Applied Maths Seminars 2015/16 Semester 1

All seminars at 2:00pm

23 September
SCH.0.13
Prof Massimiliano Zecca (Mechanical, Electrical and Manufacturing Engineering, Loughborough University)
Research challenges in the wearable biorobotics research group

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14 October
SCH.1.05
Dr James Sprittles (Mathematics Institute, University of Warwick)
Singular Capillary Microflows: Modelling, Computation & Scaling

Understanding the formation of liquid drops, their interaction with solid surfaces and coalescence with surrounding drops is the key to optimising a whole host of technological processes, including a number of emerging microfluidic devices such as 3D-printers and lab-on-a-chip devices. Accurate experimental observation of these phenomena is complex due to the small spatio-temporal scales or interest and, consequently, mathematical modelling and computational simulation become key tools with which to probe such flows.

Drop formation, dynamic wetting and coalescence are all so-called 'singular' capillary flows, in which classical modelling approaches lead to infinite values of flow variables and computation becomes increasingly complex. In this talk, I will describe the mathematical models proposed for this class of flows and the techniques which have been used to obtain both approximate and exact computational solutions. Simulations will reveal (a) the dominant physical mechanisms in these flows, (b) the accuracy of scaling laws proposed for them and (c) a number of previous mis-conceptions in the published literature.

Finally, if time permits, I will discuss how microscopic modelling frameworks could provide insight into these flows which cannot be obtained from a purely macroscopic approach.

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4 November
SCH.0.13
Prof Yury Stepanyants (School of Agricultural, Computational and Environmental Sciences, U. Southern Queensland)
Transformation of internal waves at the bottom ledge

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11 November
SCH.0.13

Dr Andrea Cangiani (Department of Mathematics, University of Leicester)
Finite Elements on polytopic meshes and beyond

Real-life models are often characterized by localised features. For instance, solution layers/singularities, domains with complicated/moving boundaries, and multi-physics matching. These features make the design of accurate numerical solutions challenging, or even out of reach unless computational resources are smartly allocated. Complexity reduction can be achieved through the following framework: new Finite Element Method (FEM) approaches allowing for general partitioning of the computational domain combined with automatic adaptive meshing. For instance, general non-matching/curved mesh elements can ease the treatment of multi-physics boundaries, while local geometric and solution features can be resolved adaptively. I will present two approaches to extending the FEM to general meshes while maintaining the ease of implementation and computational cost comparable to that of standard FEM: the Virtual Element Method (VEM) and a discontinuous Galerkin method. Recent work on adaptive algorithms based on rigorous a posteriori error bounds will also be presented and demonstrated on problems with internal possibly curved interfaces modelling semi-permeable membranes.

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18 November
SCH.1.05
Dr Marc Pradas (Department of Mathematics, Open University)
Analysing complex behaviour in interfacial flows

Interfacial flows are found in a vast spectrum of natural and engineered systems and they are often characterised by the presence of a wide range of different scales which are nonlinearly interacting with each other. As a result, these systems may exhibit complex behaviour and generic features, such as collective behaviour and self-organisation processes; or intermittent and pinning-depinning dynamics. In this talk I will show several problems exhibiting these types of behaviour, including multiphase flows in disordered media and capillary flows in microengineered devices. We have developed a number of novel methodologies for the study of these systems which I will outline in the talk.

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25 November
SCH.0.13
Dr Andrew Watson (Aeronautical and Automotive Engineering, Loughborough University)
Maths and Society

A growing system will continue to grow in the absence of constraints. In a finite space growth of system that requires space can only continue for a finite time. (Non spatial systems such as money can grow to enormous sizes). Hence the human population cannot grow for ever. Therefore at some stage it must stop growing which in the absence of exogenous causes the curtailment to growth will be caused by endogenous effects such as energy inputs and/or environmental effects and/or economic causes.

The mathematics of growth can be described by the exponential function. For a finite commodity exponential expiry times can be calculated which gives a bound on the limits to growth. If infinite growth is impossible is it possible to move to a system of sustainability? If sustainability is not possible at the current size of the system then is contraction the only option? If contraction is the only option then what time span will this contraction cover and what choices are available?

The talk will discuss the issue of growth and the predicaments that we are facing in terms of energy, the environment and the economy.

