



# Isaac Newton Institute for Mathematical Sciences

*Annual Report 2009–2010*



UNIVERSITY OF  
CAMBRIDGE

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## APPENDICES

Please note that the following statistical information may be obtained from the Institute on request, or from [www.newton.ac.uk/reports/0910/appendices.html](http://www.newton.ac.uk/reports/0910/appendices.html)

- 1 Invited Participants
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# Director's Foreword



**David Wallace**  
**Director of the Institute**

The Institute has three overarching objectives: to organise research Programmes of the highest quality in mathematical

sciences, broadly defined; to attract to the Programmes the best scientists from all over the world; and to ensure that at least 80% of the Programmes are interdisciplinary.

As well as the themed research Programmes of one, and (mainly) four and six months' duration, the Institute seeks wider impact in a number of ways:

- Recognising that it is unrealistic in other than the most exceptional circumstances for researchers and leaders in business and in government to participate in Programmes for any length of time, the Open for Business meetings offer a concentrated engagement with leading researchers, including panel discussions and informal networking. These benefit from working with the Knowledge Transfer Network in Industrial Mathematics, and with the Centre for Science and Policy at Cambridge.
- Short follow-up meetings for previous Programmes are proving very popular with organisers, and are emerging as an invaluable way not only for refreshing and consolidating collaborations but also for tracking the impact of the original Programmes.
- Multiscale Numerics for the Atmosphere and Ocean (2012) was developed as a result of a cross-disciplinary Scoping Meeting supported by the Institute. We welcome approaches from other disciplines for similar Scoping Meetings.
- It was a great pleasure this year to work with Mathematisches Forschungsinstitut Oberwolfach, in hosting, for the first time in the UK, the Imaginary exhibition. As an event in the Cambridge Science Festival, it attracted approaching 1,000 visitors including some fourteen parties from schools; its international reach is reflected in the winners of the online competition – from the UK, Iran and China.
- The Institute strives to play its part in pro-

moting better gender balance in mathematics. Activities this year have included a two-day Women in Mathematics meeting in April, coverage of the Institute activities in the European Mathematical Society newsletter, an interview for Science magazine, and an initiative to showcase the achievements of women visitors to the Institute. See [www.newton.ac.uk/women/sixquestionswith/](http://www.newton.ac.uk/women/sixquestionswith/)

- The webcasting and web archive of the Institute have taken another step forward with the equipping of the second seminar room for video recording. Some 180,000 downloads, totalling more than 50 Tbytes, have been made since July 2008.
- The dinners hosted by Howard and Veronika Covington, primarily for business people from the City, continue to grow in popularity. Ten were held in the year of this report, including two larger events at the Royal Society, with a total of more than 150 attending. I am particularly grateful to the many mathematicians and scientists who gave their time.

These and other activities are reported in more detail in the three sections of this report: Science at the Institute; Serving the Community; and Management and Statistics. Each section is introduced by the relevant Chair: John Ball for the Scientific Steering Committee; Caroline Series for Institute Correspondents; and Howard Covington for the Management Committee. Their commitment and expertise is vital and I am particularly grateful to them, and indeed to all involved in the governance of the Institute and the organisation of Programmes. Special thanks to Howard, for his leadership in fundraising, and as convener of the committee for the appointment of my successor. I offer my deep thanks also to staff who have again performed superbly in an extremely busy year.

Finally, I will be delighted to welcome the new Director, John Toland, whose appointment begins on 1 October 2011. He brings great distinction and this is excellent news for the Institute and the Mathematical Sciences Community.

A handwritten signature in dark ink that reads "David Wallace". The signature is written in a cursive, slightly slanted style.

## Science at the Institute



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

This has been a very busy year. Ten proposals were considered in our October meeting and nine in May, compared with six and seven the previous year. We approved a total of five proposals, and five were carried forward for resubmission in October 2010.

The table of future Programmes is shown opposite. It remains very healthy in terms of commitment; a minimum of 18 months' lead time is needed to organise the longer programmes but we must be careful not to over-commit into the future. Two features are worth emphasising. The breadth of subjects means that we are more dependent than ever on referees who are domain experts for each

proposal – we received more than 110 reports in the course of the year. Second, it is pleasing to note Programmes which have been proactively stimulated, most notably those in environmental science. Multi-scale Numerics was formulated during a Scoping Meeting at Reading, promoted and supported by the Institute, and attended by 80 participants.

My thanks go to Edmund Burke and Peter Green for their contributions as retiring members. With input from the Learned Societies, the Nominating Committee (myself, David Harman and Caroline Series this year) identified Muffy Calder and Wilfrid Kendall as our preferred nominees, and I am pleased that they have agreed to join the Committee from 1 January 2011. Endre Süli was appointed for a full term of four years, and Cédric Villani co-opted for a further two years in his role as Director, Institut Henri Poincaré. A vacancy is being held open in SSC, pending the outcome of the cross-Research Council application which is currently under consideration.

## Scientific Steering Committee

Membership of the Scientific Steering Committee at 31 July 2010 was as follows:

Sir John Ball FRS FRSE (Chair)	University of Oxford
Professor K Ball ( <i>ex-officio</i> )	ICMS
Professor EK Burke	University of Nottingham
Professor DR Fearn FRSE	University of Glasgow
Professor É Ghys	École Normale Supérieure de Lyon
Professor PJ Green FRS	University of Bristol
Professor D Preiss FRS	University of Warwick
Professor SR Reid FEng	University of Aberdeen
Professor M-F Roy FEng	Institute of Mathematical Research of Rennes
Professor E Süli	University of Oxford
Professor R Twarock	University of York
Professor C Villani	Institut Henri Poincaré
Professor T Wooley FRS	University of Bristol
Sir David Wallace CBE FRS FEng (Secretary)	Director, Newton Institute

The Scientific Steering Committee (SSC) meets twice each year to consider proposals for programmes (of 4-week, 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 16 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
2009	<i>Algebraic Lie Theory</i>	<i>The Cardiac Physiome Project</i>	<i>Dynamics of Discs and Planets</i>	
	<i>Discrete Integrable Systems</i>	<i>Non-Abelian Fundamental Groups in Arithmetic Geometry</i>		
2010	<i>Stochastic Processes in Communication Sciences</i>	<i>Statistical Challenges Arising from Genome Resequencing</i>	<i>Mathematical and Statistical Approaches to Climate Modelling and Prediction</i>	
	<i>Stochastic Partial Differential Equations</i>	<i>Gyrokinetics in Laboratory and Astrophysical Plasmas</i>	<i>Partial Differential Equations in Kinetic Theories</i>	
2011	<i>Moduli Spaces</i>	<i>Design and Analysis of Experiments</i>		
	<i>Discrete Analysis</i>	<i>Inverse Problems</i>		
2012	<i>Mathematics and Applications of Branes in String and M-Theory</i>	<i>Topological Dynamics in the Physical and Biological Sciences</i>		
	<i>Semantics and Syntax: A Legacy of Alan Turing</i>	<i>Spectral Theory of Relativistic Operators</i>	<i>Multiscale Numerics for the Atmosphere and Ocean</i>	
2013	<i>The Mathematics of Liquid Crystals</i>	<i>Polynomial Optimisation</i>	TBA	
	<i>Grothendieck–Teichmüller groups, Deformation and Operads</i>	<i>Mathematical Modelling and Analysis of Complex Fluids and Active Media in Evolving Domains</i>	TBA	

