Applied and Computational Mathematics Seminars 2015-2016

All seminars are held at 14:10 in Room M/2.06, Senghennydd Road, Cardiff unless stated otherwise. Programme organiser and contact: Dr Nikos Savva.

26 April 2016
Speaker: Prof. Demetrios Papageorgiou (Imperial)
Title: TBC

19 April 2016
Speaker: Dr. Marc Pradas (Open University)
Title: TBC

12 April 2016
Speaker: Dr. Christian Thomas (Imperial)
Title: TBC

29 March 2016
Speaker: BAMC Practice Talks
Title: BAMC Practice Talks

15 March 2016
Speaker: Dr. Barbara Szomolay (Cardiff)
Title: TBC

8 March 2016
Speaker: Dr. Sara Jabbari
Title: TBC

1 March 2016
Speaker: Prof. Stephen Garrett
Title: TBC

23 February 2016
Speaker: Dr. Jamal Uddin

Title: TBC

16 February 2016

Speaker: Prof. Peter Thomas

Title: Complexity, Segregation and Pattern Formation in Particle-Laden Rotating-Drum Flows

Abstract: An overview of our experimental programme investigating particle-laden flows in partially-filled drums, rotating around a horizontal axis, is presented. For homogeneous liquids this flow has been studied since the late 1930s - motivated by its relevance to the pulp and paper industry. However, we started investigating how the dynamics of the flow are affected when the liquid becomes 'contaminated' by successively increasing amounts of small, solid particles. This revealed a new particle-segregation phenomenon accompanied by the formation of various modes of spatial and spatiotemporal patterns. Long-term observations of the system, lasting up to about 5 weeks, have uncovered the existence of very complex, but often highly symmetric, temporal pattern dynamics. In order to begin to understand the underlying processes we have recently studied the flow by means of the Positron Emission Particle Tracking (PEPT) technique. This allows observing the motion of a single, radioactively tagged, particle among thousands of other particles.

9 February 2016
Speaker: Applied Maths Staff
Title: Research Showcase

2 February 2016

Speaker: Dr. Melina Freitag

Title: Computing defective eigenpairs in parameter-dependent eigenproblems

Abstract: The requirement to compute Jordan blocks for multiple eigenvalues arises in a number of physical problems, for example panel flutter problems in aerodynamical stability, the stability of electrical power systems, and in quantum mechanics. We introduce a general method for computing a 2-dimensional Jordan block in a parameter-dependent matrix eigenvalue problem based on the so called Implicit Determinant Method. This is joint work

with Alastair Spence (Bath).

26 January 2016

Speaker: Dr. Catherine Powell (Manchester)

Title: Stochastic Galerkin FEM for PDEs with Random Inputs: Fast and Accurate UQ

Abstract: Many engineeering-inspired problems require the numerical solution of a PDE or system of PDEs with uncertain parameters (associated with material properties, boundary conditions, geometry etc). For example, consider flow in a porous medium with uncertain porosity coefficients, heat diffusion in an object with uncertain geometry, or the Navier-Stokes equations with uncertain viscosity. Although numerical methods for dealing with parameter uncertainty in PDE-based models have existed for several decades in engineering circles, uncertainty has only been fully embraced and analysed rigourously by applied mathematicians relatively recently. Indeed, `uncertainty quantification (UQ)' is now a major trend in mathematics.
Unlike traditional sampling methods, so-called stochastic Galerkin finite element methods (SGFEMs) construct approximations that are functions (usually polynomials) of the uncertain parameters. That is, the parameters act as coordinates. The SGFEM approximation is sought in a tensor product space, combining standard finite element functions in the spatial coordinates with an appropriate set of multivariate polynomials in the uncertain parameters. When the number of parameters is small, SGFEMs exhibit superior convergence to standard sampling methods in many applications. However, SGFEMs do still receive bad press due to the potentially very high dimension of the approximation space required in some applications, and the perceived `intrusive' nature of the computations.
In this talk, we will give a short review of some recent developments from the mathematics community to (i) speed up the numerical solution of the large linear systems of equations associated with SGFEMs and (ii) estimate the a posteriori error in a given SGFEM approximation, leading to potential adaptive and low-dimensional enrichment strategies for the SGFEM approximation space.

21 January 2016

Speaker: Prof. Eugene Benilov (Limerick)

Title: Hydraulic jumps in a shallow flow down an inclined substrate

Abstract: This work examines free-surface flows down an inclined substrate. The slope of the free surface and that of the substrate are both assumed small, whereas the Reynolds number Re remains unrestricted. A set of asymptotic equations is derived, which includes the lubrication and shallow-water approximations as limiting cases (as Re $\to$ 0 and Re $\to \infty$, respectively). The set is used to examine hydraulic jumps (bores) in a two-dimensional flow down an inclined substrate. An existence criterion for steadily propagating bores is obtained for the (η, s) parameter space, where η is the bore's downstream-to-upstream depth ratio, and s is a non-dimensional parameter characterising the substrate's slope. The criterion reflects two different mechanisms restricting bores. If s is sufficiently large, a 'corner' develops at the foot of the bore's front – which, physically, causes overturning. If, in turn, η is sufficiently small (i.e. the bore's relative amplitude is sufficiently large), the non-existence of bores is caused by a stagnation point emerging in the flow.

15 December 2015

Speaker: Prof. Massimiliano Gei (ENGIN)

Title: Modelling soft dielectric elastomer generators: material nonlinearities, failure modes, optimization of performance

8 December 2015

Speaker: Dr. Marco Ellero (Swansea)

Title: Smoothed Dissipative Particle Dynamics method: towards a thermodynamically-consistent discretization of stochastic partial differential equations.

