MATH-IMS Joint Applied Mathematics Colloquium Series
The Chinese University of Hong Kong

This MATH-IMS Joint Colloquium Series is organized by Center for Mathematical Artificial Intelligence (CMAI), under Department of Mathematics and Institute of Mathematical Sciences (IMS) at The Chinese University of Hong Kong. The colloquium series focuses on mathematics and applications of artificial intelligence, big data and related topics.

Date: October 30, 2020 (Friday)
Time: 4pm – 5pm (Hong Kong Time)
Zoom Link: https://cuhk.zoom.us/j/92775210812

Topological protection in collective dynamics

Speaker: : Professor Pierre Degond
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Joint work with Antoine Diez and Mingye Na (Imperial College London)

Abstract: States of matter (such as solid, liquid, etc) are characterized by different types of order associated with local invariances under different transformation groups. Recently, a new notion of topological order, popularized by the 2016 physics Nobel Prize awarded to Haldane, Kosterlitz and Thouless, has emerged. It refers to the global rigidity of the system arising in some circumstances from topological constraints. Topologically ordered states are extremely robust i.e. "topologically protected" against localized perturbations. Collective dynamics occurs when a system of self-propelled particles organizes itself into a coherent motion, such as a flock, a vortex, etc. Recently, the question of realizing topologically protected collective states has been raised. In this work, we consider a system of self-propelled solid bodies interacting through local full body alignment up to some noise. In the large-scale limit, this system can be described by hydrodynamic equations with topologically non-trivial explicit solutions. At the particle level, these solutions persist for a certain time but eventually decay towards a uniform flocking state, due to the stochastic nature of the particle system. We show numerically that the persistence time of these topologically non-trivial solutions is far longer than for topologically trivial ones, showing a new kind of "topological protection" of a collective state. To our knowledge, it is the first time that a hydrodynamic model guides the design of topologically non-trivial states of a particle system and allows for their quantitative analysis and understanding. In passing, we will raise fascinating mathematical questions underpinning the analysis of collective dynamics systems.

Bio: Pierre Degond is currently a Chair Professor in Applied Mathematics at Imperial College London. Before joining the College, Prof. Degond was at the "Institut de Mathématiques de Toulouse" in France where he held a Senior Researcher position from the French Research Centre CNRS. Pierre Degond was trained at the Ecole Normale Supérieure in Paris, then appointed by Ecole Polytechnique in Palaiseau as a Junior Researcher at CNRS. Later he was appointed as a full Professor in Ecole Normale Superieure of Cachan before joining back the CNRS in Toulouse where he founded the Applied Math group. He moved to Imperial College in 2013.
The research interests of Prof. Degond lie in collective dynamics, decision making and self-organization in complex systems arising from biology and social sciences. His methods combine analysis, asymptotic theory and multiscale numerical techniques. Pierre Degond has been awarded the Jacques-Louis Lions prize 2013 of the French Academy of Sciences and he is a Royal Society Wolfson Research Merit Award holder.