



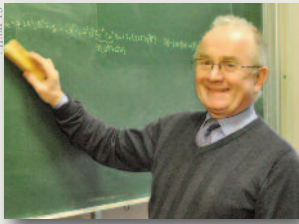
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APPENDICES: Statistical information on the following areas is available online at [www.newton.ac.uk/reports/1112/appendices.html](http://www.newton.ac.uk/reports/1112/appendices.html)

- 1 Invited Participants
- 2 Junior Members of the Newton Institute
- 3 Country of Residence of Participants
- 4 Preprints and Papers Produced or in Preparation by Participants
- 5 Seminars and Lectures
- 6 Seminars Given Outside of the Institute

## Director's Foreword



Twenty years ago the Isaac Newton Institute was founded to nurture UK research in the mathematical sciences and their applications by:

- being a locus for focused collaborative timely research;
- involving the best researchers in the world;
- engaging with mathematical challenges wherever they emerge;
- giving UK researchers, especially early career researchers, access to world leaders.

Twenty years later it is regarded as one of the premier institutes of its kind in the world. From the outset, its range was broad and nowadays the scope of its activity includes areas covered in the USA by at least eight NSF-funded specialised institutes.

My first year as Director has been dominated by four interlocking activities: the scientific programme; events around the 20th Anniversary; fundraising; preparing a proposal to the Research Councils for renewed support.

The scientific quality of proposals, on themes of topical interest and likely to have a lasting impact, remains high and we will continue working to maintain that high standard. In addition, the Institute is working to provide an independent forum for activity allied to mathematical research. To be called the *Turing Gateway to Mathematics* (because of the wide scope of Turing's influence) it will aim to become a recognised centre for impact, outreach and interdisciplinarity across the mathematical sciences and beyond.

20th Anniversary events:

- Nine 20th Anniversary Lectures have been organised across the country
- January–June: Turner Prize winner Grenville Davey was the Institute's first Artist in Residence and presented it with some of his work
- April–June: an exhibition of Henry Moore stringed figures and the mathematical models which inspired them was held jointly at the Science Museum and the Royal Society

*Intersections: Henry Moore and Stringed Surfaces* was covered by press and radio nationally and internationally

- May: Rothschild Visiting Professor, Andy Strominger, gave a public lecture to a packed audience in London: *The Edges of the Universe: Black Holes, Horizons and Strings*
- July: Fields Medallist, Wendelin Werner, gave a powerful lecture *Randomness, the Continuum and Reality* on the anniversary day itself (for mathematicians the Fields Medal is equivalent in esteem to a Nobel Prize)
- July: Astronomer Royal, Lord Martin Rees, became an Honorary Fellow in recognition of his role as one of its founding fathers and of his long-term, and continuing, support

I am very grateful to the Research Councils, in particular EPSRC, and other donors listed later in this Report who have supported the science at the Institute over the past year. Additionally, I would like to thank the benefactors who supported the many non-academic activities which made the Anniversary Year events such a success.

In the current financial climate fundraising is simultaneously more important and more difficult. Against this background there have been some notable successes that are reported by the Chair of the Management Committee.

Preparation of a proposal for Research Councils' renewed funding has been completed in the understanding that no more than 56% of the Institute's scientific activity can be supported from that source after 2014, down from 73% in 2013. However, the Institute is committed to maintaining its hard-won reputation for mathematical excellence even in this challenging economic environment. This will mean continuing to deliver ground-breaking research of the highest international standard, and extending the reach of mathematics into application areas by developing the *Turing Gateway to Mathematics* project. Throughout, it will strive to maintain the culture of innovation, creativity and achievement for which it is widely recognised.



## Institute News

### 20th Anniversary Celebration Day



Peter Goddard

Over 100 guests were invited to attend a special Celebration Day on Wednesday 11 July 2012. Staff, former staff and past Directors and Deputy Directors together with supporters and friends of the Institute gathered for an afternoon of lectures and exhibitions to mark the 20th Anniversary of the inauguration of the Institute.

The afternoon began with a special video message given by Sir Michael Atiyah, the Institute's first Scientific Director, followed by a fascinating talk by former Deputy Director Professor Peter Goddard who spoke on the early history of the Institute. This was followed by tea and 20th

Anniversary cake which featured a representation of the Institute's portrait of Isaac Newton. In the afternoon Fields Medallist and former Leibniz Fellow at the Institute, Professor Wendelin Werner, gave a seminar suitable for a general scientific audience entitled *Randomness, the Continuum and Reality*.

Throughout the afternoon guests were able to view a number of exhibitions and presentations about the architecture of the building, the history of the Institute and the current scientific work taking place on our programmes.



Wendelin Werner

### Anniversary Lectures Around the UK

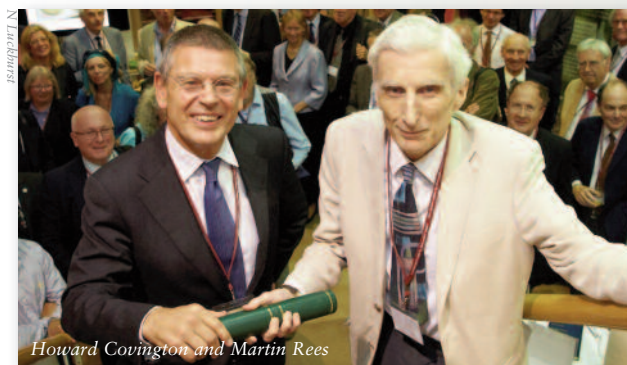
During 2012 the Institute organised a *Newton Institute 20th Anniversary Lecture Series*. The Institute sponsored lectures around the UK which were given by participants on Institute programmes. The lectures that were given are listed below:

- 18 April 2012 **Alain Connes** *The Spectral Point of View on Geometry and Physics*, Cardiff
- 20 April 2012 **Joel Hamkins** *The Automorphism Tower Problem for Groups*, Bristol
- 4 May 2012 **Rajesh Gopakumar** *Who's Afraid of Higher Spin Theories?*, Durham
- 9 May 2012 **Andrew Strominger** *The Edges of the Universe: Black Holes, Horizons and Strings*, Royal Society, London
- 16 July 2012 **Luca Cardelli** *Biological Switching Algorithms*, Liverpool John Moores
- 2 October 2012 **John Hannay** *Classical Holonomy; Some Physics of Round Trips*, RAL
- 17 October 2012 **Louis Kauffman** *Virtual Knot Theory*, Warwick

- 9 November 2012 **Jörn Behrens** *Scientific Computing Methods Behind Tsunami Early Warning*, Bath
- 3 December 2012 **Tudor Ratiu** *Applications of Geometric Mechanics*, Glasgow

### Honorary Fellowship for Martin Rees

Lord Martin Rees has been awarded an Honorary Fellowship of the Isaac Newton Institute in recognition of exceptional service to the Institute. The presentation was made as part of the Institute Celebration Day on 11 July 2012. Chair of the Management Committee, Howard Covington, presented Lord Rees with a Fellowship Scroll.



Howard Covington and Martin Rees

## Science at the Institute



**John Ball,**  
Chair of the Scientific  
Steering Committee

It has been a pleasure for the *Scientific Steering Committee* (SSC) to work with the new Director, John Toland, in helping to chart the future scientific course of the Institute. The table of upcoming programmes reflects the strength and variety of proposals that the Institute continues to receive. Throughout the year there were nineteen full proposals, eight of which were in response to a special call under the heading *Mathematics of Planet Earth 2013*; in addition there were four preliminary proposals and two *Follow-up Meeting* proposals. Nine full proposals and two *Follow-up*

*Meeting* proposals were accepted, and three others were invited to resubmit. In addition two scoping meetings, intended to lead to full proposals were initiated. This is a healthy state of affairs. This year the SSC paid particular attention to the lengths of proposed programmes, to ensure that they were appropriate for what was being planned.

At the end of 2012, David Preiss and Marie-Francoise Roy (former president of the Société Mathématique de France) stand down from the SSC; Steven Cowley, CEO of the UKAEA, Michael Harris, Institut de Mathématiques de Jussieu, and Emily Shuckburgh, British Antarctic Survey, have agreed to serve from January 2013. The Institute is indebted to all members of this Committee, and the many mathematical scientists from around the world who have acted as referees, for their impartial contributions to the peer review process which is so essential to its work.

## Scientific Steering Committee

Membership of the Scientific Steering Committee at 31 July 2012 was as follows:

Sir John Ball FRS FRSE (Chair)	University of Oxford
Professor K Ball ( <i>ex-officio</i> )	ICMS
Professor M Calder FRSE	University of Glasgow
Professor W Kendall	University of Warwick
Professor J Lygeros	ETH Zürich
Professor D Preiss FRS	University of Warwick
Professor S Richardson	University of Cambridge
Professor M-F Roy FEng	Institute of Mathematical Research of Rennes
Professor E Süli	University of Oxford
Professor R Thomas	Imperial College, London
Professor R Twarock	University of York
Professor C Villani	Institut Henri Poincaré
Professor JF Toland FRS FRSE (Secretary)	Director, Newton Institute
Professor T Wooley FRS	University of Bristol

The *Scientific Steering Committee* (SSC) meets twice each year to consider proposals for programmes (of 1-month, 4-month or 6-month duration) to run two or three years later. Successful proposals are usually developed in a discussion between the proposers and the SSC conducted through the Director, and may well be considered at more than one SSC meeting before selection is recommended. Proposers may wish to submit a shorter ‘preliminary’ proposal in the first instance with a view to obtaining feedback from the SSC prior to the submission of a ‘full’ proposal. Complete details of the Institute’s regular call for proposals, including guidelines for submission, can be found on the Institute’s website at [www.newton.ac.uk/callprop.html](http://www.newton.ac.uk/callprop.html).

## Future Programmes

The schematic below shows recent and forthcoming programmes selected by the Scientific Steering Committee. Long-stay participation in a programme is at the invitation of the programme organisers; anyone interested should contact them directly. One- or two-week workshops are advertised, and applications invited with specific deadlines. Visits of one or two days are always welcome; we ask only that [reception@newton.ac.uk](mailto:reception@newton.ac.uk) is emailed in advance to assist us with planning; see page 22 for more details.

Further details of each of these programmes, including the names and contact details of the organisers, can be found on the Newton Institute website at [www.newton.ac.uk/programmes/](http://www.newton.ac.uk/programmes/). Further information on how to participate in programmes can also be found on the website at [www.newton.ac.uk/participation.html](http://www.newton.ac.uk/participation.html).

