Isaac Newton Institute for Mathematical Sciences

Newsletter

Programmes in 2009/10

Non-Abelian Fundamental Groups in Arithmetic Geometry investigated current problems in a topic that stretches back to the birth of mathematics, the deep relationships between geometry, numbers and abstract algebraic structures. It built on a programme in 1993 when Sir Andrew Wiles delivered his celebrated proof of Fermat's Last Theorem at the Institute. *Dynamics of Discs and Planets* developed our understanding of recently discovered planetary systems and their formation from discs of dusty gas. This is a field of extraordinary progress, with over 400 extra-solar planets known. *Stochastic Partial Differential Equations* brought together experts in the mathematics used to model many phenomena affected by randomness such as financial markets, interacting species, epidemics and the plasma of particles inside nuclear fusion reactors to explore common approaches. *Stochastic Processes in Communication Sciences* developed new mathematics to apply to modern communications networks such as fixed line, wireless and internet networks in order to model and optimise the way they operate. This research is also highly relevant for increasingly complex electrical power networks. *Gyrokinetics in Laboratory and Astrophysical Plasmas* explored a relatively new approach to understanding low-frequency fluctuations in plasmas, which can have major implications for astrophysics research and fusion reactors. Finally, *Statistical Challenges Arising from Genome Resequencing* investigated the best approaches to the significant mathematical, statistical and computational challenges arising in genome resequencing. This is an area that promises vital developments in plant and animal science, as well as great medical benefits, particularly in understanding diseases. ◗
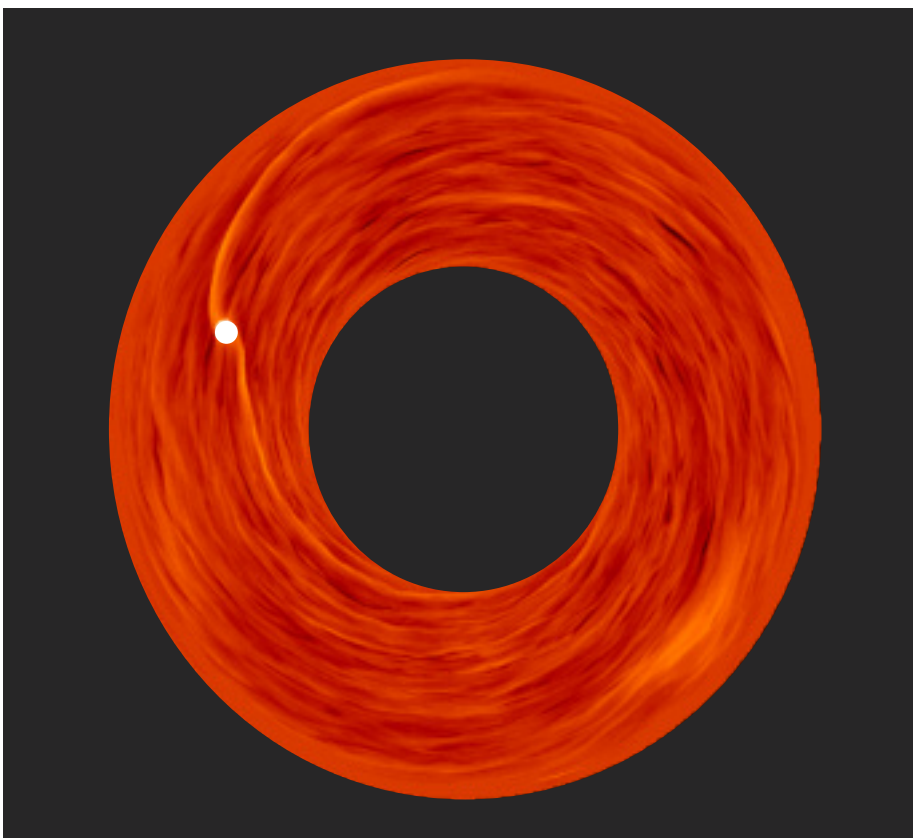
Science at the Institute