Key: nominal programme duration     6 months     4 months     1 month

# Non-Abelian Fundamental Groups in Arithmetic Geometry

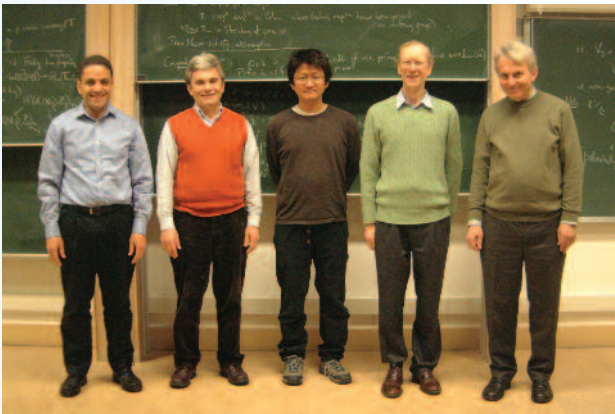
20 July to 18 December 2009

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

## Report from the Organisers:

J Coates (Cambridge), M Kim (University College London), F Pop (Pennsylvania), M Saidi (Exeter) and P Schneider (Münster)

S Greenham



M Saidi, F Pop, M Kim, A Wiles and J Coates

## Scientific Background

The ancient problems of diophantine equations and diophantine geometry are still central to research in number theory today, and the programme explored some of the most promising approaches to these problems. The two principal themes were anabelian geometry and non-commutative Iwasawa theory, and the mathematical ideas underlying them. More specifically, the programme concentrated on:

- (i) the section conjecture of Grothendieck;
- (ii) the main conjectures of non-commutative Iwasawa theory;
- (iii) the applications of non-abelian fundamental groups to the study of multiple zeta values and rational points on hyperbolic curves.

Connections between topics (ii) and (iii) were developed throughout the programme. Such connections are very surprising because, until recently, the study of rational points on hyperbolic curves had seemed to have little to do with  $L$ -functions and their special values. Indeed, it may well be that current research on these problems is somehow parallel to the situation at the end of the nineteenth century, when the reciprocity law of class field theory was emerging in a number of seemingly

different and unrelated forms, and the fundamental unity of the subject only became clear in the 1920s with Artin's work.

## Programme Structure

There was a loose division of the activities into the areas of anabelian geometry and non-commutative Iwasawa theory, with many of the boundaries being left intentionally unclear. In all, there was one workshop concerned with Iwasawa theory, one with anabelian geometry, a Spitalfields Day on potential modularity, and two workshops where a conscious effort was put in to bring together people of diverse specialities. The workshops were supplemented by intensive lecture series.

## Workshops

### Introductory Workshop

Workshop, 27–31 July 2009

Organisers: J Coates, M Kim, R Taylor, A Wiles

The workshop included a broad range of experts on motives, automorphic forms, and Galois representations, in addition to a corps of specialists on anabelian geometry and Iwasawa theory. A goal was to survey the different topics or areas to which the themes of the programme would eventually contribute, as well as to advertise its main ideas in relatively concrete form to the arithmetic community at large.

### Anabelian Geometry

Workshop, 24–28 August 2009

Organisers: M Kim, F Pop, M Saidi

This workshop surveyed various perspectives on Grothendieck's section conjecture and its ramifications, including the theory of the Brauer–Manin obstruction, reconstruction theorems for fields and schemes, as well as connections to Diophantine geometry and logic.

## *Non-Commutative Algebra and Iwasawa Theory*

A Satellite Meeting at ICMS Edinburgh,  
28 September–2 October 2009

Organisers: K Brown, D Burns, J Coates,  
P Schneider

The aim of the workshop was to discuss related recent developments in non-commutative algebra and Iwasawa theory. Iwasawa theory, via its main conjectures, remains the only systematic method known today for studying the mysterious connections between purely arithmetic problems and special values of complex  $L$ -functions, typified by the Birch–Swinnerton-Dyer conjecture. There is ever-growing evidence that these main conjectures hold in vast generality, in particular, for all motives over  $p$ -adic Lie extensions of number fields. At the same time, the Iwasawa algebras of compact  $p$ -adic Lie groups provide one of the most interesting examples of non-commutative rings. The workshop included lectures by both number theorists and experts in non-commutative algebra, aimed at explaining to each other their results, conjectures, and hopes for future work.

### *Potential Modularity*

Spitalfields Day, 30 October 2009

Organisers: J Coates, T Dokchitser, V Dokchitser,  
M Saidi

The theorems of R Taylor and collaborators on potential modularity have resulted in dramatic recent progress on long-standing problems of number theory, including a proof of the Sato–Tate conjecture and important cases of the Fontaine–Mazur conjecture. This workshop explained the techniques involved in the key results to students and non-specialist number theorists.

### *Final Workshop*

Workshop, 14–18 December 2009

Organisers: D Burns, J Coates, G Henniart, M Kim,  
F Pop, M Saidi

In addition to talks on anabelian geometry and Iwasawa theory, there were several lectures by top experts on rational points on varieties,  $p$ -adic representations, special values of complex  $L$ -functions, automorphic forms, and the interactions between these areas. This provided not only a picture of the problems discussed/solved during the



S.J. Wilkinson

*Participants in the Final Workshop  
14–18 December 2009*

programme, but also fleshed out future possibilities for applying non-abelian techniques to a broad range of arithmetic investigations.

## *Lecture Series*

### **P Deligne: *Multiple Zeta Values***

Drawing on his work in the 80s, P Deligne surveyed the state of the art on the ring of multiple zeta values, including connections to Grothendieck–Teichmüller theory and recent results of Furusho.

### **F Pop: *Anabelian Geometry I-IV***

The lectures focused on the so-called (anabelian) Bogomolov’s Programme, which has as final aim the reconstruction of function fields  $K/k$  of varieties of dimension  $> 1$  over algebraically closed base fields  $k$  from the pro- $l$  abelian-by-central Galois group  $\Pi_K$  of  $K$ . The lectures presented the ‘local theory’ with the several subtleties of the valuation theory of  $K$ , and the way they are reflected in  $\Pi_K$ . Based on this, it was shown how one can functorially reconstruct  $K/k$  from  $\Pi_K$  when  $k$  is an algebraic closure of a finite field, thus completing Bogomolov’s Programme in this case.

### **H Nakamura: *Anabelian Geometry V-VIII***

These lectures described results of the lecturer and many others on the centralizer of the outer Galois action on arithmetic fundamental groups of hyperbolic curves, discussing when these centralizers are spanned by geometric automorphisms.

### **M Saidi: *Anabelian Geometry IX-XII***

These lectures described recent results of the lecturer and A Tamagawa on how to reconstruct hyperbolic curves over finite fields from their geometrically pro- $\Sigma$  arithmetic fundamental groups for a set of primes  $\Sigma$  not containing the characteristic of the base field and finitely many primes.

**C Breuil: *Representations of Galois and of  $GL_2$  in Characteristic  $p$***

This was a course on the  $p$ -adic and mod  $p$  local Langlands correspondence, with a careful discussion of the results of Colmez on  $GL_2(\mathbb{Q}_p)$ , and some intriguing proposals for the problem of extending the correspondence to finite extensions of  $\mathbb{Q}_p$ .

**J Coates and R Sujatha: *Iwasawa Theory of Elliptic Curves over  $p$ -adic Lie Extensions of Dimension greater than 1***

The lectures surveyed what is known about the  $M_H(G)$ -conjecture, which is of central importance in non-commutative Iwasawa theory, especially for the formulation of the main conjectures.