	JAN	JUL	SEP	DEC	
2011	Moduli Spaces		Design and Analysis of Experiments		
	Discrete Analysis		Inverse Problems		
2012	Mathematics and Applications of Branes in String and M-theory		Topological Dynamics in the Physical and Biological Sciences		
	Semantics and Syntax: A Legacy of Alan Turing		Spectral Theory of Relativistic Operators	Multiscale Numerics for the Atmosphere and Ocean	
2013	The Mathematics of Liquid Crystals		Polynomial Optimisation	Mathematical Challenges in Quantum Information	
	Grothendieck–Teichmüller Groups, Deformation and Operads	Mathematical Modelling and Analysis of Complex Fluids and Active Media in Evolving Domains		Infectious Disease Dynamics	The Holographic Principle
2014	Free Boundary Problems and Related Topics		Theory of Water Waves	TBA	
	Inference for Change-Point and Related Processes	Mathematical, Statistical and Comp. Aspects of the New Science of Metagenomics	Advanced Monte Carlo Methods for Complex Inference Problems	Interactions between Dynamics of Group Actions and Number Theory	Quantum Control Engineering
2015	Periodic and Ergodic Spectral Problems		Metric and Analytic Aspects of Moduli Spaces	TBA	
	Random Geometry		TBA		

Key: nominal programme duration     6 months     4 months     2 months     1 month



# Design and Analysis of Experiments

18 July to 21 December 2011

[www.newton.ac.uk/programmes/DAE/](http://www.newton.ac.uk/programmes/DAE/)

## Report from the Organisers:

RA Bailey (Queen Mary), B Bogacka (Queen Mary), SGM Biedermann (Southampton), H Dette (Bochum), P Goos (Antwerp), AG Lynch (CRUK Cambridge) and H Maruri-Aguilar (Queen Mary)



SGM Biedermann, H Maruri-Aguilar, RA Bailey,  
B Bogacka, AG Lynch and H Dette

## Background

Design of experiments (DOE) is an area of statistical methodology with applications in many fields where experiments are done to develop new theories or to confirm existing hypotheses. Manufacturing processes, computer experiments to model climate change, and trials to improve large-scale primary care or to find effective drugs for cancer patients are a few examples. Even small improvements in methodology can have huge effects when applied across a range of topics.

Researchers in different fields may become specialised, use a different vocabulary for the same thing, and reinvent the same ideas, unaware of developments in other areas. Statisticians who use one part of mathematics to further the design of experiments may know little about other parts of mathematics that can also be used. For example, use of symmetry groups can cut down computer

searches for designs, but those who know the group theory and those who design search algorithms do not always talk to each other.

## Programme Structure

There were six workshops, all in the first half of the programme; this had the desired effect of introducing people to aspects of the design and analysis of experiments, and application areas, with which they were unfamiliar. There were two *Open for Business* days in addition to the *Cambridge Statistics Initiative* (CSI) meeting. J Stufken, Rothschild Distinguished Visiting Fellow, gave a general lecture on orthogonal arrays and the Fisher Memorial lecture on causal inference from experimental data was given by AP Dawid.

## Experiments for Processes With Time or Space Dynamics

### Workshop, 18–22 July 2011

Organisers: D Uciński and A Curtis

This workshop brought together researchers from many scientific areas that use optimum experimental design to deal with large-scale and highly complex systems where time and/or space are inevitable components. It focused on applications, to promote cross-fertilisation between engineering, applied mathematics and design of experiments experts. Invited speakers from outside the usual statistical community gave talks on design in chemical engineering, biochemical engineering, control engineering and geophysics. These were complemented by talks on mixed-effect models, stochastic dynamic models, adaptive design, random-graph models, statistical learning, designs accounting for correlations in time or space, designs for processes modelled by partial differential equations, and designs for ill-posed problems. Hard computational issues were also addressed.

*Optimum Design for Mixed Effects Non-Linear and Generalised Linear Models*  
**Workshop, 9–12 August 2011**

Organisers: B Bogacka and S Leonov

This brought together topics seldom united in meetings. Introductory lectures by D Bates, E Demidenko and VV Fedorov gave very good theoretical background which embedded design issues in the more general setting of modelling and estimation when there are random effects. Other talks covered more specific issues of optimum design when population variability is represented by such effects, covering linear models, generalised linear mixed models, and non-linear models. The last day was devoted to population optimum design of experiments. Applications included cancer, Alzheimer's disease, HIV, drug-drug interaction, and sensor location.

*Design of Experiments in Healthcare*  
**Workshop, 15–19 August 2011**

Organisers: S Biedermann, V Dragalin, S Eldridge, H Großmann, M Krams and P Mueller

The workshop was organised around many themes, with mini workshops for each. The focus on one topic at a time created the right atmosphere to generate discussion and reflection on challenges and open problems. Topics addressed included: treatment individualisation; covariate adaptive designs; early-phase model-based design; sequential and other Bayesian designs; cluster-randomised trials; stepped wedge designs; and three sessions devoted to designs for choice experiments that emphasised applications in health economics. Highlights were: an adaptive model-based approach that provides information about important subpopulations of patients; the exploration of individual versus collective ethics; and a current high-profile trial showcased by D Berry.

**Open for Business Pharmaceutical Day**

This focused on the design of dose-ranging studies. Researchers from pharmaceutical companies and academia discussed current attempts to use design of experiments to overcome recognised inefficiencies of traditional drug development, as well as to meet new challenges in designing clinical trials. In addition to talks on methodology and on real applications, challenges were presented by



*Participants at the workshop 'Experiments for Processes With Time or Space' in July 2011*

representatives of both the pharmaceutical industry and the regulatory authorities. The day closed with a panel discussion on optimal design in drug development.

*DEMA 2011: Designed Experiments: Recent Advances in Methods and Applications*  
**Workshop, 30 August–2 September 2011**

Organisers: S Biedermann, SG Gilmour, H Großmann, S Lewis, B Torsney and D Woods

Starting with J Wu's keynote talk on post-Fisherian experimentation, this workshop attracted a large number of high-profile speakers from around the world. It covered a range of methodological topics, including high-dimensional responses and screening in the presence of model uncertainty, and application areas such as clinical trials and computer experiments. Participants appreciated the visit to Rothamsted Experimental Station, the birthplace of modern design of experiments. The lively, high quality poster session was well received.

*Accelerating Industrial Productivity via Deterministic Computer Experiments and Stochastic Simulation Experiments*  
**Workshop, 5–9 September 2011**

Organisers: D Bingham, AM Dean, T Santner, B Ankenman and B Nelson

This workshop brought together researchers concerned with deterministic computer experiments and those concerned with stochastic simulation experiments. With speakers from academia and industry, and from UK and US national research centres, it addressed needs arising from applications such as the atmospheric sciences, oceanography, medical research and engineering. Topics discussed included stochastic simulation techniques for dealing with input uncertainty and model



uncertainty, and issues for computer simulators, such as interpolation, calibration and discrepancy of simulator results from physical experiment data. Panel sessions covered issues such as robustness, the interface of physical experiments and computer models, and future challenges for incorporating multiple modes of experimentation.

### *Algebraic Method in Experimental Design Workshop, 26–27 October 2011*

Organisers: H Maruri-Aguilar and HP Wynn

The central aim of this more informal workshop was to apply recent progress in the new algebraic method in experimental design to classical combinatorial designs. RA Bailey gave an introductory lecture on graphs and blocks designs. On the algebraic side, there were sessions on monomial ideals and on boundary exponential models. Progress was made in a number of areas including on correlations between different measures of connectivity for block designs.

### *Cambridge Statistics Initiative Special Meeting, 26 September 2011*

Organisers: S Chiappa, I Cosmo and A Lynch

This special one-day meeting included 37 presentations covering topics such as genomics, statistical theory, presentation and communication of statistical ideas, collaboration with scientists in various fields, and design and analysis of experiments. There were over 100 participants, including over 20 from the DAE programme.

### *Open for Business Industry Day 30 November 2011*

Organiser: D Woods

This brought together researchers and practitioners from academia, including an encouraging number of early career researchers and PhD students, and from UK industries ranging from software development to chemical engineering. The keynote lecture, given by T Davis, demonstrated the importance of using subject-specific knowledge in the design and analysis of industrial experiments. It was followed by presentations from the automotive, consumer, pharmaceutical and oil industries, demonstrating the application of novel design methods and presenting some new challenging problems. There were very successful break-out sessions and a panel discussion.

## *Outcome and Achievements*

The main programme had 72 visiting fellows, with participants from over 20 countries. A further 198 people attended one or more of the workshops. In addition to mathematicians and statisticians, participants came from medical departments, environmental and agricultural science, software firms, pharmaceutical companies, the aerospace industry and utility companies. New collaborations were formed; old collaborators began new work together; others completed shared projects.

At least 9 books will contain new material developed during the programme: the next edition of Rosenberger's book on randomisation will incorporate material on cluster randomised trials; T Santer's forthcoming book on design of computer experiments has been influenced by talks in the fifth workshop; and D Uciniski is editing a book based on the first workshop. Most participants worked on at least three new papers and there are already 38 preprints.

Long-stay participants included both established and early career researchers. Some PhD students were able to attend and gain from interactions and collaborations with people whom they would not otherwise have met. Non-UK participants made numerous fruitful visits to other UK institutions. S Gilmour and LA Trinca presented a read paper to RSS on work begun at the 2008 programme with about 20 participants adding to the discussion at the meeting; these contributions have been published with the paper.

As the workshops demonstrated, different application areas favour different optimality criteria. Designs for categorical treatments have different desiderata from those for continuous treatments. Constraints in chemical engineering are quite different from those in clinical trials. New work was done in and between many areas.

Outside the workshops, there were many informal discussions of 1–3 hours with about 10–20 people: topics included systematic versus randomised designs; factorial designs; multi-stratum designs; algebraic and graph-theoretical approaches to block designs; numerical algorithms for finding optimal designs; computer experiments and space-filling designs; designs for neighbour effects.

# Inverse Problems

25 July to 21 December 2011

[www.newton.ac.uk/programmes/INVI](http://www.newton.ac.uk/programmes/INVI)

## Report from the Organisers:

M Brown (Cardiff), T Fokas (Cambridge), Y Kurylev (University College London), WRB Lionheart (Manchester) and WW Symes (Rice)



WW Symes and T Fokas

## Scientific Background

When exploring for oil or gas, shock waves from an explosion on the earth's surface are reflected by the material below and data is collected at the surface. The inverse problem is to determine the structure of the earth beneath, from the outcome of this experiment, without digging a hole. Similarly, in medicine, there are techniques for visualising the interior of a living body without surgery.

Inverse problems arise in a vast range of applications in what is a rapidly growing field of research. The mathematical machinery for solving such problems comes from functional analysis, partial differential and integral equations, micro-local and global analysis, differential geometry and stochastic analysis, and the implementation of the theory in practical devices involves numerical analysis and scientific computing.

## Workshops

### Introductory Workshop in Inverse Problems Workshop, 25–29 July 2011

Organisers: M Brown, M Lassas and R Potthast

The aim was to provide an overview for post-graduate students, postdocs, and researchers working on inverse problems and in related areas.

There were five 4-hour courses:

- G Uhlmann: Overview of hybrid imaging and micro-local methods
- A Nachman: Electrical impedance tomography and PDE methods
- A Kirsch: Inverse scattering problems
- S Siltanen: Numerical and statistical methods for inverse problems
- L Borcea: Imaging in random media

and 1-hour surveys of specific inverse problems by R Kress, Y Kurylev and M Burger.

### Inverse Problems in Analysis and Geometry Workshop, 1–5 August 2011

Organisers: M Brown, H Isozaki, Y Kurylev, L Pivrinta and G Uhlmann

The goal was to develop new methods in analysis and geometry for studying inverse problems and to identify unexpected applications of inverse-problem techniques in other areas. Participants were given wider perspectives of the subjects as a whole in lectures by:

- A Ruiz: Harmonic analysis for inverse problems;
- EB Davies: Generalisations of classical Ambarzumyan uniqueness results using spectral theory;
- L Robbiano: Carleman-type estimates applied to inverse problems;
- H Isozaki: Scattering for asymptotically hyperbolic manifolds and corresponding inverse problems;
- U Leonhardt: The relations between quantum and electromagnetic invisibility, meta-materials and inverse problems.

