□ Mike Jeffrey (University of Bristol)

Hidden Dynamics and the pilots' dilemma

It is a basic fact of dynamical systems – simply systems evolving in time – that if they aren't differentiable, then their solutions are not unique. Models with discontinuities turn up across modern biology and engineering wherever there are regulatory, control, or decision processes. Much of the literature in these "nonsmooth systems" seeks to resolve non-uniqueness, but here's the simple fact: you cannot banish non-uniqueness altogether. And you don't want to.

Non-uniqueness is a taboo of rigorous mathematics, but is a vital part of most modern day applications. It gives insight into the sensitivity and complexity of regulatory processes, and opens up entire new scales of modelling. I'll discuss the basic reason that non-uniqueness cannot be got rid of, and how we're starting to tackle it.

I'll show how we use "hidden dynamics" to understand the ghosts of un-modellable quantities that arise whenever a decision or switch is enacted. And I'll give toy examples inspired by a range of applications from biology, engineering, and human behaviour, including a thought experiment called the pilots' dilemma.

□ Michela Ottobre (Heriot-Watt University)

Non mean-field models for collective behaviour: some modelling questions

We consider Interacting Particle dynamics with Vicsek type interactions, and their macropscopic PDE limit, in the non-mean-field regime; that is, we consider the case in which each particle/agent in the system interacts only with a prescribed subset of the particles in the system (for example, those within a certain distance). It was observed by Motsch and Tadmore that in this non-mean-field regime the influence between agents (i.e., the interaction term) can be scaled either by the total number of agents in the system (global scaling) or by the number of agents with which the particle is effectively interacting at time t (local scaling). We compare the behaviour of the globally scaled and the locally scaled system in many respects; in particular we observe that, while both models exhibit multiple stationary states, such equilibria are unstable (for certain parameter regimes) for the globally scaled model, with the instability leading to traveling wave solutions, while they are always stable for the locally scaled one. This observation is based on a careful numerical study of the model, supported by formal analysis. Based on work with P. Butta', B. Goddard, T. Hodgson, K.Painter.

□ Natalia Kopteva (University of Limerick)

Time-fractional subdiffusion equations: gentle introduction, regularity, maximum principles, and numerical analysis

Over the past decade, there has been a growing interest in evolution equations of parabolic type that involve fractional-order derivatives in time of order in (0, 1). Such equations, also called subdiffusion equations, arise in various applications in engineering, physics, biology and finance. Hence, it is quite important to develop efficient and reliable computational tools for their numerical solution.

In this talk, I will touch on similarities and differences between fractional-parabolic equations and their classical counterparts, including the non-local nature of fractional-order derivatives, initial-time solution singularities, and slower long-term solution decay, as well as the proofs of some regularity properties and maximum principles. Then we shall consider some robust numerical methods for such equations, as well as the derivation of a-priori and a-posteriori estimates of the computational errors.

□ **Silvia Gazzola (University of Bath)**

Regularising inverse problems by Krylov methods.

Linear inverse problems are ubiquitous in many areas of Science and Engineering and, once discretised, they lead to ill-conditioned linear systems, often of huge dimensions. Regularization consists in replacing the original system by a nearby problem with better numerical properties, in order to find a meaningful approximation of its solution. After briefly surveying some standard regularization methods, both iterative (such as many Krylov methods) and direct (such as Tikhonov method), this talk will introduce a recent class of methods that merge iterative and direct approaches to regularization. In particular, strategies for choosing the regularization parameter and the regularization matrix will be emphasised, eventually leading to the computation of approximate solutions of Tikhonov problems involving a regularization term expressed in a p-norm.