The Institute continues to run a series of ground-breaking programmes at the leading edge of mathematical research. As well as stimulating the creation of new mathematics, these programmes make major contributions to the solution of problems at the frontiers of knowledge in many other research areas in physics, engineering, medicine, communications technology, finance and climate science to name but a few. ◗

Simulation of a low mass planet (white circle) embedded in a turbulent proto-planetary disc; the planet's gravity excites spiral waves in the disc that drive inward migration. The migration is modified by interaction with the background turbulent density fluctuations. One of the elements studied on the 'Dynamics of Discs and Planets' programme (Richard Nelson)

Current Programmes

Two programmes are running to the end of the year. *Mathematical and Statistical Approaches to Climate Modelling and Prediction* aims to reduce the uncertainty in climate predictions by exploring ways of incorporating and relating models at different resolutions, linking deterministic and stochastic models and improving the theoretical basis for climate prediction and the estimate of errors. *Partial Differential Equations in Kinetic Theories* aims to advance the mathematical analysis of problems that occur in the modelling of the collective motion of large numbers of individual particles such as molecules in rarefied gases, beads in granular materials, charged particles in semiconductors and plasmas, dust in the atmosphere, cells in biology or individuals in economic trading.

Marine terminus of Belcher Glacier, Devon Island, Nunavit Canada. Photographed in July 2008 as part of the Glaciodyn IPY project. (Lev Tarasov)

Future Programmes

The pipeline of future programmes is very strong, and all slots are now filled to the end of 2012. In 2011 we have four programmes.

Moduli Spaces will advance moduli theory, a branch of mathematics that goes back at least to Riemann in the mid-nineteenth century. It is the theory of family relationships between objects in algebraic geometry, a subject that itself explores deep relationships between geometry, numbers and algebraic structures and, among other things, is the mathematical under-pinning of much of string theory.

Many problems in theoretical computer science and combinatorial optimisation are actually geometric problems in disguise or are so complex that approximation algorithms can best be devised by embedding the underlying combinatorial structure into a familiar geometry. *Discrete Analysis* will bring together researchers in combinatorial mathematics and mathematical computer science to explore these problems.

The optimal design for dynamical models and experiments is crucial to many areas such as pharmacokynetic studies, designs for industrial experimentation, and designs of climate simulation experiments. It uses mathematical techniques such as Galois theory, non- linear optimization and algebraic geometry. *Design and Analysis of Experiments* will explore among other things stochastic simulation to explore industrial process enhancement and the design of experiments in healthcare.

Inverse Problems involve the construction of a model of a cause from the analysis of its effects. They are pervasive, arising in areas as diverse as medical imaging, non-destructive testing, oil and gas exploration, land-mine detection and process control. An example in medical imaging is the construction of a three-dimensional image of a body through the analysis of magnetic resonance effects.

Programme titles for 2012 convey something of the content: *The Mathematics and Applications of Branes in String and M-theory; Semantics and Syntax: a Legacy of Alan Turing; Topological Dynamics in Physical and Biological Sciences; Spectral Theory of Relativistic Operators; Adaptive Mesh Modelling of the Atmosphere and Ocean.*


Alan Turing sculpted in slate at Bletchley Park (Jon Callas)

Follow-up and Open for Business Meetings

The Institute is continually looking for ways to add value to the Programmes that we run. Short Follow-up meetings are proving increasingly popular with organisers of previous Programmes. They provide an effective way to strengthen collaborations started during the original Programmes, and because many results and developments may emerge only years after a Programme has finished, they will be extremely helpful to the Institute in demonstrating success and impact. Another initiative which has gained momentum over the past year has been the series of Open for Business meetings. Open for Business meetings are aimed at industry participants and are typically for half a day, starting with a few very high level overviews of key issues from the research and business perspectives, followed by a panel discussion and then networking over a reception and dinner at Churchill College. Recent examples are Quantitative Finance, Energy Systems and Genome Resequencing. 🌑
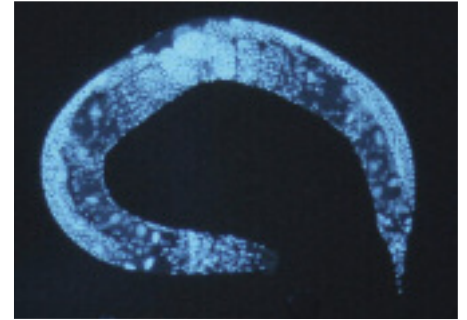
C. elegans, a transparent nematode. This was the first multicellular organism to have its genome completely sequenced (National Human Genome Research Institute)