**P Schneider: *The Algebraic Theory of  $p$ -adic Lie Groups***

The fundamental object of non-commutative Iwasawa theory is the completed group ring (or the Iwasawa algebra) of a Galois group which also is a  $p$ -adic Lie group. Lazard's seminal paper in 1965 developed a technique to analyze the structure of these rings. This course gave a self-contained and complete treatment of Lazard's theory.

**M Kim: *Motivic Fundamental Groups and Diophantine Geometry***

These lectures gave an introductory survey of the applications of non-abelian fundamental groups to the arithmetic of hyperbolic curves. In particular, the construction of Selmer varieties and unipotent Albanese maps were carefully discussed.

**M Kakde: *The Main Conjectures of Iwasawa Theory***

The main conjectures of Iwasawa theory propose that arithmetically important modules for the completed group algebras of (essentially)  $p$ -adic Galois groups can be analyzed using suitable  $p$ -adic  $L$ -functions. This lecture series presented the basic formalism of the main conjectures in a form that made the transition from the commutative to the non-commutative case transparent and uniform, and outlined the lecturer's results for totally real fields.

***Outcomes and achievements***

The programme attracted over 80 visitors from many parts of the world. Continuations of previous collaborative projects were ubiquitous, such as

Coates–Sujatha, Cadoret–Tamagawa, Pop–Stix, Gangl–Nakamura–Schneps, Shin–Park, Saidi–Tamagawa, Ardakov–Wadsley. Many new projects were catalysed as well by the activities of the programme, as in joint work of Stix–Ciperiani (divisible elements in Tate–Shafarevich groups), Stix–Vdovina (arithmetic geometry and geometric group theory), Harari–Voloch (Skolem's problem and Brauer–Manin obstructions), Colliot–Thelene–Swinnerton–Dyer (unramified cohomology of cubic threefolds), and Antei–Saidi (solvable torsors for fundamental group schemes). Of course, many discussions that have not yet led to concrete collaborations were cited by several visitors as important stimuli to their research. Andrew Wiles, for example, took the opportunity during his visit to learn about fundamental group techniques in diophantine geometry, and the visit of the Rothschild Visiting Professor P Deligne made a major impact, his strong influence being acknowledged by Ardakov, Abrashkin, Besser, Hadian, and Gangl. Just after the end of the programme, an interesting development occurred in the work of participant Yuichiro Hoshi, who managed to construct counterexamples to the pro- $p$  analogue of the section conjecture. This refined considerably our understanding of the mathematical subtleties surrounding Grothendieck's conjecture and brought to the fore the natural question of non-abelian local conditions appropriate to the pro- $p$  section conjecture.

In addition to research papers, a volume of proceedings will be published by Cambridge University Press in 2011. The volume will contain articles from Pop, Nakamura, Saidi, Schneider, Kakde, Coates, Sujatha, Kim, Buzzard, Breuil, Emerton, and Calegari. It is expected that this will be the first publication in which the study of arithmetic fundamental groups will be surveyed in conjunction with Iwasawa theory and the various aspects of the Langlands programme.

One other major publication that can be said to have been influenced by the programme is the book by Schneider on Lazard's theory of  $p$ -adic Lie groups. Preparation of the lecture series appears to have contributed greatly to furthering the completion of the manuscript.



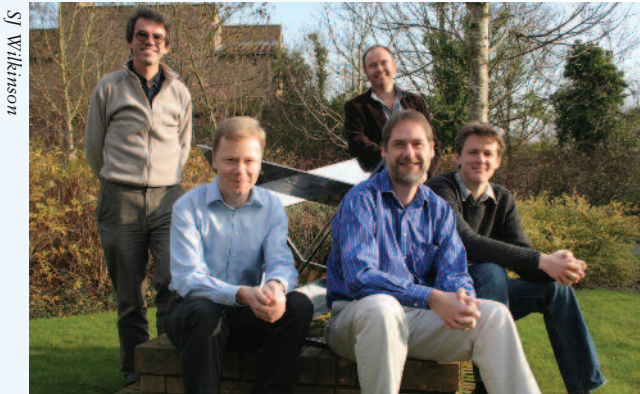
# Dynamics of Discs and Planets

12 August to 18 December 2009

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

## Report from the Organisers:

A Morbidelli (Observatory of Nice), RP Nelson (Queen Mary, London), GI Ogilvie (Cambridge), JM Stone (Princeton) and MC Wyatt (Cambridge)



A Morbidelli, GI Ogilvie, RP Nelson,  
JM Stone and MC Wyatt

## Background

Over the past decade, there has been significant progress on theoretical aspects of the planet formation process. Two viable models of planet formation have been explored: core accretion (growth of dust into planets through mutual collisions) and gravitational instability in the disc. However, many of the stages of planet formation remain poorly understood, in part because of a lack of knowledge of the physical nature of proto-planetary discs, despite recent advances from observations and from computational modelling of their (magneto-) hydrodynamics. The outcome of planet formation is also becoming more constrained, through increasing discoveries of systems with extrasolar planets or planetesimal belts analogous to the asteroid and Kuiper belts. The discovery of planetesimals and dwarf planets in the Kuiper belt beyond Neptune is also changing our understanding of the formation and evolution of the outer Solar System. At this time of unprecedented rapid progress, the aim of the programme was to consolidate and advance our theoretical understanding of how extrasolar planetary systems form and evolve, by bringing together experts in disciplines ranging from accretion disc theory, planet formation, planet-disc interaction and Solar System dynamics.

## Structure of the Programme

The scientific programme was divided into three broad themes: (1) dynamics of gaseous accretion discs; (2) dynamics of planetesimals and planets embedded in gaseous discs; (3) celestial mechanics of planet and planetesimal interactions. Equal weight was attached to each theme, and this was reflected in the participants whose expertise spanned the complete range of analytical and numerical techniques employed in this field. In practice the themes overlap to some extent, with many participants having interests in two or more themes, and interactions between the themes was important to making progress.

Throughout the programme there was a schedule of seminars and discussions, typically twice a week outside the workshops. While some preferred the conventional style of a formal seminar, as much discussion as possible was encouraged and several speakers agreed to give informal blackboard presentations, which are unusual in this subject area. One of these was even given by a participant of the concurrent *Non-Abelian Fundamental Groups in Arithmetic Geometry* programme, who had formerly worked in Hamiltonian dynamics and was familiar with the  $N$ -body dynamics of planetary systems. There were also stimulating round-table discussions on planetary migration and the excitation of eccentricity.

The Rothschild Distinguished Visiting Research Fellow was Professor D Lin.

## Workshops

*The Dynamics of Discs and Planets*  
Workshop, 17–21 August 2009

Organisers: RP Nelson, GI Ogilvie

A large international conference was held during the second week, the aim of which was to review the

current state of research in the scientific areas covered by the programme, and to define key problems as a focus of collaborative research.

To achieve these aims, the workshop programme included ten invited review talks, presented by recognised world-leaders in research, which set the broader context for each conference session and provided background material useful for PhD students and early-career researchers. A total of 30 shorter talks were also presented, describing the results of the most recent research, and 80 posters were displayed (and presented in one-minute talks).

### *Planetesimal Formation*

#### **Workshop, 28–30 September 2009**

Organisers: A Morbidelli, JM Stone

The second workshop focused on a fundamental and open issue of planet formation: the accretion of the first planetesimals. There were 13 invited talks of one hour each and four contributed talks of half an hour. An hour-long discussion concluded each day. About a third of the lectures were devoted to the properties of the proto-planetary disc in which planetesimals should have formed.

