Letter from the Head of Division

The past twelve months have been exciting times for the Division. It started in October last year with a surprise for me when I was asked to take over as Head of Division from Professor Mark Chaplain. Prof. Chaplain has served the Division in this role for six years, a burden which deserves huge respect, and also needs more time for his role as REF panel member. In December it emerged that the Division, which had outgrown its premises in the MSI building, would also not have enough space in the new built Centre for Translational and Interdisciplinary Research. Hence an alternative solution was looked for and eventually found in form of the Fulton building. This had the additional advantage that we would be closer to all our colleagues in the School of Engineering Physics and Mathematics and the main lecture theaters.

December brought also the exciting news that the Magneto-hydrodynamics (MHD) group was awarded a £750000 grant by the Science and Technology Facilities Council. Then January came with a big surprise for Prof. Mark Chaplain when he heard that he was awarded the Ivory Chair in Applied Mathematics, an honour which has not been awarded for many years.

March saw the arrival of a new member of staff, Dr. Irene Kyza (Computational Mathematics), and the award of a Dundee Fellow position to Dr. Miho Janvier (MHD), who will join us in October. Also four of our students have been presented with Dr. Charlie Dixon Awards for exceptional dedication to their studies.

Further pleasant surprises came over the summer for Dr. Mariya Ptashnyk and Dr. Raluca Eftimie in form of EPSRC First Grants and to Dr. Niall Dodds in form of a well-deserved permanent lectureship. The summer saw also some happy faces of graduating students, and a lot of sweat to the faces of staff moving to our new premises in the Fulton building. It saw also the arrival of three new postdocs, Dr. Alex Russell, Dr. Simon Candelaresi and Dr. Peter Wyper.

A very successful year for staff and students in the Mathematics Division, with all signs pointing to further growth, but hopefully this does not mean moving again in near future!

Prof. Gunnar Hornig
New lecturer in Mathematical Biology

The Division is pleased to welcome a new Lecturer in Mathematical Biology, Dr. Philip Murray.

In December 2012 the combination of an instinctive yearning for Northern latitudes, the expertise in Mathematical Biology present at the Division and the potential for collaboration with experimentalists at the CLS led Dr. Murray to his current position as a lecturer at the Division of Mathematics.

Dr. Murray’s undergraduate degree was in Theoretical Physics at University College Dublin, Ireland. Subsequently, he studied for a PhD, under the supervision of Prof. Philip Maini, at the Centre for Mathematical Biology (CMB), University of Oxford. After a brief three month sojourn to the Korean Advanced Institute for Science and Technology (KAIST), Dr. Murray returned to Oxford to do a post-doc under the guidance of Dr. Ruth Baker and Prof. Philip Maini. Additionally, over the course of his post-doc he was a Career Development Fellow at St Hugh’s College, Oxford.

Dr. Murray’s PhD thesis focussed on investigating how discrete cell based models, which are now widely used in computational biology, could be described by continuum models, with the idea being that analysis of the continuum models could then yield qualitative insight into their discrete counterparts. He found that a particular class of off-lattice, cell-based models could be described by a corresponding class of nonlinear diffusion equations.

The over-riding theme in Dr. Murray’s post-doctoral work was the development of mathematical models of oscillatory biological systems. In particular, he studied a vertebrate developmental process known as somitogenesis in which tissue segmentation occurs as a result of tightly controlled spatio-temporal patterns of gene expression. Dr. Murray and his collaborators approached the problem using the theory of phase-coupled oscillators and, in the process, stumbled upon a mechanistic basis for observed oscillatory patterns that motivates a novel twist on the oft-quoted ‘clock-and-wavefront’ model.

Additionally, Dr. Murray studied the dynamics of mammalian hair growth patterns and demonstrated that the theory of stochastic excitable media can explain a wide range of experimental observations made across different biological scales (from gene expression to skin patterns). The key biological insight from the modelling work was that the property of excitability is a neat way for a biological tissue to maintain homeostasis yet maintain the potential to regenerate: a functional unit, such as a hair follicle, has a stable steady-state in which growth does not occur but can reach a regenerative excited state, that persists only for a limited time, before returning to the dormant equilibrium. Dr. Murray is currently in the process of working with experimental collaborators in order to test predictions made by both these studies.