City Dinners

The chair of the Management Committee of the Institute, Howard Covington, hosts a series of informal dinners which give senior people primarily in financial services the opportunity to engage with leading researchers. These have included Martin Rees, Stephen Hawking, Roger Penrose and James Lovelock. It would be difficult to exaggerate the enthusiasm for these occasions – the network extends now to more than 75 individuals. As well as establishing a group of generous donors, the dinners, have built a potentially influential network of individuals, who understand the importance of the mathematical sciences, and who value fundamental science. For more information please contact david.wallace@newton.ac.uk 🌑

Energy Systems Week

The Institute hosted an Energy Systems Week, 24–27 May 2010, organised in association with the Newton Institute Programme *Stochastic Processes in Communication Systems*, the Knowledge Transfer Network for Industrial Mathematics, and the Council for the Mathematical Sciences. In addition to giving an overview of current research, this workshop provided an introduction to current modelling challenges in power systems for the benefit of systems mathematicians. Presenters included representatives from the Department of Energy and Climate Change, KEMA, National Grid, and UK Research Councils' Energy programme. 🌑

Women in Mathematics Day

The Women in Mathematics Day is an annual event organised by the London Mathematical Society and was held at the Institute for the first time on 15–16 April 2010. Sessions included talks and posters by women mathematicians in a variety of roles and at different career stages. The event included a day focussing on a number of practical sessions to help women get the most out of their careers in mathematics. 🌑


Participants in the Women in Mathematics Day (Emily White)

IMAGINARY: Through the eyes of mathematics

IMAGINARY is a travelling exhibition created by the Mathematisches Forschungsinstitut Oberwolfach and the Institute hosted the exhibitions first visit to the UK in March 2010. Our goals were to excite and inspire public engagement with mathematics, through the beautiful and elegant images that are produced using algebraic geometry, and to encourage the creative exploitation of mathematics using special software. Approximately 1,000 people visited the exhibition including a number of school groups. A picture competition ran for the duration of the exhibition and attracted entries from all of the world. The winning entries came from Cambridge and as far afield as Iran and China. For more information please see www.imaginary-exhibition.com
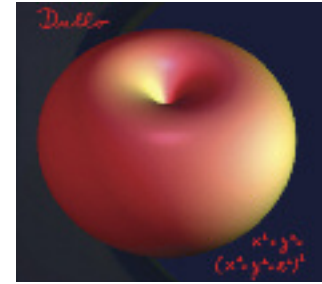
'Dullo' by Herwig Hauser

'Still life: 5 glass surfaces on a tabletop' by Richard Palais and Luc Benard

Finance

The Institute is currently receiving some 10% of the national UK research budget in mathematical sciences of the Engineering and Physical Sciences Research Council. This is a compelling measure of the national and international standing of the Institute. In the light of likely future cuts in national research funding, a major and vital activity now is to diversify the funding base of the Institute in preparation for an application to renew Research Council funding for 2014. To contribute to the Institute you can contact David Wallace at David.Wallace@newton.ac.uk or visit www.newton.ac.uk

Events of Wider Public Interest

15 November 2010 — Fields Medallist **Cedric Villani** will talk about his award at the Institute at 5pm; followed by a wine reception.

24 November 2010 — **Climate Change Question Time:** A public forum in connection with the Programme *Mathematical and Statistical Approaches to Climate Modelling and Prediction*. To take place 2–7pm at The Willis Building, 51 Lime Street, London, EC3M 7DQ. For further details see www.newton.ac.uk/programmes/CLP/ws.html

6 December 2010 — The Rothschild Visiting Professor **Tim Palmer** (University of Oxford and European Centre for Medium-Range Weather Forecasts) will give a talk entitled *Estimating and Reducing Uncertainty in Climate Prediction: The Crucial Role of Mathematics* at the Institute at 5pm; followed by a wine reception.

For further information on these and other events please see www.newton.ac.uk