Some lectures were devoted to observational constraint from observations of proto-planetary discs, from analysis of the constituents of meteorites and the chronology of their formation, and from the current size distribution of main-belt asteroids.

Five lectures discussed the mechanisms that have been envisioned theoretically for the rapid formation of planetesimals, focusing on the favoured mechanism of the creation of high-density localised clumps of small particles, whose evolution is then dominated by self-gravity.

### *Dynamics of Outer Planetary Systems*

#### **Satellite Meeting at the Royal Observatory, Edinburgh, 9–11 November 2009**

Organisers: WKM Rice, MC Wyatt

This three-day workshop, which was attended by 66 participants, focused on the dynamics and physical processes that affect the less well-studied outer regions ( $\gg 10$  AU) of planetary systems. The planetesimal populations of these regions are seen as debris discs which also provide indirect evidence for the formation of planet-sized objects, but it is only

recently that extrasolar planets have been detected there. The workshop programme was divided into six sessions with themes: observations; Solar System; planetesimal growth; planetesimal evolution; origin of outer planets; interactions with outer planets.

### *Programme Summary*

#### **Workshop, 15 December 2009**

Organisers: A Morbidelli, RP Nelson, GI Ogilvie, JM Stone, MC Wyatt

This workshop was designed to enable participants to summarise new projects or insights enabled by the programme. It consisted of 12 short (20 minute) presentations, followed by an overall summary by programme organiser A Morbidelli. Presentations were organised into three sessions on: gas dynamics in protoplanetary discs, including the effects of self-gravity and realistic thermodynamics; planet-disc interaction and migration; the  $N$ -body dynamics and stability of planetesimals; planetary systems.

The Programme Summary identified several important themes and directions for future research in the field. These included continued investigations of: the internal structure of gaseous discs, including assessing the existence and effect of a ‘dead zone’ at the disc midplane; collective effects in the formation of planetesimals; type-I migration in more realistic disc models including an accurate treatment of the thermodynamics; the dynamical process of core formation and growth for the giant planets; the relative roles played by migration and scattering in planetary systems in determining the observed radial and eccentricity distributions of exoplanets; and the mechanisms responsible for forming the terrestrial planets.

The programme ended on a high note, with much optimism and renewed vigour to tackle these and many other issues discussed.

### *Outcome and Achievements*

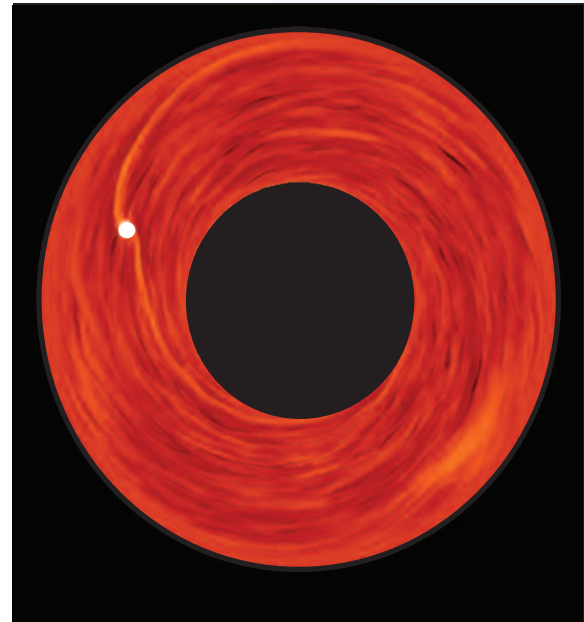
It is inevitable that we can mention here only a few highlights of the diverse research carried out during the programme. Progress on numerous topics was reported by participants, including: role of viscosity and resistivity in turbulence driven by the magneto-rotational instability in discs; corrugation modes in magnetically dead zones of protoplanetary discs; dynamics of corotation resonances; disc-driven

winds; fragmentation of irradiated protostellar discs; saturation of the streaming instability in uniform and stratified disc models; orbital evolution of planetesimals embedded in turbulent discs; planetary accretion in binary stars; formation of giant planet cores; role of gap formation by a system of giant planets as an explanation for inner holes in transition discs; planetesimal-driven migration; role of inertial waves in tidal interactions between planets and stars; viscous overstability in planetary rings; role of collisional damping in collisional cascades; steady-state planetesimal size distribution with radiation forces; dust signatures of terrestrial planet formation; collisional evolution of extreme eccentricity planetesimal populations; and formation of the outer Oort Cloud.

The programme facilitated dynamic interactions amongst participants that sparked numerous informal collaborations, the impact of which will be felt for many years to come. For example a collaboration emerged involving M Duncan, H Levison and RP Nelson (combining the  $N$ -body and hydrodynamic aspects of planet formation) to study the interaction with the gas disc of a planetary embryo migrating because of planetesimal scattering. Also, there was a new collaboration between A Morbidelli and S Raymond which set the basis for a new paradigm model of terrestrial planet formation that can explain the small mass of Mars.

The programme coincided with several important observational results, allowing participants to focus on the analysis and interpretation of the most up-to-date data. This included observations by the Herschel space observatory that will test models for the structure and evolution of debris discs. Similarly fortuitous timing with respect to the CoRoT exoplanet transit survey resulted in a new collaboration between J-L Zhou, S Ferraz-Mello and N Haghighipour to consider the origin of the two super-Earth system CoRoT-7.

For some participants, the programme allowed fundamental improvements to numerical modelling techniques that will lay the foundation for many future discoveries. For example, the Athena code used to study the non-ideal magnetohydrodynamics of dusty protoplanetary discs was extended by JM Stone to include a fully parallelised static nested mesh as well as incorporating algorithms for the



*Simulation of a low-mass planet (white circle) embedded in a turbulent protoplanetary 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. (RP Nelson)*

integration of dust particles with drag and feedback. Such techniques will allow a wide range of length scales in layered disc models.

Several participants were able to complete, or make significant progress with, major publications, including review articles by F Adams entitled *Birth Environment of the Solar System* and W Ward entitled *Planetary Migration*. A new book by N Haghighipour entitled *Planets in Binary Star Systems* was published by Springer in 2010.

The programme also connected strongly with the Institute of Astronomy (IoA) and the Astrophysics group in the Department of Applied Mathematics and Theoretical Physics at the Centre for Mathematical Sciences in Cambridge. For example, many participants were involved in a two-day meeting 6–7 September on *Angular Momentum Transport and Energy Release in Accretion Discs* held at the IoA in honour of the 60th birthday of one of the programme participants, JE Pringle.

The programme was supported by the Science and Technology Facilities Council which gave a grant to allow participants to access the High Performance Computing Service at the University of Cambridge.