New Lecturer in Mathematics

Dr. Niall Dodds has recently been promoted to Lecturer within the Division. Dr. Dodds has been in the division for over 10 years, having previously completed his PhD here before working as a teaching fellow for the last 6 years. His PhD focused on a type of equation known as “non-local differential equations”, which are differential equations that include integral terms as well as derivatives. Dr. Dodds’ work applied theoretical analysis results to the equations to develop understanding of which equations have solutions. As a teaching fellow, Dr. Dodds has built up considerable experience of teaching a wide variety of undergraduate modules, and more recently has led a series of improvements to the
undergraduate programmes. These improvements include implementing new online tutorial and assessment systems, which give students both new flexible ways to learn and quicker feedback. Also there have been exciting new Level 1 modules created in Pure Mathematics and Statistics, as well as an expanded Level 2 module in Discrete Mathematics due next year. Dr. Dodds has also coordinated the creation of a new degree for Dundee. This year, for the first time, students can study for an MMath degree (Master of Mathematics), which is a five year undergraduate degree leading to a higher qualification than the more typical honours BSc degree. This new degree will not only be offered to new applicants, but there are opportunities for existing students to transfer to this MMath degree. This will further increase the flexibility of the University of Dundee Mathematics degrees.

New Lecturer in Computational Mathematics

The Division of Mathematics is pleased to welcome a new Lecturer in Computational Mathematics, Dr. Irene Kyza, who joined the Division in March of 2013.

Dr. Kyza received a BSc in Mathematics in 2003 and a MSc in Mathematics in 2005, both from the University of Cyprus. In 2008, Dr. Kyza received a MSc in Pure Mathematics from the University of Crete, and in 2009 she received a PhD in Applied and Computational Mathematics from the same university. Dr. Kyza was a Postdoctoral Fellow in the Department of Mathematics at University of Maryland (September 2009 - August 2011) and at the Institute of Applied and Computational Mathematics of the Foundation of Research and Technology - Hellas (February 2012 - February 2013). During the fall semester of 2011-2012, she was Visiting Lecturer in the Department of Mathematics and Statistics at University of Cyprus.

Dr. Kyza’s research interests include the error control of evolution partial differential equations (PDEs) arising in several applications in biology, physics, and engineering. Her main strength is the analysis of numerical methods and, in particular, the combination of involved numerical techniques with advanced theory of nonlinear PDEs. More specifically, one of Dr. Kyza’s main research interests is the a posteriori error control and the construction of adaptive algorithms of evolution PDEs with solutions that exhibit singular behavior. Such PDEs include the semi-linear parabolic equations with solutions that may blow-up in finite time and the linear Schrödinger equation in the semiclassical regime, and appear e.g. in quantum mechanics. An important part of her research work so far has been oriented to the proof of optimal order a posteriori error estimates for those equations. This work has proven to be fruitful for the corresponding a posteriori error control of the Keller-Segel model of chemotaxis and the Schrödinger equation with cubic nonlinearities. Dr. Kyza is also an expert in the proposition of appropriate numerical methods and the error control for problems defined on time-dependent domains using the Arbitrary Lagrangian Eulerian (ALE) formulation. For realistic simulations involving fluids in three spatial dimensions, it is important that the ALE method is at least of second order of accuracy (in both time and space). Recently, with two of her collaborators, Dr. Kyza formulated and proposed unconditionally stable discontinuous Galerkin ALE methods in time of any order, for a time-dependent diffusion-dominated problem defined on deformable domains and they provided the corresponding error analysis. This significant part of her research is the first step towards the future design, study, and error control for numerical approximations of the Stokes and Navier-Stokes equations on moving domains.

