One Day of Network Dynamics

9 February 2018

Imperial College London

Supported by

10:00 – 10:40

Dr. Mauricio Barahona

To be announced

10:40 – 11:20

Dr.Wolfram Just

On synchronisation of oscillator networks with propagation delay

Kuramoto Sakaguchi type models are probably the simplest and most generic approach to investigate phase coupled oscillators. Particular partially synchronised solutions, so called chimera states, have received recently a great deal of attention. Dynamical behaviour of this type will be discussed in the context of time delay dynamics caused by a finite propagation speed of signals.

11:20 – 11:50

Coffee Break

11:50 – 12:30

Dr. Pramod Kumar

Complex Nonlinear Dynamics of Delay-coupled Semiconductor Lasers System

The semiconductor diode lasers are known to be very sensitive to the external optical perturbations such as, for example, optical self-feedback, optoelectronic feedback, optical injection due to phase-amplitude coupling factor alpha, α. Therefore, mutually delay-coupled semiconductor lasers in a face-to- face configuration show a plethora of dynamical complexity in the emitted radiation that make them ideal candidate for fundamental studies of coupled oscillators as well as for practical applications ranging from optical communications to computing. On the one hand these dynamical instabilities are undesired features and disturb the many applications where one needs the constant stable power but on the other hand they may allow for new methods for secure communications using chaos synchronization. The variety of optical complexity in these systems which we have investigated theoretically as well as experimentally are well behaving, well understandable, well classifiable in terms of complex nonlinear dynamics.

The fundamental properties of the coupled system are that perturbation to one component can affect other components, potentially causing the entire system to change the collective behaviour. Our study account for the optical complexity Inherent to real system, and allow bringing the system to a desired targeted state even when this state is not directly accessible due to constraints that limit the allowed intervention. So the systematic study and control of these nonlinear dynamics provides fundamental insight into the underlying physics of the system. On the basis of which one can redesign the device in order to stabilize the working point against environmental fluctuations or improve the processing, or simply exploit the dynamical performance of a system to one's advantages.

12:30 – 13:10

Dr. Christian Bick

Frequency synchrony and chaos in small oscillator networks

Network interactions allow identical oscillators to generate dynamics with distinct average frequencies. Nonchaotic dynamics with distinct frequencies arise in small networks of phase oscillators that are organized into two populations with disparate coupling strengths. We analyze how these solutions arise and bifurcate, both in theory and in experiment. We then turn to two population networks of identical Kuramoto oscillators with a more generic coupling scheme where both coupling strengths and phase-lags between populations are distinct. We give numerical evidence that there are chaotic attractors on which the oscillators evolve with distinct frequencies. Hence, complicated dynamics with localized frequency synchrony are expected even in the simplest description of oscillator networks.

13:10 – 14:20

Lunch

14:20 – 15:00

Tomislav Stankovski

Coupling functions in neuroscience

Interacting dynamical systems abound in nature and often the interest is not only to understand if, but also how they interact i.e. to reveal the functions and mechanisms that define and connect them. Coupling functions contain detailed information about the functional mechanisms underlying the interactions and prescribe the physical rule specifying how an interaction occurs. Using a method based on dynamical Bayesian inference, we show how one can reconstruct and assess the coupling functions from phase dynamics of oscillatory data. Then, we present number of recent applications in neuroscience – including the neural cross-frequency coupling functions in eyes open/eyes closed resting state, and the state of general anaesthesia with two anaesthetics (propofol and sevoflurane); as we also present bursting neuronal coupling functions from multielectrode array (MEA) recordings of interacting neurons from rats.

15:00 – 15:40

Dr. Sebastian Van Strien

To be announced

15:40 – 16:10

Coffee Break

16:10 – 16:50

Karl Friston

Active Inference and Bayesian mechanics

This overview of active inference offers an account of embodied exchange with the world that associates neuronal operations with inferring the causes of our sensations. Its agenda is to link formal (mathematical) descriptions of dynamical systems to a description of perception in terms of beliefs and goals. The argument has two parts: the first calls on the lawful dynamics of any (weakly mixing) ergodic system – from a single cell organism to a human brain. These lawful dynamics suggest that (internal) states can be interpreted as modelling or predicting the (external) causes of sensory fluctuations. In other words, if a system exists, its internal states must encode probabilistic beliefs about external states. Heuristically, this means that if I exist (am) then I must have beliefs (think). The second part of the argument is that the only tenable beliefs I can entertain about myself are that I exist. This may seem rather obvious; however, it transpires that this is equivalent to believing that the world – and the way it is sampled – will resolve uncertainty about the causes of sensations; i.e., minimise expected surprise or variational free energy. A special focus of this presentation will be the relationship between expected free energy and the self-organising gradient flows that characterize biological systems.

16:50 – 17:30

Dr. Greg Pavliotis

Long time behaviour and phase transitions for the McKean-Vlasov equation

We study the long time behaviour and the number and structure of stationary solutions for the McKean-Vlasov equation, a nonlinear nonlocal Fokker-Planck type equation that describes the mean field limit of a system of weakly interacting diffusions. We consider two cases: the McKean-Vlasov equation in a multiscale confining potential with quadratic, Curie-Weiss, interaction (the so-called Dasai-Zwanzig model), and the McKean-Vlasov dynamics on the torus with periodic boundary conditions and with a localized interaction. Our main objectives are the study of convergence to a stationary state and the construction of the bifurcation diagram for the stationary problem. The application of our work to the study of models for opinion formation is also discussed.