, FAB-PPI adaptively reverts to standard PPI in low prior probability regions. We demonstrate the benefits of FAB-PPI through real and synthetic examples. Joint work with Stefano Cortinovis.

6:10pm-6:30pm: Professor Andras Juhasz, Tutorial Fellow of Keble College
Mathematical Institute, University of Oxford

Title: The Unknotting Number, Hard Unknot Diagrams, and Reinforcement Learning

Abstract: I will discuss recent work on using reinforcement learning to study the additivity of the unknotting number. As a byproduct, we have obtained many new hard unknot diagrams. This is joint work with Taylor Applebaum, Sam Blackwell, Alex Davies, Thomas Edlich, Marc Lackenby, Nenad Tomasev, and Daniel Zheng.

6:30pm-7:00pm: Discussion

We look forward to seeing you there.

Best regards,
Helen Byrne and Gui-Qiang G. Chen