The lecture by U Leonhardt initiated a collaboration between A Greenleaf, Y Kurylev, M Lassas and G Uhlmann on one side, and U Leonhardt on the other, resulted in the publication of new developments in the mathematical theory of cloaking with physical applications. From their lectures, A Kirsch and A Ruiz came to recognise the complementarity of their methods, which led to collaboration on techniques based on harmonic analysis within the factorisation method. The lecture by M Salo on the recovery of conformal factors in anisotropic inverse problems elucidated relations between the method of limiting Carleman weights and the boundary control method currently being developed by D Dos Santos Ferreira, Y Kurylev, M Lassas and M Salo.

### *Analytic and Geometric Methods in Medical Imaging*

**Workshop, 22–26 August 2011**

Organisers: M Brown, T Fokas, E Haber, Y Kurylev, B Lionheart and A Nachman

This workshop was partially supported by MITACS (Mathematics of Information Technology and Complex Systems) and the University of Toronto and aimed at establishing connections between inverse-problem theory and the analysis of images obtained with current instrumentation in hospitals. The mathematical focus was on recent analytical and geometric advances over a surprisingly wide range of topics. For instance, the use of quasi-conformal mappings in the registration of biological surfaces was reported in the keynote lecture by TF Chan. In another direction, K Astala explained how quasi-conformal mappings can be used in an essential way to solve the inverse problem of Calderon in two dimensions for very rough coefficients. The Rothschild Distinguished Visiting Fellow, G Uhlmann, explained how geodesic flow leads to the solution in two dimensions of the classic open problem of recovering a Riemannian metric from the distances between the points on the boundary, and of open problems in tomography. On the image analysis side, L Cohen showed how the computation of geodesics can yield efficient methods in biological image segmentation. Geometric methods in imaging arise in the study of Riemannian metrics which are defined on shape spaces to measure similarities between shapes and perform statistical analysis for medical diagnostics.

The workshop included three lectures by some of the foremost researchers in this area, L Younes, A Trounev and M Micheli. Graph-theoretic methods in imaging were presented by N Paragios and J Darbon. On the analytic side, the lectures by G Bal, O Scherzer, S Arridge and H Amari described work on hybrid methods, a very active new area in inverse-problem theory in which one seeks significantly to improve both the quantitative accuracy and the resolution of traditional approaches by the coupling of two different kinds of physical measurements. The lecture by A Moradifard showed the connection between these problems and well-known total-variation minimisation techniques in image analysis and led to fruitful discussions between A Ciomaga, J Darbon and A Nachman.

An important analytic theme of the workshop was research in compressed sensing, reconstruction under sparsity constraints and its relationship to imaging and tomography. Recent results in this area were presented by C Schoenlieb, H Zhao, M Lassas and A Hansen.

In addition to the 30 presentations on analytic and geometric work in medical imaging, the workshop also featured an *Open for Business* event *Medical Imaging Day*, which showcased the relevance of some of these developments to clinical and business applications. Guests from companies invited to the event were amazed by new tissue images which had been obtained by novel hybrid methods, such as photo-acoustics, presented by L Wang (winner of the Joseph W. Goodman Book Writing Award for his textbook on Biomedical Optics, of the NIH FIRST award, the NSF CAREER award, and of the C.E.K Mees Medal for seminal contributions to photo-acoustic tomography). Similarly, the academics present were pleased to see how their advanced geometrical techniques (for example the use of Ricci flow and conformal maps) were being adopted by medical imaging companies with clinical applications, as described in the INI case study:- [www.newton.ac.uk/reports/casestudies/ricci.pdf](http://www.newton.ac.uk/reports/casestudies/ricci.pdf).

The animated panel discussion which followed led to valuable exchanges of ideas, in keeping with the overall atmosphere which the workshop sought to create. Many of the participants considered this to be one of the most interesting and successful meetings they had attended.



*Inverse Spectral Problems in One Dimension*  
 Satellite Meeting at ICMS, Edinburgh,  
 17–21 October 2011

Organisers: C Bennwitz, M Brown, F Gesztesy and R Weikard

Keynote speakers at the workshop were J Behrndt, F Gesztesy, P Kurasov, M Malamud, S Naboko, B Rundell, G Teschi, R Weikard. The focus was on inverse spectral problems in 1-dimension, including the role of the Dirichlet–Neumann operator,  $m$ -function inverse spectral problems that occur in the Camassa–Holm problem on the real line and inverse problems on graphs.

*Inverse Problems in Science and Engineering*  
 Workshop, 12–16 December 2011

Organisers: M Brown, T Fokas and WW Symes

This workshop included presentations on inverse problems which arise in scientific and engineering applications, including geophysical prospecting, reservoir engineering, radar imaging, x-ray computed tomography, hybrid imaging modalities in biomedical and other applications, statistical estimation in inverse problems and numerical simulation methods. It began with three hour-long tutorial lectures overviewing problems from seismic, radar, and biomedical applications.

The programme included an *Open for Business* event, *Inverse Problems in Oil and Gas Exploration*, to which leading research managers in the oil and gas business, J Robertsson (Schlumberger Cambridge Research), D Ellis (BP), H Calandra (Total E and P) and F ten Kroode (Shell International Exploration and Production) contributed. Their presentations led to a broad understanding of the size, scope, and economic meaning of oil industry data acquisition and processing, of the central role that inverse problems play in the industry, and of some future prospects and challenges facing exploration technology. Activities ended with a panel discussion.

A concern that emerged was the relationship between, and relative importance of, deterministic versus statistical and probabilistic methods for inverse problems and imaging. Another was how to evaluate analytical developments in the light of parallel developments in high-performance computing.



*Inverse Problems in Science and Engineering*

*Further activities*

Participants from this programme, D Dos Santos Ferreira, C Gillarmou, J LeRousseau and M Lassas are applying for a semester in 2014 at Institut Henri Poincaré in Paris. In addition the programme has directly led to:

- a conference at the Paris School of Mines in July *100 years of Electrical Imaging* bringing together those working in geophysics, medicine and process electrical imaging;
- a planned study group on inverse-problem challenges in land mine detection, in collaboration with the charity *Find a Better Way*;
- a bid to EPSRC's *Building Global Engagements* programme from Manchester University, with a focus on translating theoretical (mathematical) developments to a broad range of applied problems in tomographic imaging;
- an application for a *Centre in Inverse Problems* at UCL completed during the programme with the intention of involving a broad range of interdisciplinary research in the UK. This application involved organising a meeting at UCL on perspectives on inverse problems (29 September, 2011). It attracted more than 60 people from 11 departments across UCL with a number of participants from the Institute programme playing a leading role.

In summary, this programme gave rise to many new international collaborative groups bidding to various national and international funding agencies. It opened new directions and reorientated inverse problems by highlighting the fruitful directions of study with high relevance to applications.

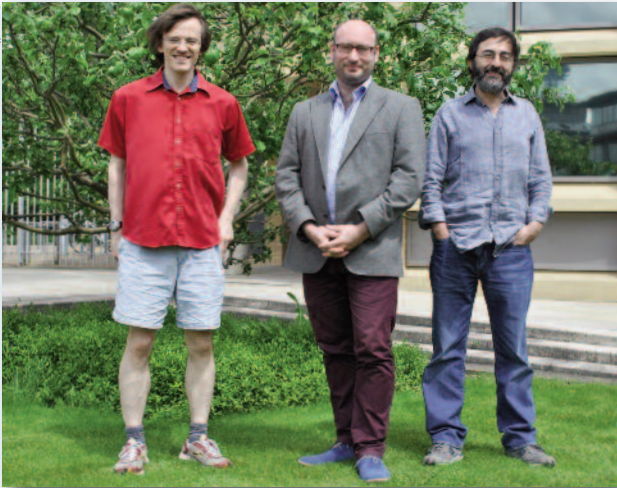
# Mathematics and Applications of Branes in String and M-theory

3 January to 29 June 2012

[www.newton.ac.uk/programmes/BSM/](http://www.newton.ac.uk/programmes/BSM/)

## Report from the Organisers:

DS Berman (Queen Mary College, London), J Conlon (Oxford), N Lambert (CERN/Kings College, London), S Mukhi (Tata Institute, Mumbai) and F Quevedo (Cambridge/ICTP, Trieste)



J Conlon, DS Berman and F Quevedo

## Scientific Background

The *Mathematics and Physics of Branes in String and M-theory* (BSM) programme was organised to stimulate collaborative research in the light of recent developments in the study of branes in M-theory.

String Theory and its strongly coupled limit, M-theory, are currently the leading candidates for a complete quantum theory of all known fundamental forces in nature. In addition, their study has sparked off remarkable new ideas in pure mathematics. The Newton Institute has previously hosted three related programmes: *Geometry and Gravity* (1994), *M-theory* (2002) and *Strong Fields, Integrability and Strings* (2007). Given the recent advances, the time was right for another Newton Institute programme in the area.

The themes of the programme were identified to be:

- string/M-theoretic geometry: properties of compactifications, classifications of solutions, dualities and their uses e.g. T-folds and U-folds, fermionic T-dualities and the incorporation of

p-form fields to give novel effective geometries;

- string/M-theoretic novel algebraic structures: three-algebras, duality groups and higher exceptional groups such as E10 and E11;
- brane physics: quantisation of branes, field theories for multiple branes and their intersections, attempts to define a fundamental theory of membranes;
- applications to strongly coupled field theory: the use of brane physics and the associated gauge/gravity duality for applications to strongly coupled systems such as nonperturbative quantum field theories and condensed matter systems etc.;
- applications to particle physics: the role of string compactifications in string phenomenology, brane constructions of the Standard Model and the combination with supersymmetry breaking;
- applications to cosmology: the dynamics of branes in order to study early universe cosmology.

## Structure

The programme was divided into a five-month section on relatively formal theoretical issues, which was organised by DS Berman, N Lambert and S Mukhi, followed by a one-month segment on applications to elementary particle phenomenology organised by J Conlon and F Quevedo. The former focused on the first three themes and the latter on the last themes, as listed above. However it is important to note that the two teams made great efforts to coordinate their activities so as to ensure a smooth programme. Furthermore there is no sharp boundary between these themes and so elements of



all of them were present at various times throughout the programme.

During the programme roughly 4–5 seminars were organised per week, except during workshops when there were several talks each day. The regular seminars were concentrated in the middle of the week with the aim of leaving two days free from seminars. The Rothschild Visiting Professor was A Strominger who gave a lecture entitled *The Edges of the Universe, Black Holes, Horizons and Strings* at the Royal Society. The programme also had a teleconference talk given by Edward Witten of the IAS Princeton, broadcast over the internet.

## Workshops

### *Mathematical Aspects of String and M-theory* Workshop, 11–13 January 2012

Organisers: P Candelas, X de la Ossa, M Gaberdiel and DS Berman

This workshop was held at the beginning of the programme and focused on some of the most formal aspects of string/M-theory. A particularly strong theme of this meeting was that of generalised geometry (generalised beyond the notion introduced by Hitchin), which arises via U-duality; generalised geometry is expected to play an important role in string/M-theory as it reflects a radically new view of spacetime. Higher spin gravity, flux compactifications and the Moonshine programme in mathematics were some of the other themes.

