

The Complexity Cluster Event Organisers Professor Gui-Qiang G. Chen, Professor Helen Byrne, and Professor Mohit Dalwadi, cordially invite you to attend a Complexity Cluster Research Workshop on Tuesday, 20<sup>th</sup> May 2025, in the Glen Callater Room, H B Allen Centre, Keble College.

The details of the event are given below.

## **Complexity Cluster Research Workshop**

**Venue:** Glen Callater Room, H B Allen Centre, Keble College

**Date:** Tuesday, 20<sup>th</sup> May 2025

**Organisers:** Professor Helen Byrne

Professor Gui-Qiang G. Chen

Professor Mohit Dalwadi

### **Programme:**

**4.00pm – 4.15pm: Coffee, Drinks & Refreshments**

**4:15pm – 4:40pm: Professor Didier Bresch**

**CNRS and Universite Savoie Mont-Blanc, France**

**Title: Mathematical Topics around Granular Media**

**Abstract:** In this presentation, I will discuss how the study of complex flow phenomena encourages further research in mathematics, both theoretically and numerically. I will focus on specific properties of phenomena related to granular materials and present recent results and open problems.

**4:45pm – 5:10pm: Dr. Keith Chambers, Mathematical Institute, University of Oxford**

**Title: Structured Population Models to Explore Lipid-Driven Macrophage Heterogeneity in Early Atherosclerotic Plaques**

**Abstract:** Atherosclerosis is a chronic inflammatory disease of the artery wall and a leading cause of death worldwide. A particular danger is the clinically silent development of its early stages. These early stages are characterised by the accumulation of fatty compounds (lipids) within immune cells called monocyte-derived macrophages (MDMs). MDMs ingest extracellular lipids, sourced primarily by low-density lipoprotein (LDL) particles, and offload them onto high-density lipoprotein (HDL) particles for clearance. The relative frequency of these and other microenvironmental interactions generates considerable cell-cell variation amongst lesion MDMs with respect to lipid content, phenotype and spatial position. Understanding this heterogeneity is key to predicting which lesions will resolve and which will persist to become life-threatening. In this talk, I will present a series of structured population models we used to explore how MDM heterogeneity arises and evolves in early atherosclerotic lesions. The model analyses, which include numerical and asymptotic solutions, implicate the bloodstream concentrations of LDL and HDL as key parameters in shaping cell-cell variation.

**5:15pm – 5:40pm: Coffee, Drinks & Refreshments**

**5:40pm – 6:05pm: Dr. Tara Trauthwein, Department of Statistics, University of Oxford**

**Title: Approximation Results for Large Networks**

**Abstract:** Networks are all around us - be it the omnipresent internet, street networks or more abstract structures like similarities in patient genes. In this talk, we will look at various mathematical models of spatial networks (or graphs), and how to show large limit results by introducing small local disturbances. The methods developed to show these (central) limit theorems are astoundingly general and apply to many problems even outside of stochastic geometry. Time permitting, we will briefly see how geometry can have an impact on the behaviour of graphs.

**6:05pm-6:30pm: Isaac Newell, OxPDE, Mathematical Institute, University of Oxford**

**Title: The Gauss Equation for Isometric Embeddings of Regularity in  $W^{1+2/3,3} \cap C^1$**

**Abstract:** Let  $u : (\Sigma, g) \rightarrow \mathbb{R}^3$  be isometric embedding of a smooth Riemannian surface in the three-dimensional Euclidean space. When  $u$  is smooth, the image surface is locally the graph of a function  $f$  satisfying the Gauss equation  $\det(D^2 f) = K_g (1 + |Df|^2)^2$ . We prove that this equation still holds in the sense of distributions when  $u$  has regularity  $W^{1+2/3,3} \cap C^1$ , via an approach based on the Cartan formalism. We also prove regularity and convexity results in the case of positive Gaussian curvature, extending earlier work by De Lellis, Conti, and Székelyhidi (Abel Symposium, 2010), Giron (DPhil thesis, 2021) and Pakzad (J. Funct. Anal., 2024). This is joint work with Luc Nguyen.

**6:35pm-7:00pm: Discussion**