In terms of funding, Dr. Kyza is the principal researcher of a three-year project entitled “Advanced Numerical Techniques for Reaction-Diffusion-Convection Models in Biology”, which is co-funded by the European Union and National Resources of the Greek State.
The enigma of solar plasma

Members of the Magneto-hydrodynamics (MHD) group are embarking on a major new project to understand the basic physical processes that go on in plasmas on the Sun and throughout the Universe. The study will focus on the solar corona, the outer atmosphere of the Sun. Magnetic loops in the solar corona, solar flares, and coronal mass ejections are among the phenomena that scientists still cannot fully explain.

Plasma, an ionised gas, clings to magnetic fields in the Sun’s atmosphere. This hot, radiating plasma allows the magnetic loops in the atmosphere to be seen by high-powered telescopes. The images these telescopes capture show that the plasma on the magnetic loops has temperatures of more than a million degrees, far higher than that of the 5800°C surface of the Sun. One of the primary aims of the new project is to understand why this dramatic temperature increase occurs. MHD group members – Professor Gunnar Hornig, Dr. David Pontin, and Dr. Antonia Wilmot-Smith – have been awarded £765,000 by the Science and technology Facilities council to carry out the research. A further £68,000 has been awarded to the group’s colleague Dr. Anthony Yeates at the University of Durham. The award has led to the expansion of the group in Dundee through the addition of two new postdoctoral researchers who arrived this summer.

Dr. Alexander Russell gained his PhD in Applied Mathematics at the University of St Andrews. His PhD studies centred on plasma physics in Earth’s upper atmosphere and near-Earth space, and included the discovery of a previously unknown wave created by electromagnetic coupling between Earth’s ionosphere and thermosphere. He was subsequently awarded a three year Royal Commission for the Exhibition of 1851 Research Fellowship, which he took up at the University of Glasgow. There, he investigated novel models for solar flares, and his research has strengthened the case that magnetic waves assist flares by transporting energy from its storage site to the places where flare radiation is produced. Alex says “My research in Dundee will aim to understand how energy stored in magnetic fields can be quickly released, triggering a turbulent relaxation to a lower energy state, and to identify the laws that determine the maximum amount of energy that can be removed from the magnetic fields in this way. The outcomes will have major implications for understanding how the Sun’s outer atmosphere is heated, and for predicting large solar storms (flares and coronal mass ejections) which can negatively affect susceptible technologies on Earth.”

The second new researcher to join the MHD group is Dr. Simon Candelaresi. Simon worked towards his PhD under the supervision of Prof. Axel Brandenburg in Stockholm between 2009 and 2012. His PhD thesis was entitled "Magnetic Helicity in Astrophysical Dynamos". Various astrophysical objects, like our Sun and galaxies, have an intrinsic magnetic field. How that field is created and maintained was one focus of Simon’s PhD studies, and he examined in particular the role played by magnetic helicity. According to Simon “Magnetic fields of non-trivial topology exist in nature and are used in laboratory experiments. These fields are often twisted or have a loop-like structure. Such twists are induced in the magnetic fields of nuclear fusion experiments in order to increase the stability of the plasma. I study the stability characteristics and relaxation behaviour of topologically intriguing fields. I am currently writing a computer code capable of running in parallel on Graphics Processing Units. With that I will investigate the relaxation of braided magnetic fields as models for solar coronal loops.”
Ivory Chair of Applied Mathematics

Professor Mark Chaplain has been awarded the prestigious Ivory Chair in Applied Mathematics. The Ivory Chair of Applied Mathematics was founded at Queen's College Dundee in 1964. The chair's name commemorates the distinguished Dundee-born mathematician Sir James Ivory. This is traditionally the established chair held by the leading applied mathematician in Dundee. Previous incumbents were Professor Douglas Jones, 1964-1992 and Professor Brian Sleeman, 1992-1995.

An evening celebratory event marking this appointment was run by the College of Art, Science and Engineering in September. Prof. Chaplain presented a lecture "Creating a Virtual Tumour: Are We Nearly There Yet?"