### *Recent Advances in Scattering Amplitudes* Workshop, 2–4 April 2012

Organisers: G Travaglini, A Brandhuber and B Spence

This workshop was set up to capitalise on the striking recent advances on performing amplitude

calculations in quantum field theory without using the traditional but increasingly intractable technique of Feynman diagrams. This is currently a very active field with deep relations to twistor theory and other topics in pure mathematics (such as symbols and motives).

### *Condensed Matter, Black Holes and Holography*

#### Workshop, 16–20 April 2012

Organisers: D Tong, J Sonner and N Lambert

One of the more surprising advances in the study of branes in string/M-theory is that, through the AdS/CFT correspondence, there are potentially important applications to other areas of physics such as Condensed Matter, where new techniques are needed to understand strongly coupled systems. This workshop was run as a pedagogical international school with lecture courses describing these new techniques. The focus ranged from quantum matter and topological phases to the gravity-fluid dynamics correspondence. This activity was particularly unique in that it brought formal string/M-theorists together with condensed matter theorists.

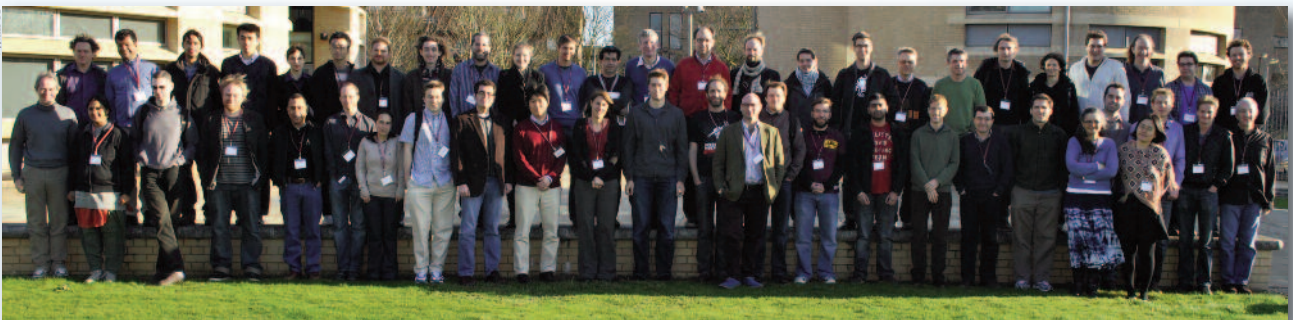
### *Branes and Black Holes*

#### Satellite Meeting at King's College London

#### 28 May–1 June 2012

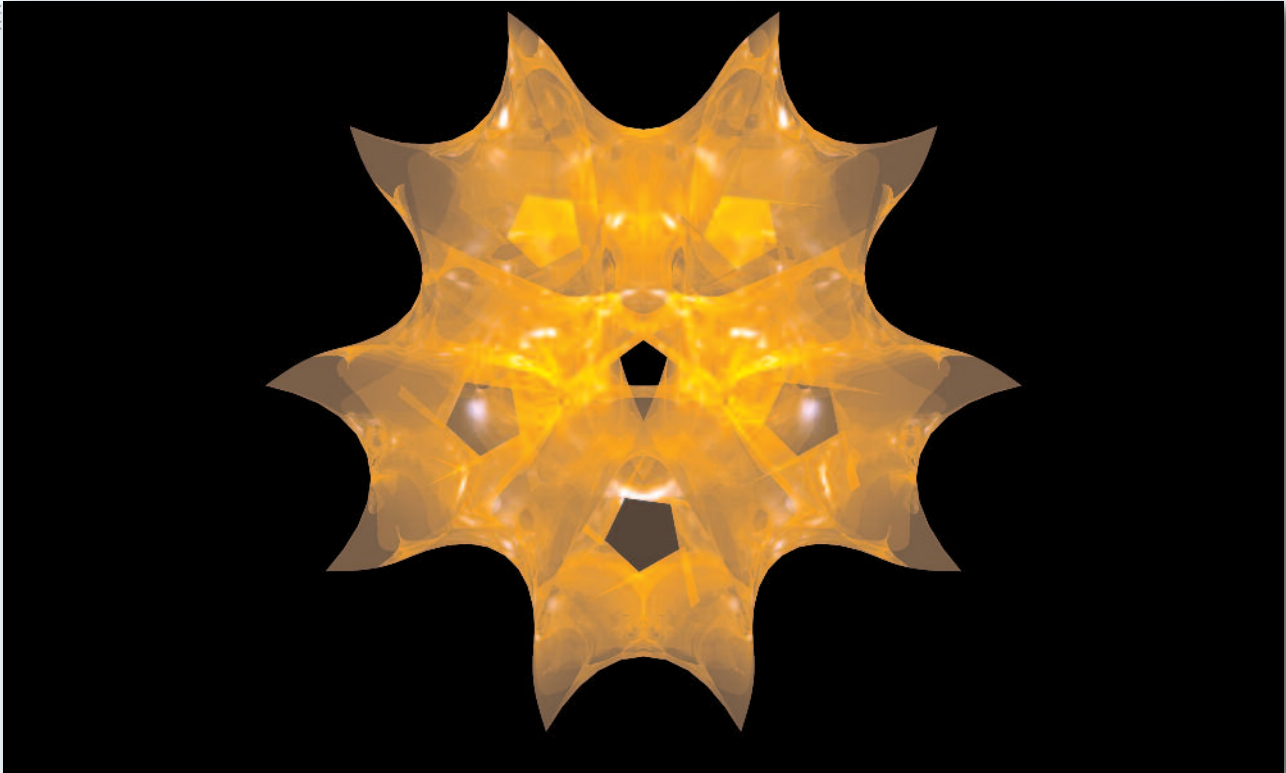
Organisers: J de Boer, S Mukhi, A Sen, A Strominger and N Lambert

This *Satellite Meeting* focused on the role that branes in string/M-theory have to play in understanding black holes in quantum gravity. The meeting brought together internationally leading scientists and covered a diverse selection of topics, notably black hole entropy and microstates, deSitter gravity, flows and stability, and topological strings.



Participants at the 'Mathematical Aspects of String and M-theory' workshop in January 2012





To make contact with the four spacetime dimensions that we are aware of, string theorists propose that six additional spatial dimensions are wrapped up on an extremely tiny length scale, much smaller than an atomic nucleus. If they are correct, the properties of these extra dimensions determine the properties of the particles and forces that we witness in our macroscopic world. The most promising compactification schemes are based on Calabi–Yau manifolds. This image shows a projection of a six-dimensional Calabi–Yau manifold known as a quintic hypersurface.

### *String Phenomenology 2012*

Workshop, 25–29 June 2012

Organisers: J Conlon, F Quevedo, D Baumann and S Abel

The final workshop was the annual international conference on *String Phenomenology* which had 135 participants from the United Kingdom, Europe, the United States and Asia. This is the main annual conference on phenomenological aspects of string theory and this was the eleventh incarnation. In addition to the plenary talks, there were a large number of parallel talks by students and junior researchers. Topics discussed included construction of string vacua, string cosmology and implications of LHC results.

### *Outcome and Achievements*

We believe that the programme has had a significant effect on the advancement of string/M-theory. It has led to a consolidation of ideas and perspectives in various topics which will shape the future research

activities of a large portion of the international community. In particular the following topics were discussed at length by an international cross-section of active researchers:

- Doubled field theory and applications to generalised geometry;
- Algebraic structures such as Lie-crossed modules and gerbes underlying the 6-dimensional (2,0) theory;
- Localisation techniques in field theories on spheres in a variety of dimensions;
- Black hole entropy and modular forms;
- Scattering amplitudes and twistorial techniques in a variety of dimensions;
- Construction and properties of string vacua.

The programme brought together researchers at all stages in their careers, from all over the world, and led to many discussions and collaborations.

# Semantics and Syntax: A Legacy of Alan Turing

9 January to 6 July 2012

[www.newton.ac.uk/programmes/SAS/](http://www.newton.ac.uk/programmes/SAS/)

## Report from the Organisers:

A Beckmann (Swansea), SB Cooper (Leeds), B Löwe (Amsterdam), E Mayordomo (Zaragoza) and N Smart (Bristol)



SB Cooper, B Löwe, A Beckmann, E Mayordomo

## Scientific Background

The *Semantics and Syntax* (SAS) programme was one of the central activities of the Alan Turing Year 2012 (ATY), a world-wide celebration of the life and work of the exceptional scientist Alan Mathison Turing (1912–1954). Participants included many leaders in their respective fields such as Rothschild Visiting Professor S Goldwasser and Microsoft Distinguished Visiting Fellow M Davies.

The programme focused on logic, complexity theory and cryptography, fields that all suffer from a divide between aspects coming from logical considerations (syntax) and those coming from structural, mathematical or algorithmic considerations (semantics). The programme sought to bridge this divide in all of the subfields involved and to bridge communication gaps between industry and research communities. It is widely recognised that the syntax-semantics divide is a major obstacle to progress and M Lynch, CEO of Autonomy, generously donated £20,000 to the programme in recognition of its high relevance to the everyday practical work of Autonomy.

*Semantics and Syntax* ensured that the different communities gained insights into outstanding problems of the other fields, including: the possibility in finite model theory of a logic capturing all structures in complexity class  $P$  of polynomial time decidable languages; the need for a proof of strong

independence results that would separate levels in bounded arithmetic; the search for strong lower bounds for expressive propositional proof systems. Particular emphasis was put on the connection between computability and computational complexity, with interesting advances derived from the combination of methods from both.

## Structure

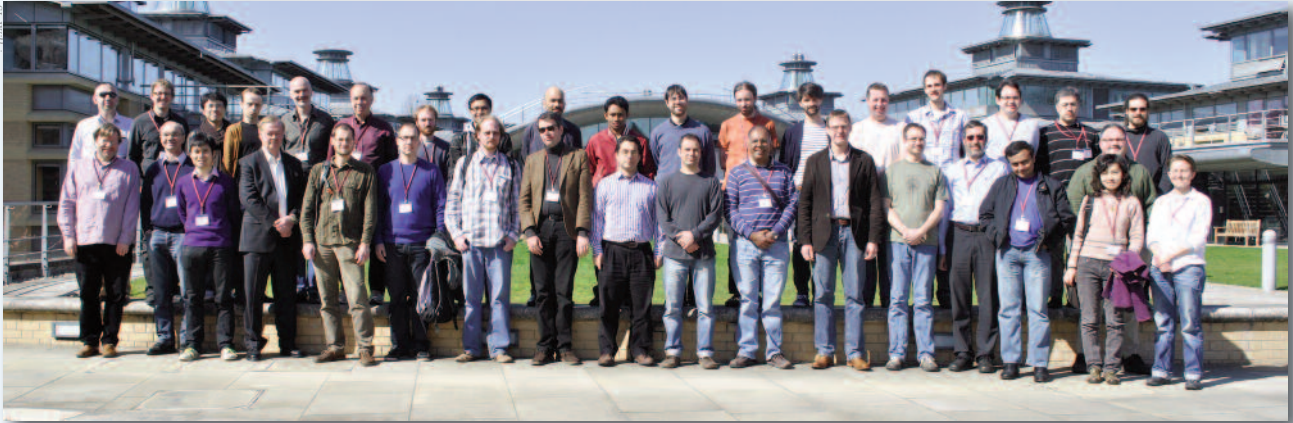
The embedding of the programme within ATY meant that there was a large number of workshops and events, some doubling as the major annual international event of the relevant sub-communities, for instance *CCR 2012*. However, the heart of the programme, opening up new dialogues, was the SAS Seminar, a series of 30-minute informal lectures in which new participants presented open problems that they intended to work on during their visit. In addition to the workshops and the SAS seminar series, participants engaged with the wider research community, both in academia and industry, in Cambridge and across the UK. Moreover, beyond the immediate activity at the Institute, the international conferences *EuroCrypt 2012* and *CiE 2012*, both held in Cambridge during the course of the programme, brought several hundreds of the leading thinkers within our fields and provided further opportunities for interaction.