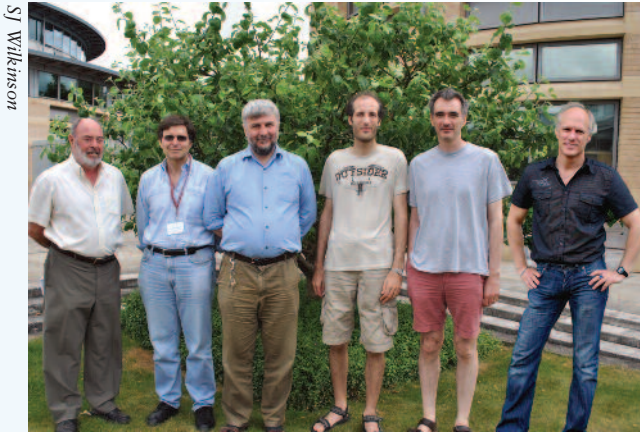
# Stochastic Partial Differential Equations

4 January to 2 July 2010

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

## Report from the Organisers:

Z Brzeźniak (York), M Hairer (Warwick), M Röckner (Bielefeld), P Souganidis (Chicago), R Tribe (Warwick)



*D Elworthy (workshop organiser) together with programme organisers P Souganidis, Z Brzeźniak, M Hairer, R Tribe and M Röckner*

## Scientific Background

Over the past two decades, the theory of Stochastic Partial Differential Equations (SPDEs) has emerged as a new area of mathematics that combines elements of both traditional PDE theory with tools from stochastic analysis and probability theory. Besides forming a branch of pure mathematics in their own right, SPDEs are used to model physical systems subject to the influence of internal, external or environmental noise. They also arise when considering deterministic models with random initial conditions, or as tractable approximations to complex deterministic systems. In many cases, the presence of noise leads to new phenomena, with recent examples in the physical sciences, biology and financial modelling.

The programme brought together the world leaders in SPDEs working on theoretical aspects, on numerical approximations, and on the application of SPDEs to real-world problems. The programme also identified future research trends in the field. From the viewpoint of the fundamental theory (existence / uniqueness / regularity), it was clear there are interesting examples of SPDEs for which some of the expected well-posedness results break

down, either due to the roughness of the solutions, or due to the irregularity of their nonlinearity. Furthermore, the current theory is largely for Gaussian noises, and one on-going emphasis was on systems driven by Lévy noise, for which the existing theory is still sparse. Another recent development that showed great potential during the programme is the use of the theory of rough paths to analyse solutions to SPDEs in various contexts. Finally, much work was done on the study of qualitative features of specific models, for example the fractal dimension of hitting sets, the description of solutions by reduced models in certain regimes, the study of the appearance of intermittency, asymptotic behaviour etc.

## Programme Structure

The programme was organised around a backbone of three week-long workshops. These were interweaved with two focused two-day mini-sessions, one satellite workshop, several focused mini-courses, and an extensive visitor programme. The mini-courses were given by Da Prato on Kolmogorov equations in infinite dimensions, by Ondřejat on the stochastic wave equations, and by Barbu on the differences between stochastic and deterministic nonlinear PDEs in the corresponding infinite-dimensional Cauchy problems.

## Workshops and Meetings

### Stochastic Partial Differential Equations

#### Opening Workshop, 4–8 January 2010

Organisers: Z Brzeźniak, M Röckner

The opening conference focussed on surveying the latest developments throughout the field. Several speakers discussed foundational issues on well-posedness of equations. The theory of large deviations for infinite-dimensional systems (addressed in particular by Cerrai, Millet, Sanz-Solé and Zabczyk) became a recurrent theme for the entire programme.

Another recurrent theme that emerged during the workshop is that of stochastic fluid dynamics. Indeed, a significant group of participants (Kim, Hairer, Millet, Lototski, Barbu, Mattingly, Truman, Mohammed, and Stannat) reported on progress in the understanding of various aspects of the stochastic Navier-Stokes and Burgers models, an area of application which has seen intensive recent work.

### *SPDEs and their Applications*

**Workshop, 29 March – 1 April 2010**

Organisers: Z Brzeźniak, P Souganidis

This workshop brought together researchers from several scientific areas that use SPDEs as a mathematical tool. It included talks on dispersive models (stochastic Korteweg–de Vries and nonlinear Schrödinger equations) by Kuksin and by Gautier; on porous media equations by Röckner and Russo; on ferromagnetic modelling by Goldys; on surface growth models by Romito. The workshop invited several speakers from outside the stochastic community (Caffarelli, Otto, Luckhaus, Le Bris, Dirr) to help guide researchers towards potential areas of application for stochastic models. Outside the workshops there were further talks from physicists: Chantrell on stochastic ferromagnetism and Turitsyn on nonlinear photonics. Later in the programme Cutland gave an approach to stochastic hydrodynamics via non-standard analysis, and R Moser discussed the Ginzburg–Landau vortices driven by the Landau–Lifshitz equation. Financial applications included Zabczyk on the Musiela SPDE with Lévy noise and Techranchi on hedging in variance swap markets.

### *Rough Paths, SPDEs and Related Topics*

**Mini Session, 6–7 April 2010**

Organisers: P Friz, M Gubinelli, Z Brzeźniak

This two-day mini-session concentrated on the theory of rough paths, with emphasis on the infinite-dimensional settings. It emerged as a powerful tool to tackle a number of problems related to the workshop, including the application of underlying ideas to numerical methods (Gyongy and Crisan), the analysis of Burgers-type equations (Hairer), the analysis of stochastic Hamilton–Jacobi equations (Souganidis, Friz), and a new functional analysis approach to (not so) rough paths (Lions).

### *Stochastic Partial Differential Equations*

**A Satellite Meeting at the University of York,  
31 May – 4 June 2010**

Organisers: Z Brzeźniak, D Elworthy, I Gyongy, R Tribe, T Zastawniak

This meeting combined the themes of the programme together with certain specific topics of interest to some UK researchers who were unable to attend the programme in Cambridge. These topics included infinite-dimensional analysis (Li, Fang, Lévy, Raimond, Thalmaier), Lévy drivers, which are now required by modellers in financial mathematics as well as in certain physical systems like climate models (Imkeller, Peszat, Hausenblas), the Zakai equation (Krylov and Rozovskii), as well as homogenisation (Pardoux, Zygouras).

### *Filtering*

**Workshop, 14–15 June 2010**

Organisers: D Crisan, R Tribe

This two day mini-session was attended by many of the world leading filtering experts. Weiss gave an account of his recent maximal regularity result for parabolic SPDEs. The session emphasised recent theoretical problems such as the smoothness, stability and long-time asymptotics of filtering equations, as well as the important numerical problem of implementation (grid methods, spectral methods and particle approximations).

### *SPDEs: Approximation, Asymptotics and Computation*

**Workshop, 28 June – 2 July 2010**

Organisers: A Debussche, M Hairer

The closing workshop for the programme focused on both theoretical and computational approximations to SPDEs. For numerical analysts, this is an area of great current interest, since many of the methods developed for the analysis of deterministic PDEs break down due to the irregularity of solutions. A number of recent developments in this direction, including stability results and error analysis, were presented by Faou, Hausenblas, Gyongy, Prohl, Voss, Larsson, and Buckwar. On a completely different note, several speakers (Stuart, Crisan, Mattingly) treated challenges to implementing Monte-Carlo methods in infinite-dimensional spaces.

## *Outcomes and Achievements*

A number of common themes emerged in the work carried out during the programme. Problems with a geometric slant arose in several contexts. Brzeźniak, Ondrejat, Prohl and Banas began to investigate the numerical approximations to stochastic geometric wave equations. Numerical work focussed their attention on questions about ergodicity for such problems. Other stochastic geometric equations such as heat flows, stochastic mean curvature flows, and the Landau-Lifshitz-Gilbert equations (LLGE) were investigated by De Bouard, Goldys, Jegaraj, Millet, Yip, Weber and others. In particular, progress was made towards proving non-uniqueness for 3D heat flow as well as a large deviations principle for 1D stochastic LLGE.