Abstract: In this talk I will present the so-called Smoothed Dissipative Particle Dynamics (SDPD), a mesoscopic particle-based method introduced a decade ago to simulate Newtonian Brownian fluids. SDPD can be viewed as a stochastic generalization of the well-known Smoothed Particle Hydrodynamics

method (SPH) - a Lagrangian meshless discretization of the Navier-Stokes equations - albeit with the proper inclusion of thermal fluctuations. Application of the GENERIC formalism (General Equation for Non-Equilibrium Reversible-Irreversible Coupling) allows to derive a stochastic particle model which maintains thermodynamic consistency, i.e. it satisfies First and Second Laws of Thermodynamics and Fluctuation-Dissipation Theorem (FDT), not only in a continuum limit, but exactly at the level of the spatial discretization. Another remarkable advantage of the method is that the application of GENERIC lead directly to a size-dependent thermal noise which satisfies FDT. In other words, the resulting stochastic equations are not scale-invariant but fluid trajectories exhibit different dynamics depending on the the physical scales set for the particles. Whenever the fluid particle size is large enough, no thermal noise will be present in the hydrodynamic variables, whereas it will show up only when the fluid description needs to be miniaturized, e.g. under microflow conditions. This property allows to formally unify the Lagrangian description of fluid flow based on a stochastic mesoscopic approach (SDPD) together with a fluctuations-free deterministic method (SPH) in the continuum limit. In addition to the Navier-Stokes equations, also other set of partial differential equations will be discussed within the thermodynamically-consistent framework, i.e. Maxwell-type equations for the modelling of viscoelastic liquids.

24 November 2015

Speaker: Dr. Daniel Loghin (Swansea)

Title: Interface Preconditioners for Generalized Newtonian Flow
Domain decomposition methods are established techniques for solving linear systems arising from the discretization of PDE.

Abstract: A key feature of these methods is the solution of the interface problem (or interface Schur complement) arising from a non-overlapping decomposition of the domain. For certain scalar PDE (e.g., elliptic problems) the fast resolution of this problem is possible through a range of robust algorithms. However, the generalization of these methods to the case of systems of PDE is not always straightforward.
In this talk we examine a class of interface preconditioners for generalized Newtonian flow models. In particular, we show that the domain decomposition formulation of the linearised problem yields a discrete interface operator which inherits the constrained form of the original problem

and is explicit in the constraints. This allows us to construct an equivalent, simpler discrete operator with a view to preconditioning the interface problem. Analysis indicates solver performance (iterations) independent of the problem size; in practice, in some cases, we also observe a much reduced dependence on other physical parameters. Numerical results using standard test problems are included to illustrate the procedure and verify the optimality of the proposed solver technique.

10 November 2015
Speaker: Professor Stephen Garrett (Coventry)
Title: TBC

3 November 2015

Speaker: Mr. Togni Riccardo Togni (ENGIN)

Title: A numerical study of turbulent Rayleigh-Benard convection

Abstract: Thermally driven turbulence plays a major role in several natural phenomena and industrial processes. It occurs in Earth's outer core, atmosphere and oceans, but also in heat exchangers for power plants and electronic devices. The above-mentioned flows are dominated by buoyancy, nevertheless they can present very complex features due to the coupling with other effects, e.g. Coriolis force, magnetic fields and phase changes. Turbulent Rayleigh-B´enard convection (RBC) is the paradigm for all these phenomena and it consists of a fluid layer heated from below and cooled from above in a vertically bounded domain. RBC is a simple model which, however, still preserves the salient features of convection. A study of turbulent RBC, by means of Direct Numerical Simulations (DNS) performed with a pseudo-spectral code, is presented. The flow is described qualitatively in terms of turbulent structures and quantitatively by means of single-point and two-point statistics. An attempt will be made to explain the results obtained, followed by a brief overview of the possible applications in turbulence modelling.

20 October 2015

Speaker: Dr. James Sprittles (Warwick)

Title: Singular Capillary Microflows: Modelling, Computation & Scaling.

Abstract: 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.

13 October 2015
Speaker: Current Applied Maths PhD students
Title: Research Showcase

6 October 2015
Speaker: Current Applied Maths PhD students
Title: Research Showcase

29 September 2015

Speaker: Dr. Hayley Wyatt (Cardiff)

Title: The effect of engineered surface topography on the tribology of CFR-PEEK for novel hip implant materials

Abstract: In 2013 76,274 hip implants were performed across England and Wales, with this number expected to continue to increase. Therefore there is a need for hip implant design to evolve to improve the life-span of the device and reduce the adverse effects of wear particles. One such technique for reducing wear is surface texturing, where micro-textures are applied to the surface of the specimen, reducing the coefficient of friction of the materials and thus reducing wear. This study aimed to investigate the effect of different surface topographies upon the tribological performance of CFR-PEEK for application to hip implants. Six different surface textures were developed using laser surface texturing of CFR-PEEK. The six designs consisted of circular dimples varying in diameter from 50 – 150 µm and spacings of 2 times and 3 times the dimple diameter. Additionally one polished disc was used for a baseline reading, with an Ra the same as that of an acetabular lining. Textures were characterised using surface profilometry and their wear performance was assessed using pin – on – disc wear testing. The results from the study found all textured surfaces to have a lower mean coefficient of friction (CoF) when compared to the polished disc over a 40 hour test duration, with the performance of each texture varying significantly. The results from this study demonstrate the potential of using surface topography for improving the performance of hip implants and also highlighted the significance of creating the optimal texture design.