## Workshops

### *The Mathematical Legacy of Alan Turing* Spitalfields Day, 9 January 2012

Organiser: B Löwe

This LMS-funded Spitalfields Day provided the general mathematical public (with strong emphasis on postgraduate students) a glimpse of the current state of the art and an understanding of the scope and research aims of the programme. H Woodin, G Barmpalias, N Smart, and A Dawar gave survey



Participants at the workshop on ‘Logical Approaches to Barriers in Complexity II’ in March 2012

lectures, introducing the issues pertinent to their respective fields. The event was attended by T Chouard, editor of *Nature*, who was doing research for an Alan Turing special feature. A report on the Spitalfields Day is published on pp. 20–21 of the April 2012 issue of the LMS newsletter.

#### *Is Cryptographic Theory Practically Relevant?* Workshop, 31 January–2 February 2012

Organisers: K Paterson and N Smart

With around 100 participants from around the globe, this workshop addressed the divide between theory and practice in cryptography. Topics covered ranged from the challenges faced by the banking industry to car security through, to smart metering systems in the energy supply market. A number of new research directions arose from the workshop, including a collaboration between academics and Cryptomathic on a system for secure messaging between HSMs (Hardware Security Modules) used in the financial sector.

#### *Pattern Formation: The Inspiration of Alan Turing*

##### A Satellite Meeting at St John’s College, Oxford 14–16 March 2012

Organisers: B Fiedler, B Löwe and P Maini

In addition to computer science, mathematical biology was a topic of particular interest to Turing. This *Satellite Meeting* made a link to the morphogenesis community in Oxford and, in the spirit of the programme, bridged the gap between the theoretical work of the mathematical biologist and the empirical laboratory work that confirms or refutes the predictions of the theoretical model.

Participants included mathematicians, biologists and chemists, and a number of important research collaborations were started at the workshop.

#### *Logical Approaches to Barriers in Complexity II*

##### Workshop, 26–30 March 2012

Organisers: A Beckmann and A Dawar

This workshop brought together many leading researchers from the communities working on logical descriptions of complexity, i.e. descriptive complexity, propositional proof complexity and bounded arithmetic. Highlights included reports on recent results within (J Krajicek, N Schweikardt) and between (AA Atserias, Y Chen) these subfields.

#### *Formal and Computational Cryptographic Proofs*

##### Workshop, 26–30 March 2012

Organisers: N Smart and S Goldwasser

This workshop, attended by around 80 people including academics and industrialists, aimed to bridge the gap between protocol analysis based on formal methods, as espoused by theoreticians, and techniques in industry based on complexity theoretic arguments. For over two decades the latter has been considered the *de facto* verification technique with the former being considered fundamentally flawed. However, the advent of formal methods based tools for automatic complexity theoretic verification of protocols is now becoming a reality. Different application domains were considered, including verifying the secure dismantling of nuclear weapons. A particular highlight was the Rothschild Seminar on randomised algorithms given by S Goldwasser.



### *The Incomputable*

**A Satellite Meeting at Chicheley Hall, Newport Pagnell, 12–15 June 2012**

Organisers: SB Cooper and M Soskova

This *Satellite Meeting* at Chicheley Hall, Newport Pagnell, bridged the gap between the mathematical theory of computability and its relevance for the real world, a core aspect of Turing’s scientific legacy; it reunited, in a way not attempted since Turing’s premature passing, (in)computability theory and ‘big science’. With a stellar list of speakers including S Abramsky, T Slaman, Y Matiyasevich, S Friedman, J Knight, A Sloman, C Teuscher, R Downey, L Floridi, and JD Hamkins, the event was generously supported by the John Templeton Foundation.

### *7th Conference on Computability, Complexity and Randomness*

**Workshop, 2–6 July 2012**

Organisers: E Mayordomo and W Merkle

This workshop constituted the 7th annual meeting of the active algorithmic randomness community. With speakers from across all continents, topics addressed included: algorithmic randomness; computability theory; Kolmogorov complexity; computational complexity; reverse mathematics and logic.

### *Outcome and achievements*

This was a very productive programme with major advances being made in each of the fields involved. In cryptography, new directions and tools were developed for the utilisation of (syntactic) formal methods to produce (semantic) complexity theoretic proofs. The combination of computability-theoretic and complexity-theoretic methods yielded a number of breakthroughs such as the efficient construction of absolutely normal numbers, and progress in Martin-Löf randomness ( $K$ -triviality, relative complexity, etc.) and in effective dimension (applications to random fractals). The connection between the complexity of indistinguishability in counting logics and the complexity of proofs in certain semi-algebraic proof systems has been identified as an area for future research.

A key aim was to bridge divides and as a result of the programme there is a growing community which

aims to cement links between theoretical and industrial cryptography: funding has been obtained for a 2013 follow up conference to *Is Cryptographic Theory Practically Relevant?*. Numerous new interactions were established on topics ranging from automated verification of protocols through to smart metering and zero-knowledge proof compilers, and on an authenticated encryption method for use in HSMs.

In complexity theory, the workshop *Logical Approaches to Barriers in Complexity II* stimulated interaction between the two separate communities. In particular, new collaborations occurred between: A Beckmann, P Pudlak and N Thapen on connections between computational games and automatability of proof systems; A Beckmann, SR Buss, SD Friedman and N Thapen on set-theoretic analogues of time and space complexity classes; S Abramsky and PG Kolaitis on relations between quantum foundations and relational database theory.

The programme also reached out to issues linking logic to some research areas in the (digital) humanities: a research group on formal models of narrative (A Block, B Fisseni, C Leon, B Löwe, D Sarikaya), and one on natural language proof checkers for mathematical proofs (JA Alama, M Cramer, B Fisseni, P Koepke, H Schwichtenberg, B Seyfferth, FS Tanswell) discussed and exchanged ideas.

Three months after the end of the programme, over fifty preprints have been submitted to the *Newton Institute Preprint Series* with more anticipated in the following months. R Downey and M Fellows have finished a book on parametrised complexity, and the abstracts of the SAS Seminar and all of the workshops will be published collectively as a book entitled *Acts of the SAS Seminar* in the series *Texts in Computing* (College Publications). Additionally, our community has embraced the recording and streaming of seminars. During the last week of June alone, there were over 1000 views of SAS-related videos. The most viewed lecture from the *Semantics and Syntax* programme was N Smart’s lecture on *Modern Cryptography for Non-cryptographers* which achieved a total of 335 views.

# Impact Driven Activity

## *Follow-up Meetings*

### *Perspectives in Algebraic Lie Theory*

12–16 September 2011

Organisers: M Geck, A Kleshchev and G Röhrle

The *Algebraic Lie Theory* (ALT) programme in 2009 was a success with a great impetus and stimulus in the research community. This led to the desire to run a *Follow-up Meeting* to this theme which was subsequently held in September 2011.

The purpose of this event was threefold: firstly to determine the extent that the field has evolved by bringing together some of the researchers who made major contributions to the 2009 ALT programme; secondly to provide a platform for presenting new results in the field, in particular developments that arose from work done by 2009 ALT participants during their time at the Institute; and thirdly to engage with individuals who were, for various reasons, unable to attend the 2009 programme. We were very pleased that in particular K Erdmann, R Kessar, A Lauda, G Lusztig, GR Robinson, and T Tanisaki were able to attend this event.

In all there were a total of 20 one-hour lectures allowing additional time for discussions and further interactions in between and after each lecture. One of the highlights of the workshop related to further developments in the categorification and geometrisation in Lie theory and representation theory.

Of particular note were the excellent lectures given by G Lusztig and A Premet. Premet spoke on an extension of the Dynkin–Kostant theory of unipotent elements in reductive algebraic groups which is valid over fields of arbitrary characteristic. His talk included an announcement of the case-free proof of Lusztig’s conjectures on unipotent pieces.

As anticipated, around 60 people attended the workshop with a high number of UK speakers and participants. We were particularly pleased that a large number of early career researchers attended.

A major achievement of the meeting was to provide a forum for presenting and discussing new ideas and developments. The *Follow-up Meeting* demonstrated that the original ALT programme sustained and

brought about ongoing and new collaborations and helped focus new research directions.

We gratefully acknowledge the coordinated financial support from the French-UK network *Representation Theory Across the Channel* (funded by EPSRC and CNSR) and the German DFG-Priority Programme *Representation Theory*. This made it possible to fund the costs for a number of speakers from UK, France and Germany, and to allow especially early career researchers from these countries to attend the meeting.

### *Noncommutative Geometry*

16–20 April 2012

Organisers: DE Evans, N Higson and S Majid

This meeting took place at Cardiff University and was a *Follow-up Meeting* to a 6-month research programme, entitled *Noncommutative Geometry* (NCG), held at the Institute in 2006. The *Follow-up Meeting* concentrated on nine themes: non-commutative algebraic geometry; representation theory aspects of Baum–Connes; noncommutative geometry and symplectic geometry; free aspects of noncommutative geometry; noncommutative geometry and conformal field theory; non-commutative geometry and categorification; noncommutative geometry and quantum field theory; noncommutative spacetime and cosmology; the standard model and beyond.

Particularly notable talks included those by: A Connes which incorporated a musical demonstration of the  $q$ -deformed spherical Laplacian (which comes out of quantum groups); P Baum who spoke on progress made by him and his collaborators Aubert and Plymen on Geometric structure in the representation theory of reductive  $p$ -adic groups; and P Smith who spoke on links between algebraic geometry and operator algebras which has its roots in the NCG meeting. There were also interesting talks by P Hemmings (EPSRC Lead, Mathematical Sciences Capability Delivery) and Vivienne Blackstone (EPSRC Portfolio Manager in Mathematical Physics). They gave a presentation on changes at EPSRC particularly relating to mathematical physics.

The participants at the Cardiff meeting appreciated the fact that the *Follow-up Meeting* incorporated all main themes of the Newton Institute programme which had been spread out over several workshops. In the 2006 programme, participants commented that the value of the meeting was in the very broad interpretation of Noncommutative Geometry, the ability of the speakers to present their results effectively to an audience with such diverse backgrounds, and also for inviting rising stars to speak at the meeting as well as more established ones.

## Open for Business

Open for Business events form part of the Institute's mission to foster links between academic research and the business world. The aim is to bring together academic researchers in the mathematical sciences with industrial, commercial and government organisations and individuals to enable formal and informal discussion and networking.

The events that took place this year are:

- *Pharmaceutical Day* 16 Aug 2011;
- *Medical Imaging Day* 23 Aug 2011;
- *Design and Analysis of Experiments Industry Day* 30 Nov 2011;
- *Inverse Problems in Oil and Gas Exploration: Contemporary Views* 14 December 2011;
- *Maths Underpinning Energy workshop* 12 March 2012.