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2 December
SCH.0.13
Dr Philip Browne (University of Reading Meteorology Department)
Data assimilation: the link between observations and models

To predict the weather, the best model in the world will be useless if it does not start from initial conditions close to the truth. In order to do this initialisation, independent observations are taken. The scientific process of combining the observations with the model is known as data assimilation. In most cases, the number of observations is much much less than the number of initial values to be specified. In numerical weather prediction, this discrepancy currently runs at 3 orders of magnitude. Therefore we must use mathematical techniques to initialise the whole state, making optimal use of the information in the observations. The mathematical formalism for data assimilation is Bayes' Theorem. In this talk I will describe how a fully nonlinear solution to Bayes' theorem is unattainable in large systems. We can however, make certain assumptions that reduce the problem to one tractable enough to produce good forecasts. I will discuss the nature of these assumptions and the numerical techniques used to solve the resulting problems.

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17 December (Thursday)
SCH.0.13
Prof Roger Grimshaw (Department of Mathematics, University College London)
Tsunamis: the contrast between elevation and depression waves

Applied Maths Seminars 2015/16 Semester 2

A number of UCAS visit days and other events occur in semester 2 thus seminars are not always regular.

17 February
SCH.0.13
3:00pm: Dr Leandro Farina (UFRGS, Porto Alegre, Brazil)
Mapping submerged flat plates onto circular plates in the presence of water waves

The problem of interaction of water waves with a thin rigid plate can be reduced to a hypersingular (finite part) integral equation, when the plate is submerged. If the plate is circular, this equation can be solved for the jump in the velocity potential by a semi-analytical spectral method. The unknown is expanded in terms of certain orthogonal functions over the unit disc: a Fourier series in the azimuthal angle, with the coefficients expanded in terms of Gegenbauer polynomials. This approach has two virtues: all hypersingular integrals are evaluated analytically and the edge condition on the plate is satisfied automatically. In this talk, we establish a convergence proof and show how this method can be extended to the case where the plate is non-circular. Numerical results are presented for a class of nearly circular plates. Extensions of the method to the cases of porous plates and of a plate under an ice cover will be proposed.

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15 March (Tuesday)
SCH.0.13
2:00pm: Prof Wooyoung Choi (NJIT, USA)
Modelling nonlinear ocean waves and its challenges

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23 March
LMS 2016 lectures (Prof Edgar Knobloch and guests, lectures all week)

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30 March
U.0.005 (Brockington Extension)
1:30pm: Dr Pooja Panchmatia (Chemistry, Loughborough University)
How computational tools are used to explain and predict structure-property relationships in Energy Storage Materials

Declining fossil fuel reserves and ever-increasing demands for energy make developments in energy storage capabilities vital. Battery usage is becoming increasingly widespread, but this is presenting new challenges due to materials scarcity and limitations in battery performance. It is vital that the increased exploitation of existing battery materials and the development of next generation batteries proceed through sustainable approaches. This talk will focus on the use of computational methods to *explain and predict structure-property relationships that are key for the optimisation of energy storage materials.*

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13 April
SCH.0.13
2:00pm: Dr Elisa Mele (Biomaterials, Loughborough University)
Biomimetic architectures with controlled wetting properties and enhanced biocompatibility

Nature provides numerous examples of multifunctional structures characterised by specific chemical composition and multiscale hierarchical organisation. In my research I take inspiration from nature to develop biomimetic coatings, capsules and scaffolds for biomedical applications by combining natural materials and nanotechnology.

Some topics of the seminar will be:

- *Surfaces with unidirectional water spreading and superhydrophobicity produced by replicating the topography of Strelitzia reginae leaves;*
- *Structures with complex shape and anisotropic chemical character obtained by controlling the floating of drops of sodium alginate (a polysaccharide derived from brown algae) on the surface of aqueous solutions;*
- *Cell-Instructive materials for promoting skin regeneration by mimicking the extracellular matrix of human tissues.*

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4 May
SCH.1.05
2:00pm: Dr Chris Bick (Maths, Exeter)
Angular Frequency Synchronization and Localized Dynamics in Symmetrically Coupled Oscillators

The emergence of collective behavior is a fascinating feature of interacting oscillatory units in nature and technology. Apart from full synchronization, solutions where a localized subset of oscillators are synchronized have attracted an enormous amount of attention recently. Weak chimeras—originally defined for networks of phase oscillators where the state of each oscillator is given by a single phase-like variable—provide a rigorous notion to describe such dynamics in terms of frequency synchronization along trajectories. We extend the definition to more general classes of oscillators by relating frequency synchronization to the symmetry properties of the system. Moreover, we discuss some persistence results for weak chimeras in coupled phase oscillators. In particular, we explicitly give coupling functions which give rise to chaotic weak chimeras for which the underlying dynamically invariant sets have trivial or nontrivial symmetries.

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18 May
SCH.1.05
3:00pm: Dr Ruben Sevilla (Swansea)
High-order methods for computational electromagnetics