Funding for research projects in Mathematical Biology

Professor Mark Chaplain in collaboration with Professor Alistair Thompson (Ninewells Hospital; Principal Applicant on the grant) have recently been awarded a 5-year Breakthrough Breast Cancer Grant: “Predicting and measuring response to neoadjuvant chemotherapy through novel imaging, tissue analysis and modelling of peritumoral tissues”. This proposed research aims to use modern imaging techniques, immunohistochemistry, cell biology and mathematical modelling to establish features of the peritumoral tissues surrounding a primary breast cancer, monitor changes in the peritumoral tissues with neoadjuvant drug therapy and examine the underlying biology of the peritumoral components. Data obtained from cancer patients will be used to parameterise multiscale computational models and to make quantitative predictions and attempt to understand the relevance of the peritumoral tissues to neoadjuvant chemotherapy.

Dr. Mariya Ptashnyk and Dr. Raluca Eftimie were awarded each an EPSRC First Grant, for their projects in the area of mathematical biology.

- Dr. Ptashnyk’s project investigates the biomechanics of plants, and in particular it focuses on the multiscale modelling and analysis of the mechanical properties of plant cell walls and tissues. The main force for plant cell elongation (the internal turgor pressure) acts isotropically, and so it is the microscopic structure of the cell wall, surrounding each plant cell, that controls the anisotropic growth of plant cells and tissue. A microscopic model of plant cells will allow us to consider non-homogeneous distributions of plant cell wall structural elements. The multiscale analysis will enable us to identify the influence of microscopic molecular interactions on the macroscopic mechanical behaviour and help to illuminate the mechanisms responsible for changes in the microscopic properties of plant cell walls and tissues in response to mechanical forces.

- Dr. Eftimie’s project focuses on the collective movement of cells (where cells stay connected as they move) under the influence of various cell-cell signaling pathways. Despite recent advances in identifying the communication mechanisms involved in individual cell movement, there are still many open questions regarding the mechanisms involved in collective cell movement and how these mechanisms influence the movement of various cell types. To formulate hypotheses that could help address these questions, the research will focus on deriving and investigating analytically a class of mathematical models that describe cell movement and cell-cell interactions via different communication mechanisms.
Young Researchers in Mathematics (YRM)

YRM is an annual event organised by and for post-graduate students and post-doctoral fellows. YRM 2013 was held in June at the University of Edinburgh, and consisted of a lively and diverse programme of talks from both early career and established researchers with plenary speakers Prof. Dusa McDuff, FRS and Sir Michael Atiyah, FRS.

Rebecca Cornwell, a PhD student in the Division of mathematics, who attended this event, shared her experience with this meeting: “I attended the Mathematical Biology track where topics included seasonal voles cycles, virus structures, analysis of back pain treatment trials and a fascinating talk by Prof. Jonathan Sherratt from Heriot-Watt University on sand dune patterns. I will be the University of Dundee representative for YRM 2014 which will be held at the University of Warwick so look out for further information from me nearer to the 2014 meeting.”

Rebecca also attended the Ento’13 conference:

“Ento ‘13, held at The University of St Andrews in September 2013, comprised both the International Symposium and the National Science Meeting of the UK Royal Entomological Society. The theme of this year’s International Symposium was “The Evolution of Insect Mating Systems” and, from a mathematical perspective, the highlights were talks by Australian National University’s Prof. Michael Jennions on sex ratio theory with engaging and memorable animations including “propeller male” and Prof. Hanna Kokko on the effects of local adaptation on female choice of mates. Both talks were visually appealing and conveyed the excitement and potential of mathematical models to a non-specialist audience. As part of the general entomological talks, Dr. Ali Karley of The James Hutton Institute presented a summary of recent work on aphid susceptibility to parasitism by braconid wasps including work by members of the Mathematics Division, namely Ananthi Anandanadesan, Prof. Mark Chaplain and myself. Feedback to her talk was very positive and there is much interest in hearing more about our host-parasitoid modeling work.”

Congratulations to our PhD graduates!