In joint work with Stinga, Gyongy exploited area processes to obtain sharp almost-sure-rate-of-convergence results, and applied these results to the numerical approximation of nonlinear filters. Souganidis worked on the generalisation of his earlier work with PL Lions on fully nonlinear SPDEs to other classes of equations. There was substantial discussion between Lyons and other participants (De Bouard, Friz, Hairer and others) on the applicability of rough paths theory in the theory of SPDEs, as well as between Lions and Lyons on the foundations of the theory of rough paths. From a different perspective, Hairer showed that certain SPDEs can be interpreted as processes taking values in the space of rough paths. This sheds light on the fact that some equations are classically ill-posed, but that natural approximations to them can still converge to a well-defined limit.

Malliavin calculus was exploited by many workers. Dalang and Sanz-Solé generalised previous works on the hitting probabilities for systems of stochastic wave equations to equations with multiplicative noise. Gauthier and E Nualart began to work on the applications of Malliavin calculus to nonlinear Schrödinger equations.

SPDEs driven by Lévy noise received considerable attention. Priola, Zabczyk and Xu started to study the ergodic properties of semilinear SPDEs driven by cylindrical alpha-stable processes. Brzeźniak, Hausenblas and Zhu proved a maximal inequality for stochastic convolutions in Banach spaces.

Hausenblas and Blömker worked on the amplitude equation for SPDEs with Lévy noise, while Mueller and JL Wu obtained some interesting results on the hitting probabilities for SPDEs driven with Lévy noise.

There was a flurry of activity related to the question of ergodicity of Markov processes generated by SPDEs. Several recent results, some obtained or improved during the programme, were presented by Mattingly (on work with Hairer on the exponential ergodicity for degenerate SPDEs), Bessaih (on the application to shell models) and Szarek (on work with Komorowski and Peszat on the implications of the e-property). The problem of the existence of solutions for multi-dimensional stochastic Burgers equation was positively resolved by Goldys, Neklyudov and others. Hairer and Maas completed work on the numerical approximation of stochastic Burgers-type equations, while Hairer and Weber started work on giving meaning to Burgers-type equations with multiplicative noise that are classically ill-posed. Inspired by a visit from Roger Moser, participants started to work on the development of stochastic models of vortex motion for Ginzburg–Landau equations and stochastic equations of ferromagnetism.

Infinite dimensional analysis is becoming an established tool in this area. Bogachev, Da Prato and Röckner worked on uniqueness of Fokker–Planck equations in infinite dimensions, with applications to SPDEs with singular drift coefficients. Goldys and Da Prato and co-workers developed the theory of functions of bounded variation in (BV) Hilbert spaces. Their work is the first study of BV functions in infinite dimensions where the reference measure is not Gaussian. It was successfully applied to the existence and uniqueness of strong solutions for the stochastic reflection problem on a regular convex set in Hilbert space.

There was progress in the wide range of applications: Barbu and co-workers proved existence and uniqueness of solutions for the stochastic porous media equations, whilst Röckner and co-workers established the existence of a random attractor for the stochastic porous media equation; F-Y Wang solved the long-standing problem of dimension independent Harnack inequalities for multiplicative noise, and in particular for pure jump-type noise.

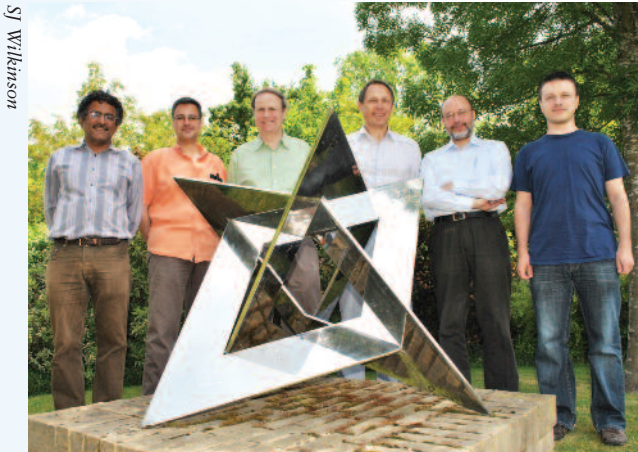
# Stochastic Processes in Communication Sciences

11 January to 2 July 2010

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

## Report from the Organisers:

V Anantharam (Berkeley), F Baccelli (INRIA Paris - Rocquencourt), D Denisov (Cardiff), S Foss (Heriot-Watt and Institute of Mathematics, Novosibirsk), PW Glynn (Stanford) and T Konstantopoulos (Heriot-Watt)



V Anantharam, T Konstantopoulos, PW Glynn, S Foss, F Baccelli and D Denisov

## Scientific Background

There has been a connection between probability (stochastic processes) and communications (networks, information theory) almost since the invention of the telephone. Indeed, as soon as a system becomes large or complex, probability theory seems to be the right tool to describe its behaviour and to help in its design. In our information age, the rapid progress in communication sciences (wireless communications, Internet) impacts all aspects of society, from science to economy and political planning.

The programme brought together experts in the fields of probability and communications to review current knowledge and trends and to develop them further. The research challenges in the latter field (from telephone networks to wireless communications and the Internet) have spurred the development of the mathematical theory of stochastic processes, particularly in the theory of Markov processes, point processes, stochastic networks, stochastic geometry, stochastic calculus, information theory, and ergodic theory — to name but a few.

Conversely, many applications to communications would not have been possible without the development of stochastics.

## Structure of the Programme

The programme was attended by 89 visiting fellows participants and 25 programme participants, several of whom were young researchers or graduate students. It also hosted several workshops and special events, with many more participants as listed below. Most of the regular talks were recorded and are now available on the Newton Institute website. Several participants also gave invited seminar talks at other UK universities.

## Workshops

### *New Topics at the Interface Between Probability and Communications*

#### Workshop, 11–15 January 2010

Organisers: V Anantharam, F Baccelli

The workshop brought together leading experts to survey the range of problems in the modern communication sciences that are studied using stochastic techniques, and to give their individual perspectives on important future directions in the field.

A number of outstanding lectures were delivered during this workshop. The topics that were surveyed included limit theorems for stochastic networks (K Ramanan), scheduling, load balancing, and congestion control (A Ganesh, J Tsitsiklis, J Walrand, D Wischik), rate and delay guarantees in wireless networks (P Kumar, M Medard, D Tse), aspects of heavy-tailed and long-range-dependent behaviour in networks (B Prabhakar, S Resnick), the role of iterative algorithms (L Massoulié, A Montanari), and novel estimation techniques for large scale problems (A Orlitsky). A refereed poster session, as well as two very lively open problem sessions, rounded out the workshop.

### *Communication Architecture for the Future*

**Open for Business Event, 11 March 2010**

Organisers: R Gibbens, S Zachary, R Leese,  
T Konstantopoulos, B Mestel

This half-day workshop was supported also by the Higher Education Innovation Fund (HEIF4) of the University of Cambridge. It brought together experts in UK wireless spectrum auctions with researcher in auctions theory. It was a great opportunity to compare theory and practice, and discuss future directions.

### *Stochastic Networks*

**Workshop, 22–26 March 2010**

Organisers: T Konstantopoulos, K Ramanan

Stochastic Networks is a multifaceted area field dealing with the stability, control, performance, approximation and design of stochastic models of networks. It gives rise to challenging and subtle mathematical problems, whose solution often requires a combination of ideas and techniques from several branches of mathematics, including probability theory, stochastic processes, analysis, optimization, combinatorics and graph theory. This workshop brought together experts in this area to survey recent developments and identify future research directions.