## Gender Balance

### European Girls' Mathematical Olympiad

The first European Girls' Mathematical Olympiad was held in April 2012 and was hosted by Murray Edwards College at the University of Cambridge. With teams of four girls from 20 countries (16 European countries with four additional 'guest' nations including Afghanistan, Indonesia, Saudi Arabia and the USA) taking part this event was deemed to have been a huge success. During their stay the girls visited the Institute and were given a guided tour of the Centre for Mathematical Sciences at the University of Cambridge by the Institute Deputy Director, Dr Christie Marr.



*Participants in the European Girls' Mathematical Olympiad*

### European Congress of Mathematics

The Deputy Director, Dr Christie Marr, attended ECM, the 6th European Congress of Mathematics, in Krakow in July 2012. She presented on the Institute's Gender Balance Action Plan, as one of 5 panelists on the panel organised jointly by the European Mathematical Society (EMS) Women in Mathematics Committee and European Women in Mathematics (EWM). The session was chaired by Caroline Series.

### Gender Balance Action Plan

The Institute continues to pursue its Gender Balance Action Plan (GBAP), developed in 2010, to involve as many women as possible in all aspects of its programming and closely monitors participation rates of women: it is a requirement that proposals and final reports present this data. This year it took steps to obtain an Athena Swan Award but the advice received was that with only two permanent academic staff and no enrolled students INI is currently ineligible. Nevertheless it abides by the spirit of Athena Swan [www.athenaswan.org.uk](http://www.athenaswan.org.uk).

### Six Questions With...

Throughout 2011/12 the Institute added a further 7 women to the interview series that showcases the achievements of women mathematical scientists. The interviews with Dr Sarah Hart (Birkbeck, University of London), Professor Rosemary Bailey (Queen Mary, University of London), Dr Stefanie Biedermann (University of Southampton) Dr Alia Sajjad (Government of Punjab, Pakistan) Professor Alessandra Giovagnoli, (University of Bologna) can be found in the growing collection on our website at [www.newton.ac.uk/women/sixquestionswith/](http://www.newton.ac.uk/women/sixquestionswith/).



## Serving the UK Community



**Caroline Series,  
Chair of  
Correspondents**

The Institute maintains a list of Correspondents in UK HEIs, learned societies, commercial organisations and research institutes to act as a channel of communication between the Institute and the mathematical sciences community. Correspondents are regularly informed about Institute activities. It is their responsibility to disseminate information to relevant individuals within their institution, whether in mathematics departments or in other scientific groups appropriate to each event. Correspondents also provide invaluable feedback, particularly at the Annual Meeting of Correspondents (see below). The Institute continues to extend the network into other institutions and disciplines and further nominations are encouraged.

As part of an outreach and impact agenda, Correspondents' Day traditionally involves a distinguished lecture on mathematics of general scientific interest. As described below, the 2012 Correspondents' Day Lecture was given by Fields Medallist Sir Tim Gowers.

This is my last report as Chair of Correspondents. It has been a privilege to have had such close involvement with the Institute over a number of years, particularly with the Directors David Wallace and John Toland, and the Chair of the Management Committee Howard Covington. I also would like to thank the Institute's wonderful staff for their support, especially the Deputy Directors Ben Mestel and Christie Marr who, together with Sarah Fendt, have managed the Correspondents' Days and with whom it has been a great pleasure to work, Christine West for her ever efficient management and advice, and Sara Wilkinson for publicity and maintaining communication with Correspondents. I would also like to wish my successor Professor Michael Singer well as he steps into his new role.

### *Annual Meeting of Correspondents*

There were 50 attendees at Correspondents' Day, with representatives from universities, organisations and learned societies from across the UK.

The day began with a Welcome Introduction from John Toland followed by a provocative and stimulating lecture by Sir Tim Gowers entitled *Will Computers Ever Become Mathematical Researchers?* He concluded in the affirmative with a timeline of steps necessary for this to become a reality.

A panel session, *Looking to the Future of INI: The Graduate Perspective*, explored the personal impact that time at the Institute can have, in particular for early career researchers. Speakers Marek Kubik, a PhD student at the University of Reading, Timothy Logvinenko, a post-doctoral research fellow at the University of Warwick and Joseph Conlon, a recently appointed lecturer at the University of Oxford, gave personal reflections. Marek and Timothy spoke of

opportunities to meet and interact with others, and of the influence of INI on long-term research directions. Joe, one of the Organisers of the *Mathematics and Applications of Branes in String and M-theory* programme, spoke of how the INI administrative support enabled him to focus on the science whilst leading research in his field.

The day concluded with lively and informative discussion sessions focussing on the challenges faced by the Institute in the current economic climate, its role in nurturing early career researchers and the enduring issue of gender imbalance in the mathematical sciences generally. Younger members spoke of the need for INI to further embrace social media as a means for communicating to its various communities.

In closing remarks, Caroline Series, the outgoing Chair of Correspondents, introduced her successor as Professor Michael Singer.

*The table opposite shows the current list of Newton Institute Correspondents both in UK higher education and in learned societies, commercial organisations and research institutes.*

## Newton Institute Correspondents

Aberdeen	A Sevastyanov	London, Imperial College	K Christensen
Aberystwyth	RJ Douglas	London, King's College	K Rietsch
Aston	D Saad	London Metropolitan	P Calay
Bath	J Faraway	London, Queen Mary	PJ Cameron
Belfast, Queens	AW Wickstead	London, Royal Holloway	J Crampton
Birmingham	CW Parker	London School of Economics	J van den Heuvel
Bradford	A Vourdas	London, University College	ER Johnson
Brighton	PJ Harris	Loughborough	AP Veselov
Bristol	F Mezzadri	Manchester	M Prest
Brunel	I Smolyarenko	Napier	T Muneer
Cambridge	N Dorey	Newcastle	CF Barenghi
Cardiff	KM Schmidt	Nottingham	S Coombes
City	O Kerr	Open	UG Grimm
Dundee	G Hornig	Oxford	S Lauritzen
Durham	O Hryniv	Plymouth	C Christopher
East Anglia	S Stevens	Portsmouth	AD Burbanks
Edinburgh	A Bayer	Reading	S Langdon
Essex	DB Penman	St Andrews	DG Dritschel
Exeter	A Gilbert	Salford	RD Baker
Glasgow	C Athorne	Sheffield	K Mackenzie
Greenwich	K Parrott	Southampton	CJ Howls
Heriot-Watt	JR Cruise	Staffordshire	BL Burrows
Hertfordshire	S Kane	Stirling	R Norman
Huddersfield	A Crampton	Strathclyde	M Ainsworth
Hull	JW Elliott	Surrey	M Wolf
Keele	JJ Healey	Sussex	E Burman
Kent	PA Clarkson	Swansea	T Brzeziński
Lancaster	S Power	Ulster	M McCartney
Leeds	A Pillay	WIMCS	EB Davies
Leeds Metropolitan	E Guest	Warwick	C Series
Leicester	F Neumann	West of England	K Henderson
Liverpool	V Goryunov	York	N MacKay
Liverpool John Moores	PJG Lisboa		
BBSRC	M Roberts	Microsoft Research Group	CM Bishop
BCS	B Mitchell	Nat. Ocean. Centre, Liverpool	J Polton
British Geological Survey	RM Lark	Nat. Ocean. Centre, Southampton	M Srokosz
Edinburgh Mathematical Soc.	TH Lenagan	NERC	N Garnett
EPSRC	C Tansley	OCISB	R Baker
ESRC	R Tyrrell	OR Society	R Hibbs
European Bioinformatics Institute	C Brooksbank	Pirbright Institute	D Schley
ICMS	K Ball	Rothamsted Research	M Semenov
Institute of Actuaries	M Lyons	Royal Academy of Engineering	J McWhirter
IMA (Academic)	P Glendinning	Royal Society	M Taylor
IMA (Organisational)	D Youdan	Royal Statistical Society	S Olhede
Institute of Physics	R Behrend	Rutherford Appleton Laboratory	N Gidopoulos
John Innes Centre	S Maree	Schlumberger	P Hammond
LMS	U Tillmann	Smith Institute	C Cawthorn
Mathematical Association	C Ogden	STFC	S Verth
Met Office	MJP Cullen		

## Institute Activities

### *Seminars in the UK*

Visiting Fellows on Newton Institute programmes are strongly encouraged to visit other institutions within the UK during their stay at the Institute, and 194 visitors did so during 2011/12 delivering a total of 266 seminars in 51 different institutions. To promote this activity, the Institute covers on request the travel costs within the UK for any overseas Fellow.

Lists of future participants, with dates of their visits to the Institute, can be found on the individual programme web pages. In addition, the Institute has set up a register, with titles of topics, of those Fellows who are willing to travel to other UK institutions to give seminars. Correspondents are urged to ensure that organisers of local seminar series know about and consult this register when planning their schedule of speakers. Potential speakers may be contacted directly using the details listed in the register, which can be found at [www.newton.ac.uk/programmes/speakers.html](http://www.newton.ac.uk/programmes/speakers.html).

Alternatively, advice on suitable speakers may be obtained from the organisers of any Institute programme via the Institute.

### *Seminars on the Web*

All Institute seminars and lectures are, with the permission of speakers, advertised in advance, streamed live and made available on the web in perpetuity. Thanks to a one-off equipment grant from EPSRC, the Institute has state-of-the-art streaming and video-conference facilities.

In addition to broadcasting its own lectures, the Institute uses its facilities to provide distinguished scientists who are unable to attend in person with the opportunity to lecture during programmes or workshops. These interactive sessions are held in the Institute's lecture theatre, with question and answer sessions between the audience and the speaker at a different location.

The library of online seminars is becoming a significant scientific resource. During 2011/12 within the four programmes covered by this report and including other events an additional 770 seminars were added. There is significant evidence,



*Fan Yang before her seminar on 'Model Checking for Modal Intuitionistic Dependence Logic'. Her talk can be viewed or downloaded from our webseminars page at [www.newton.ac.uk/programmes/SAS/seminars/2012032616001.html](http://www.newton.ac.uk/programmes/SAS/seminars/2012032616001.html)*

both statistical (see [www.sms.cam.ac.uk/institution/INIMS/statistics](http://www.sms.cam.ac.uk/institution/INIMS/statistics)) and anecdotal, that in the UK and elsewhere people monitor INI activity and attend seminars remotely when they cannot participate.

### *Short Visits to the Institute*

Any researcher associated with a UK University, academic institution or R&D group in industry or commerce may visit the Newton Institute for up to two days without an invitation, in order to attend seminars or to work with colleagues. We ask that [reception@newton.ac.uk](mailto:reception@newton.ac.uk) is emailed in advance to assist us with planning. We are unable to guarantee office space, accommodation or meals, but visitors are welcome to use the common areas of the building and our library. More information is available at [www.newton.ac.uk/shortvisits.html](http://www.newton.ac.uk/shortvisits.html)





## Management and Statistical Reports



**Howard Covington,**  
**Chair of the Management**  
**Committee**

The Management Committee is responsible for financial management and the allocation of resources at the Institute and also oversees fundraising. In the challenging financial climate, and with cuts in Research Council funding imminent, it is natural for me to concentrate on fundraising in this report.

The University of Cambridge regards the Institute as a flagship activity and the Institute works closely with University of Cambridge's Development Office to raise funds. The Vice-Chancellor this year

committed £440k to underwrite unfunded projects and the University has recently allocated a Knowledge Transfer facilitator to support our new Turing Gateway to Mathematics project. This level of additional support from the University is very encouraging.