In the last academic year, three more PhD students passed the Viva of their PhD: Andrew Savory (for his Thesis “Swimming patterns of zoospores”), Marc Sturrock (for his Thesis “Spatio-temporal modelling of gene regulatory networks containing negative feedback loops”) and Daniela Schlüter (for her Thesis “A multiscale systems biology study of in-vitro cell migration and cancer cell invasion”). Dr. Sturrock is currently a Postdoctoral Fellow at the prestigious Mathematical Biosciences Institute at Ohio State University (http://mbi.osu.edu). Dr. Schlüter is currently a Research Assistant in Pharmacokinetic Modelling at Cranfield University (http://www.cranfield.ac.uk). Dr. Savory is currently a programmer/consultant at Caltech International (http://www.caletech.com), a software company that provides accounting and business solutions.
PhD Student Prize
While still a PhD student in Dundee, Daniela Schlüter was awarded a Society of Industrial and Applied Mathematics (SIAM) prize for the best student contributed talk at the recent British Applied Mathematics Colloquium (BMAC), which was held at the University of Leeds between 9-12 April, 2013. BMAC is an annual multidisciplinary applied mathematics meeting which provides opportunities for young researchers to network and present their work in a friendly environment, as well as learning about different mathematical applications and techniques. Daniela said: “To win a SIAM prize is incredible. I feel very honoured and happy that my research has been recognised at this level.”

Congratulations to our 2013 graduates!
Congratulations to all mathematics students who graduated in 2013!

Charlie Dixon Award for undergraduate mathematics students
In 2013, four mathematics students have been presented with Dr. Charlie Dixon Award for exceptional dedication to their studies. The awards, made available for the first time this year, are given to mathematics students from the Dundee area, and are very generously provided by the Memorial Fund of the late Dr. Charlie Dixon. Students Craig Johnston, Maggie Long, Rachel Meldrum and Andrew McQueen were presented with the awards as they, each in their own way, have shown tremendous endeavour in their studies. The awards were presented by Mr. Bob Adams, Tayside Investment Ltd. and Mr. Iain Reid, Campbell Boath Solicitors who, along with Mr. Kenneth Whitehurst also of Tayside Investments Ltd., from the Trusteed of the Charlie Dixon Memorial Fund.

Dr. Charlie Dixon was a Senior Lecturer in the Mathematics Department at the University of Dundee and had worked there for over 47 years until his retirement in 2000, making him one of the University’s longest serving members of staff. Dr. Dixon was a dedicated and enthusiastic teacher and was the students’ perennial favourite. He was an avid supporter of extending access to University to those who might not have considered further studies, was the founding member of the University’s School Liaison Office and the first Dean of Students for the Faculty of Science and Engineering. Sadly, Dr. Dixon died suddenly in 2009, but was active to that last. These awards represent a fitting continuation to his efforts.
In Praise of iGEM

The Dundee iGEM team came in for special attention recently. The Team, who include mathematics students Craig Johnston and Rachel Findlay, were listed in the Guardian's "In praise of..." series.

As mentioned in previous Maths Newsletters, each year, undergraduate mathematics students add their logical skills to the interdisciplinary iGEM team who enters an international competition open to university, college and school students. This year, the Dundee team (under the supervision of Dr. Fordyce Davidson and Dr. Lionel Dupuy for mathematics and Prof. Frank Sargeant and Prof. Tracy Palmer for microbiology) is tackling the very topical problem of algal blooms - the blue-green slime that when conditions are right, appears as if by magic in fresh water lakes. Such a bloom almost stopped the sailing events at the Beijing Olympics in 2008. Closer to home, each year lakes and reservoirs throughout the country are affected. The toxins produced by the microscopic algae can be lethal to animals such as dogs and very serious for humans. So early detection and quick response are the key to keeping the public safe, and then getting the water open again as soon as possible. This is the task the Dundee team set themselves this year - to design and build a sensor and clean-up device that combined machine and microbe - a cybug! Will they succeed? Watch this space....

Links:  
http://2013.igem.org/Team:Dundee
http://www.theguardian.com/commentisfree/2013/aug/21/in-praise-of-igem