The workshop hosted a number of high-quality lectures by experts in the field, young researchers and researchers in related areas. The Rothschild Visiting Professor B Hajek gave a lecture on mathematical models of peer-to-peer communication networks. An impressive lecture was given by M Bramson on a truly exceptional result exhibiting a 6-dimensional reflecting Brownian motion which is positive recurrent but with divergent fluid limit. The workshop closed with a short overview lecture by F Kelly, one of the founders of the field.

### *Spatial Network Models for Wireless Communications*

**Workshop, 6–9 April 2010**

Organisers: V Anantharam, F Baccelli

This workshop gathered 86 attendees from all over the world and had 16 lectures and a poster session.

Two communities met, it is believed, for the first time: specialists on random graphs and stochastic geometry applied to networks, and specialists in

wireless networks interested in the development of modelling tools involving spatial components. Several areas of common ground between these two communities became evident, in particular the role played by phase transitions arising in percolation in the analysis of connectivity in large networks.

The main outcomes of the workshop were: connections between the network geometry and the quality and quantity of information transmission; methodological advances based on network information theory and spatial stochastic networks; and the identification of several classes of new mathematical problems stemming from wireless network design. The workshop received additional support from the USA NSF and the EU EuroNF Network of Excellence.

### *Stochastic Processes in Communication Sciences for Young Researchers*

**Satellite Meeting at ICMS, 7–11 June 2010**

Organisers: D Denisov, M Lelarge and B Zwart

The meeting was supported by the EuroNF Network of Excellence. Although aimed at young researchers, the meeting attracted interest from more experienced researchers as well. The workshop included both research talks together with more elementary tutorials.

There were five tutorial sessions given by leading experts: B Blaszczyzyn, P Robert, R van der Hofstad, M Wainwright and D Wischik covering: stochastic geometry and wireless networks; probabilistic methods in the analysis of stochastic networks; processes on random graphs; graphical models and message-passing algorithms; and queuing theory for switched networks.

In addition, several research talks were given to cover recent developments including message passing algorithms; social networks; wireless networks; importance sampling; and stability for networks. Importantly, this workshop also gave an opportunity for younger researchers to present their results to a broader audience. This resulted in a number of interesting talks and a poster session.

### *Energy Systems Week*

**Open for Business Event, 24–27 May 2010**

This four-day workshop, held under the auspices of the programme, is described on page 21.





Participants at the 'Simulation of Networks' workshop on 22 June 2010

### *Simulation of Networks*

#### Workshop, 21–23 June 2010

Organisers: S Asmussen, J Blanchet, S Foss, P Glynn

This workshop focussed on stochastic simulation and, in particular, on the design and analysis of Monte-Carlo methods for rare events – a topic that is known to be both challenging and important within applied probability at large. A number of significant contributions were discussed, including new insights into the understanding of particle methods for rare events, optimally designed algorithms for a large class of stochastic networks, and asymptotically optimal algorithms for many server systems. The workshop was organised jointly with RESIM, which is an international workshop on rare event simulation that is held every two years and has a very strong international representation. Keynote papers are planned to be published in a special issue of *Questa*.

### *Statistics of Networks*

#### Workshop, 24–25 June 2010

Organisers: S Foss, P Glynn, R Nowak, S Resnick, D Towsley, D Veitch

This workshop brought together leading data-oriented researchers in the many disciplines that are now utilizing network models in the study of fundamental questions arising in their fields. Network models have become a fundamental tool in understanding and predicting phenomena in areas as disparate as biology, finance and the evolution of social communities. Specific areas addressed by the workshop included statistical analysis of network traffic (including inference in the presence of missing data), detection of network intrusion and congestion, determination of community structure,

use of multiscale methods, and development of graphical modelling and inference tools.

### *Outcomes and achievements*

The *Stochastic Partial Differential Equations programme* ran simultaneously with this programme and resulted in a great synergistic atmosphere with participants of one programme interacting and attending talks of the other.

Many important collaborations were started or developed during the programme. Examples include: collaboration between H Thorisson, G Last and P Mörters on random time shifts and two-sided Brownian motion; between I Ziedins, T Kurtz and M Reiman on diffusion approximation for loss networks; between T Konstantopoulos and V Anantharam on the integral representation of Skorokhod reflection; between A Rybko, S Zuyev and Y Sinai on a class of Markov processes; between K Debicki and M Mandjes on asymptotics of the supremum of a Gaussian queue; between J Martin and S Foss on the last passage percolation; between M Zazanis and T Konstantopoulos on iterates of Bernstein operators; between I Norros, D Denisov and N Leonenko on multifractals; between J Cruise, D Wischik and D Shah on scheduling problems, between M Mandjes and P Glynn on workload autocorrelation of queues fed by long-range dependent inputs. A new line of research was also started by F Baccelli, A Rybko and A Vladimirov on phase transitions for queueing dynamics of wireless networks.

The list is far from exhaustive. Many papers and several books have been completed during the programme. Several papers have appeared as preprints of the Newton Institute.

## Serving the UK Community



**Caroline Series,**  
**Chair of**  
**Correspondents**

I am pleased to introduce the ‘Serving the UK Community’ section of the Annual Report which contains key information and statistics on how the Institute serves the UK Mathematical Sciences community, together with a brief guide as to how researchers at all levels can engage with Institute activities.

The involvement of the community is one of the Institute’s major strengths. A key role is played by the network of Correspondents from UK higher education and research institutes. Correspondents act as a two-way channel of communication between the Institute and UK researchers; their work is invaluable to ensuring the Institute remains fully embedded in the community. They receive regular electronic bulletins about ongoing activities at the Institute which they forward to colleagues not only in mathematics, but also in all those interdisciplinary fields for whom Institute programmes may be of interest. If for any reason your institution is not represented, please do contact either myself or the Deputy Director to find out what is involved. The list of

Correspondents can be found opposite.

As Chair of Correspondents, it is my role to represent the mathematics community on the Institute’s Management Committee, which meets three times a year. Please feel free to contact me to discuss any aspect of the Institute's work about which you have ideas or concerns.

As usual, the Correspondents’ Annual Meeting was held in June. The meeting is an important vehicle for input into the Institute’s activities and Correspondents present were balloted as to how satisfied they were with their opportunities to do this. I am pleased to report that 91% were either Satisfied or Highly Satisfied. (The full result was: Highly satisfied 41%; Satisfied 50%; Neither Satisfied nor Dissatisfied 9%; Dissatisfied 0%; Highly Dissatisfied 0%.)

Topics discussed at the meeting included proposals for a new design of the Institute’s website, the Gender Balance Initiative, and the Institute’s cross-council funding application. Correspondents were generally supportive of the Institute’s outreach activities, which this year included the Imaginary exhibition, Open for Business events (including Energy Systems Week) and the Women in Mathematics two-day event held in April 2010, described on page 20. The meeting concluded with a fascinating talk by Professor Ray Goldstein (Cambridge) on Evolution of biological complexity.

### *UK 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, and 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.

### *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)

## Newton Institute Correspondents (as at 31 July 2010)

Newton Institute Correspondents act as a channel of communication between the Institute and the UK mathematical sciences community (see page 16). Further nominations are encouraged.