The Institute's Development Board has raised endowments and donations from more than 30 individuals, trusts and corporations. This year these include an individual endowment of £250k, and a donation of £100k to enable thirteen additional participants to spend three months each at the Institute. Support from donors is greatly appreciated. Donors are listed later in this report and significant donors are recorded on an elegant honours board at the entrance to the Institute building.

## Management Committee

Membership of the Management Committee at 31 July 2012 was as follows:

Sir John Ball FRS FRSE	<i>Chair of the Scientific Steering Committee</i>
Professor JW Bruce	<i>London Mathematical Society</i>
Mr H Covington (Chair)	<i>General Board</i>
Professor N Dorey	<i>Faculty of Mathematics</i>
Professor PH Haynes	<i>Head of Department, DAMTP</i>
Dr P Hemmings	<i>EPSRC</i>
Professor JME Hyland	<i>Head of Department, DPMMS</i>
Professor R Langley	<i>Council of the School of Technology</i>
Dr J Lasenby	<i>Trinity College</i>
Professor N Manton	<i>St John's College</i>
Dr CM Marr (Secretary)	<i>Deputy Director, Newton Institute</i>
Professor C Series	<i>Chair of Correspondents</i>
Professor J Stirling CBE FRS	<i>Council of the School of Physical Sciences</i>
Professor JF Toland FRS FRSE	<i>Director, Newton Institute</i>

The Management Committee is responsible for overall control of the budget of the Institute and for its financial planning. The Director is responsible to the Management Committee, which provides essential advice and support in relation to fundraising activities, employment of the staff of the Institute, appointment of the organisers of programmes and general oversight of Institute activities. Its aim is to facilitate to the fullest possible extent the smooth and effective running of the Institute's programmes and all related activities.

## Programme Participation

A total of 2055 visitors was recorded for 2011/12.

This total includes 437 Visiting Fellows and 114 Programme Participants. Within the four programmes there were 25 workshops (periods of intense activity on specialised topics) which attracted a further 838 visitors (i.e., those not already attending the programme).

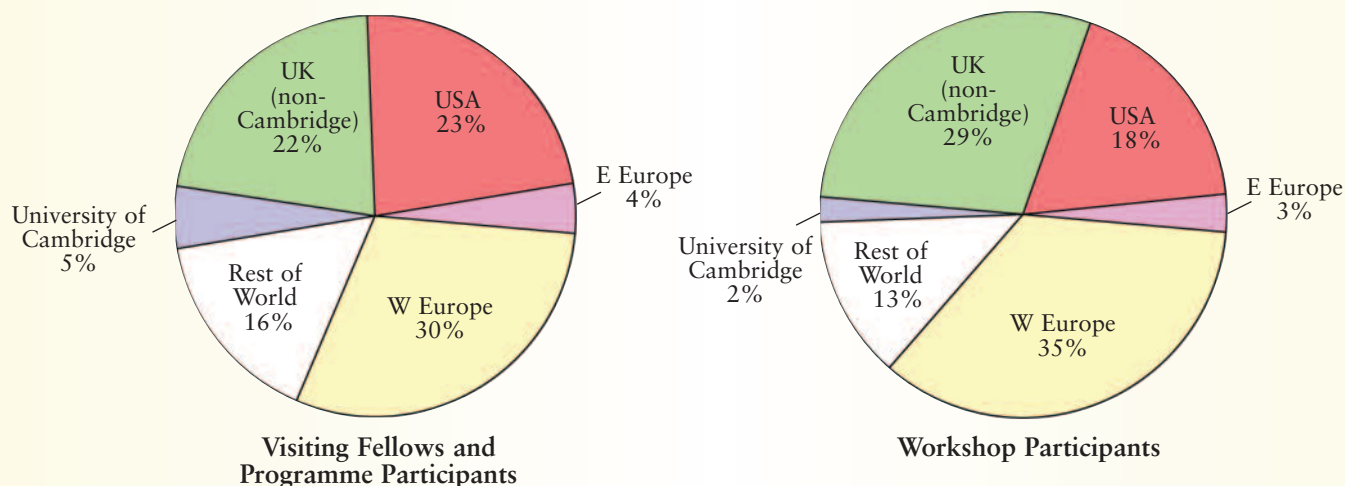
In addition to workshops, which serve to widen UK participation in programmes, the Institute from time to time arranges less formal special academic

meetings as well as talks for the general public, so further opening up the activities of the Institute. More than 666 visitors attended such events and took part informally in Institute activities or attended *Satellite Meetings* and *Follow-up Meetings*.

Within all the programmes, workshops and other activities, 770 seminars were given at the Institute during the year. The Institute also funds visits by programme participants to other UK institutions to give seminars (see page 22), and 262 such seminars took place this year.

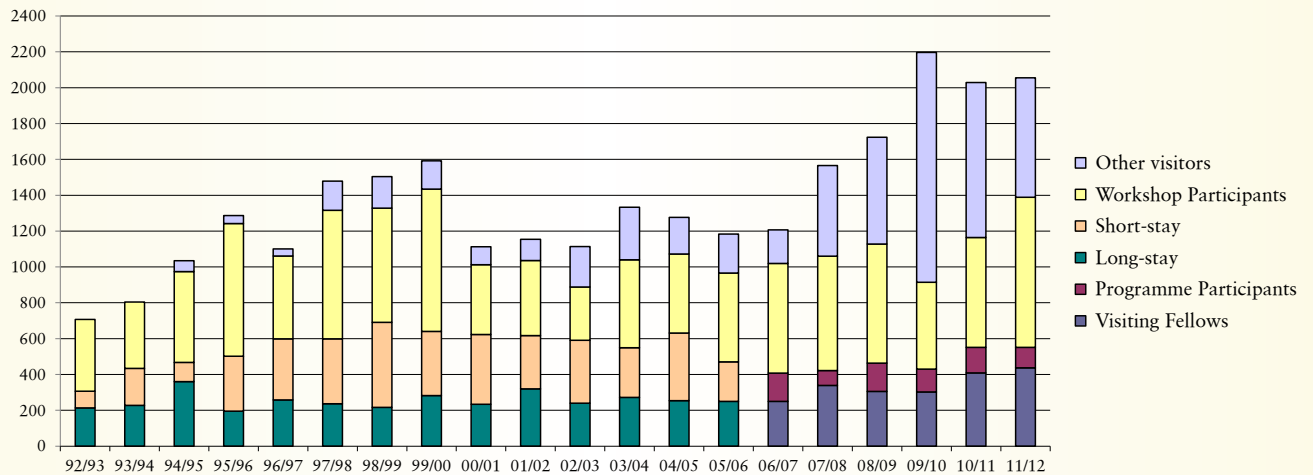
Programme	Visiting Fellows	Mean stay (days)	Programme Participants	Mean stay (days)	Workshop Participants
<i>Design and Analysis of Experiments</i>	72	63	16	19	198
<i>Inverse Problems</i>	106	29	21	22	145
<i>The Mathematics and Applications of Branes in String and M-theory</i>	148	24	33	33	225
<i>Semantics and Syntax: A Legacy of Alan Turing</i>	111	40	44	64	270
	<b>437</b>	<b>36</b>	<b>114</b>	<b>41</b>	<b>838</b>

The pie charts below show the percentages of Visiting Fellows, Programme Participants and Workshop Participants broken down by country of residence:

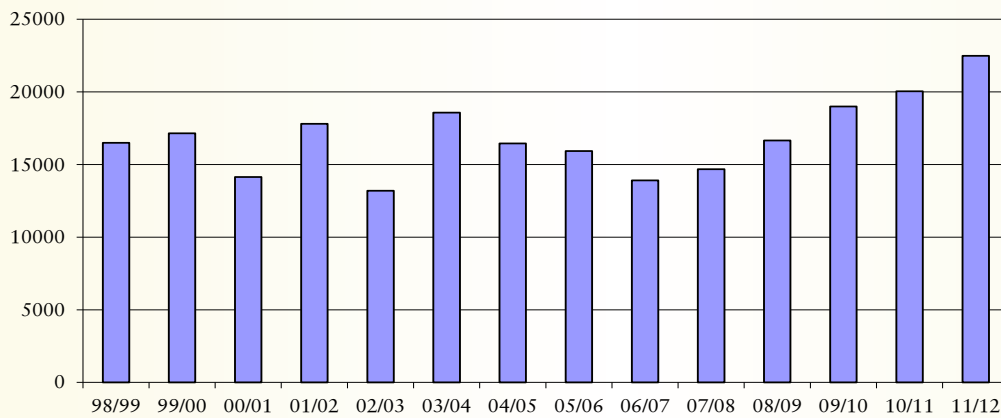




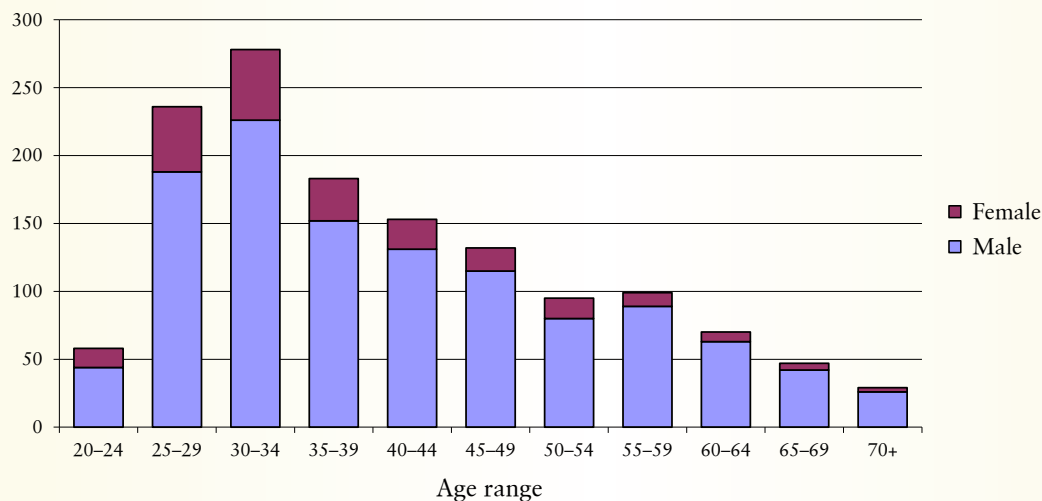
The following chart summarises the total participation figures since the Institute began:



The chart below summarises the total number of person-days for Visiting Fellows and Programme Participants combined, *excluding* Workshop Participants.



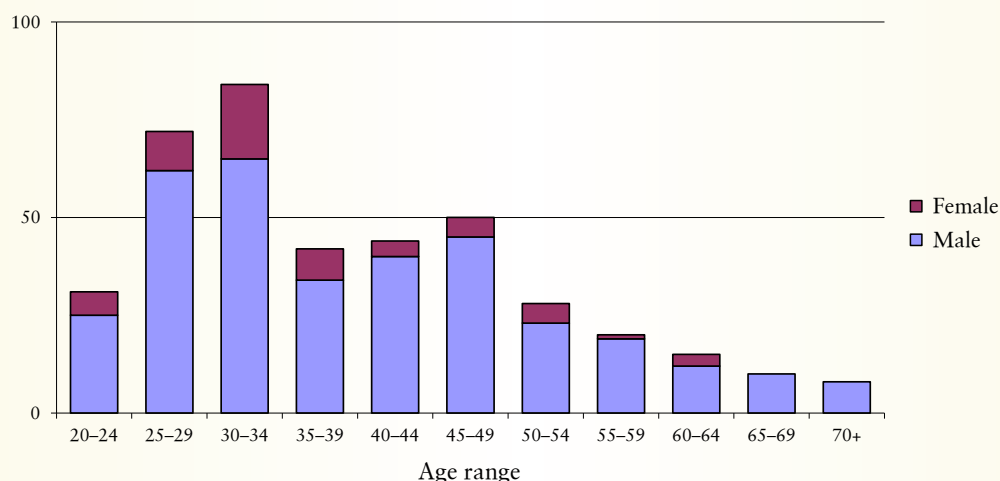
The numbers of all Visiting Fellows, Programme Participants *and* Workshop Participants combined in 2011/12 are shown below, by age and gender:



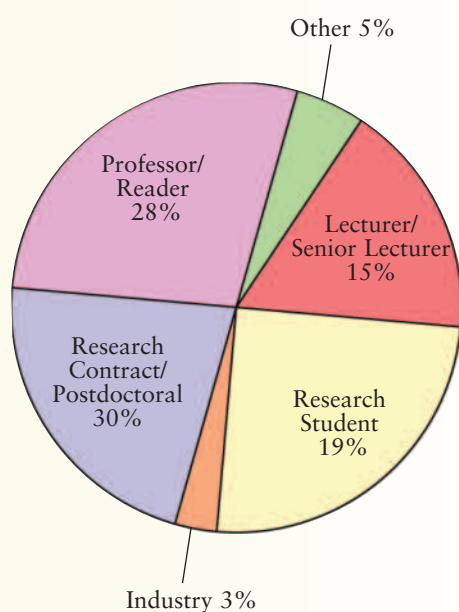
## UK Participation

The statistics presented on this page relate only to visitors whose home institutions are in the UK; overseas visitors' data are not included.

The age range and gender balance of all Visiting Fellows, Programme Participants and Workshop Participants from UK institutions in 2011/12 are illustrated below:



The following diagrams indicate the academic status and geographical distribution of all Visiting Fellows, Programme Participants and Workshop Participants from UK institutions during 2011/12:



More detailed statistics, including visit dates, home institutions, seminars given and papers written are shown in the Appendices, available at [www.newton.ac.uk/reports/1112/appendices.html](http://www.newton.ac.uk/reports/1112/appendices.html)

## Finances

### *Accounts for August 2011 to July 2012 (Institute Year 20)*

Please note that financial reporting mechanisms have changed resulting in the restating of income and expenditure for reporting year 2010/11.

	2010/11 Year 19 £'000	2011/12 Year 20 £'000
<b>Income</b>		
Research Grants and Contracts <sup>1</sup>	1,495	1,949
Contribution from the University of Cambridge <sup>2</sup>	450	479
Donations <sup>3</sup>	251	123
Additional Workshop Income	105	204
Endowment and Investment Income <sup>4</sup>	143	161
Net Housing Surplus <sup>5</sup>	(99)	66
Other Income	14	16
<b>Total Income</b>	<b>2,359</b>	<b>2,998</b>
<b>Expenditure</b>		
Staff Costs	692	696
Travel and Subsistence <sup>6</sup>	676	960
Workshop Expenditure	370	483
Other Institute Activities <sup>7</sup>	48	49
Other Operating Expenses <sup>8</sup>	150	161
Overheads paid to University <sup>9</sup>	388	463
<b>Total Expenditure</b>	<b>2,324</b>	<b>2,812</b>
<b>Surplus / (Deficit)</b>	<b>35</b>	<b>186</b>

### *Notes to the Accounts*

#### **1. Research Grants and Contracts.**

The income breaks down as follows:

EPSRC Salaries	312	360
EPSRC Travel and Subsistence	637	962
EPSRC Workshop Income	217	261
EPSRC Other Costs	2	22
EPSRC Estates and Indirect Income	247	262
Leverhulme Trust	80	82
<b>Total</b>	<b>1,495</b>	<b>1,949</b>



**2. Contribution from the University of Cambridge.** The amounts received break down as follows:

Rothschild Visiting Professorships (drawdown)	34	15
Rothschild Mathematical Sciences (income)	101	103
Contribution Towards Institute Operating Costs	292	354
SRIE, HEIF, CIF, HEFCE Funding	23	7
<b>Total</b>	<b>450</b>	<b>479</b>

The income from the Rothschild Mathematical Sciences Fund supports the Professorship held by the Director.

**3. Donations.** A total of £379k received via the Cambridge University Development Office was capitalised and is not included in this figure.

BBSRC	25	0
MRC	25	0
NERC	90	0
STFC	29	5
Autonomy	0	20
Garfield Weston Foundation	15	16
London Mathematical Society	25	27
Microsoft	20	30
PF Charitable Trust	20	23
Cambridge Philosophical Society	2	2
<b>Total</b>	<b>251</b>	<b>123</b>

**4. Endowment and Investment Income.** Income received from the Newton Trust fund, the Anonymous Donation Endowment, reserves and deposits.

**5. Net Housing Costs.**

Income	485	689
Expenditure	584	623
<b>Total</b>	<b>(99)</b>	<b>66</b>

**6. Travel and subsistence.** Expenditure incurred by Programme Visitors including Junior Members.

**7. Other Institute Costs.** These costs relate to the Open for Business, 20th Anniversary and other fundraising activities as well as expenses from meetings of the Institute's committees, Institute Correspondents, programme organisers and the travel expenses of overseas participants who visit other UK institutions to give seminars during their stay.

**8. Other Operating Expenses.**

Building maintenance	26	31
Catering	19	30
Consumables	14	19
Computing and Audio Visual	45	60
Equipment and Furniture	25	5
Library	15	5
Publicity	6	11
<b>Total</b>	<b>150</b>	<b>161</b>

**9. Overheads Paid to University.** Includes Estates and Indirect costs on grants and overheads on Trust Funds.

## *Grants and Donations August 2011 to date*

In addition to substantial funding from the Engineering and Physical Sciences Research Council, the Institute is indebted for continuing support from the Cambridge Philosophical Society, the Leverhulme Trust, the London Mathematical Society, PF Charitable Trust, NM Rothschild and Sons, and the University of Cambridge. We are very grateful to the following organisations for their specific support during the year: Autonomy Systems Limited, the Beecroft Charitable Trust, the Biotechnology and Biological Sciences Research Council, the Economic and Social Research Council, ENCRYPT EC Network, the Garfield Weston Foundation, GLC Charitable Trust (with special thanks to Lawrence and Rosemary Staden), Institute for Particle Physics Phenomenology, Henderson Global Investors, John Templeton Foundation, Lazard Asset Management – UK, Microsoft Research Cambridge, the National Environmental Research Council, the National Science Foundation (USA), the Science and Technology Facilities Council and the Turner–Kirk Charitable Trust.

Individuals gave generously in support of our activities: Elena Ambrosiadou, Michael Astor, Iain Bratchie, Howard & Veronika Covington, Mrs Ann and the late Professor Roy Garstang, Clive Humby & Edwina Dunn, Dr Jonathan Hodgson, Steve Mobbs, Tracey Olsen, Sachin Shende, Simon Yun-Farmbrough, David & Elizabeth Wallace as well as donations from individuals who prefer to remain anonymous.

## *Cumulative Financial Grants and Donations above £10,000 since 1992 (listed in order of cumulative value)*

EPSRC / STFC / NERC / BBSRC / ESRC	Cambridge Philosophical Society
Trinity College (Isaac Newton Trust)	David and Elizabeth Wallace
NM Rothschild and Sons	TSUNAMI
University of Cambridge	Daiwa Anglo-Japanese Foundation
European Union	BNP Paribas
Leverhulme Trust	Hamish Maxwell
Hewlett-Packard	Anonymous Donation
Anonymous Donation	Deutsche Forschungsgemeinschaft
Dill Faulkes Foundation	Office of Naval Research
St John's College	European Science Foundation
NATO	Emmanuel College
CNRS	Jesus College
London Mathematical Society	Medical Research Council
Rosenbaum Foundation	Royal Commission for the Exhibition of 1851
PF Charitable Trust	Schlumberger
Clive Humby and Edwina Dunn	British Aerospace
Garfield Weston Foundation	Rolls Royce
Microsoft Corporation/ Microsoft Research	Thriplow Trust
Clay Mathematics Institute	British Gas
Howard and Veronika Covington	DERA
John Templeton Foundation	Magnox Electric
Sun Microsystems inc.	Paul Zucherman Trust
Apple Computers Ltd.	Steve Mobbs
David Harding Foundation	Anonymous Donation
Gonville and Caius College	Nomura Corporation
Prudential Corporation plc	Bank of England
GLC Charitable Trust	Michael Astor
Henderson Global Investors	European Molecular Biology Organisation
Turner–Kirk Charitable Trust	Iain Bratchie
Institute of Physics	Applied Probability Trust
National Science Foundation	Benfield Greig
Wellcome Trust	Trinity College
Met Office	Unilever
Nuffield Foundation	Elena Ambrosiadou

## Grenville Davey: Artist-in-Residence



The Newton Institute was delighted to welcome Turner Prize winning sculptor Grenville Davey as the artist-in-residence for the duration of the *Mathematics and Applications of Branes in String and M-theory* programme from January to June 2012. Professor Davey worked with Dr David Berman, one of the programme organisers, who is an expert in M-theory, an extension of string theory.

Davey's recent interests and work have been inspired by the ideas from string theory and its way of describing our universe. Grenville worked with visiting mathematicians during his residency and has produced several pieces of work which are displayed at the Institute.





## Art at the Institute



In January 2012 the Institute was delighted to accept a wonderful perspex sculpture by the late Walter Ritchie entitled *Newton's Interpretation of the Cosmos*. The sculpture is on long-term loan from the Greene King Brewery who originally commissioned Ritchie to create the piece for the Isaac Newton pub in Cambridge. Following the removal from the pub, the sculpture was displayed at Woolsthorpe Manor, the birthplace of Isaac Newton, before finding a home at the Institute.

The sculpture shows five diagrams engraved into perspex behind a profile of Newton and stretching across a representation of the heavens. The diagrams show the fundamental theorem of calculus, the oblique impact of two perfectly elastic bodies, Newton's organic construction of curves, the determination of a comet's orbit by successive approximations and the reduction of the cubic.



Also in January, the Institute was kindly gifted a sculpture by artist Dick Onians entitled *Infinity*. It shows a single sided surface, such that if an ant were to walk along the length of the sculpture it would return to its original starting point having traversed both sides of the shape but not crossing an edge. The sculpture examines the endlessness of time, space, and regeneration.



The Institute has a growing collection of artworks which demonstrate the intersection between art and mathematics. For more information on our artwork please see our website at [www.newton.ac.uk/art/](http://www.newton.ac.uk/art/).

# Isaac Newton Institute for Mathematical Sciences

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Front cover: The apple *word cloud* is formed from the titles of each programme that has taken place at the Institute since it began 20 years ago together with those that are planned for the coming years; a total of 111 programmes.

Greater prominence is given to words that appear more frequently in the titles. Thus, *Theory* is the most frequent, closely followed by *Mathematics*, *Dynamics* and *Quantum*.