Aberdeen	A Sevastyanov	Manchester (Mathematics)	M Prest
Bath	JF Toland	Manchester (Physics)	AJ McKane
Birmingham	IV Lerner	Napier	T Muneer
Brighton	PJ Harris	Newcastle	CF Barenghi
Bristol	F Mezzadri	Nottingham	Y Mao
Brunel	G Akemann	Open	UG Grimm
Cambridge	N Dorey	Oxford	P Chruściel
City	O Kerr	Plymouth	C Christopher
Dundee	G Hornig	Portsmouth	AD Burbanks
Durham	WJ Zakrzewski	Queen Mary, London	PJ Cameron
East Anglia	G Everest	Queen's, Belfast	AW Wickstead
Edinburgh	A Olde Daalhuis	Reading	S Langdon
Essex	DB Penman	Royal Holloway, London	J Crampton
Exeter	D Stephenson	St Andrews	DG Dritschel
Glasgow	C Athorne	Salford	RD Baker
Greenwich	T Mann	Sheffield	K Mackenzie
Heriot-Watt	L Boulton	Southampton	CJ Howls
Hertfordshire	S Kane	Staffordshire	BL Burrows
Huddersfield	A Crampton	Stirling	R Norman
Hull	JW Elliott	Strathclyde	M Ainsworth
Imperial College London	K Christensen	Surrey	PE Hydon
Keele	JJ Healey	Sussex	M Broom
Kent	PA Clarkson	Ulster	M McCartney
King's College London	K Rietsch	University College London	ER Johnson
Lancaster	S Power	West of England	K Henderson
Leeds	A Pillay	Wales (Aberystwyth)	R Douglas
Leeds Metropolitan	E Guest	Wales (Cardiff)	KM Schmidt
Leicester	F Neumann	Wales (Swansea)	T Brzeźński
Liverpool	V Goryunov	Wales (WIMCS)	T Lyons
Liverpool John Moores	PJG Lisboa	Warwick	C Series
Loughborough	AP Veselov	York	N MacKay
LSE	M Luczak		
ATM	P Andrews	Met Office	MJP Cullen
British Computer Society	B Mitchell	Microsoft Research Group	CM Bishop
Edinburgh Mathematical Soc.	TH Lenagan	National Oceanography Centre	M Srokosz
EPSRC	M Bambury	OR Society	R Hibbs
EBI	C Brooksbank	Proudman Oceanographic Lab.	PJM Huthnance
ICMS	JF Toland	RAL	N Gidopoulos
IMA (Academic)	D Abrahams	Rothamsted Research	M Semenov
IMA (Organisational)	D Youdan	Royal Academy of Engineering	J McWhirter
Institute of Actuaries	M Lyons	Royal Society	M Taylor
Institute of Physics	C Korff	Royal Statistical Society	S Olhede
LMS	NS Manton	Schlumberger	J Sherwood
Mathematical Association	RH Barbour	Smith Institute	T Armour

## Institute Activities

### *Follow-up Events*

As stated in the Institute's Scientific Policy Statement, it is intended that each Institute programme will have long-term impact well beyond the programme itself in terms of breakthroughs, new research directions and collaborations. The Institute has therefore become proactive in arranging short follow-up events some years after programmes finish, whenever the original organisers are enthusiastic.

### *Analysis on Graphs and its Applications*

#### **Follow-up Workshop, 26–30 July 2010**

Organisers: BM Brown, P Exner, P Kuchment, T Sunada

This workshop was a follow-up to the 2007 programme *Analysis on Graphs and its Applications* (AGA). The workshop attracted 72 participants and was supported by the Meiji Institute for Advanced Study of Mathematical Sciences, the Doppler Institute (Prague) and the USA NSF.

As in the original AGA programme, the workshop concentrated on three major intertwined areas: Analysis on Discrete Graphs (also called Discrete Geometric Analysis), Analysis on Fractals, and Analysis on Quantum Graphs. The workshop focussed on developments in these subjects since the AGA programme and also discussed future research directions. Examples of progress are furnished by recent major results in understanding the possibilities, and limitations, of graph modelling of meso- and nano-structures (see the talks of Grieser, Post, Vainberg); connections between random matrix theory and quantum graphs (Smilansky); zeta functions on graphs (Terras, Trplyaev); quantum statistics (Chernyshev, Keating, Winn); nodal structure of eigenfunctions, and the structure of spectra and applications to quantum mechanics (Eastham, Schmidt, Pavlov). Specific results presented at the workshop that have arisen from the AGA programme include investigation of combinatorial graphs from the point of view of chaos and isospectrality, and the start of an investigation of nonlinear Schrödinger operators on graphs (both by Smilansky and co-workers). An

investigation of resonance properties of quantum graphs by Exner and co-workers inspired Davies and Pushnitski (and later Davies, Exner, and Lipovsky) to study semiclassical asymptotics, with the surprising conclusion that they may not be of Weyl character. A full list of the talks together with abstracts is available at

[www.newton.ac.uk/programmes/AGA/agaw06.html](http://www.newton.ac.uk/programmes/AGA/agaw06.html)

### *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 144 visitors did so during 2009/10 delivering a total of 215 seminars in 36 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*

To increase the benefit of Institute programmes to the UK mathematical community, seminars delivered during workshops or at special events at the Institute are recorded and made available with accompanying transparencies or PowerPoint files, on the web at

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

Starting from September 2007, however, full video of every seminar has been available for either

streaming or download subject to speaker permission. In time the library of online seminars should build into a substantial national resource. During 2009/10 an additional 385 seminars were added. This number is lower than in previous years for a variety of reasons, including the use of non-Institute venues without recording facilities

### *Junior Membership*

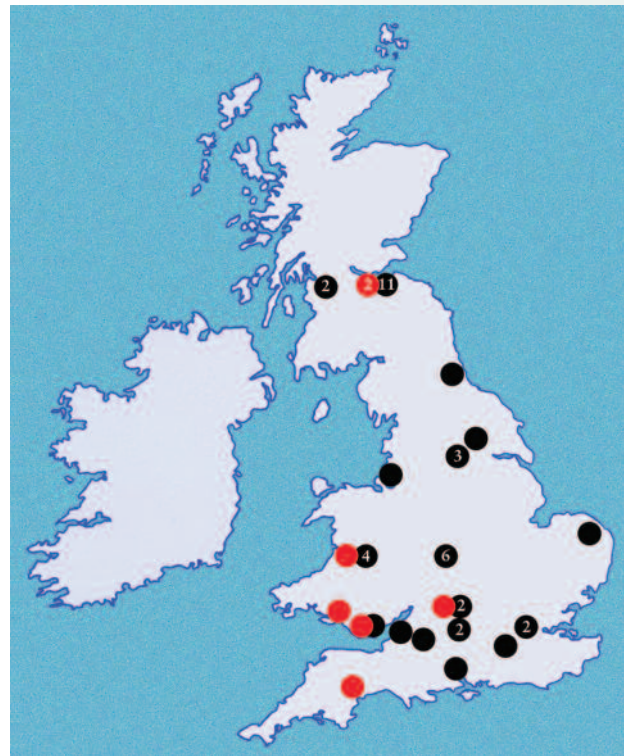
The Institute recognises that early career researchers have much to contribute to, and gain from, Institute programmes and events. In order to maximise the information available to them, and to facilitate their involvement in Institute activities by offering additional funding opportunities, there is a special scheme for Junior Membership of the Newton Institute. To be eligible you must be either a Research Student or within 5 years of having received your PhD (with appropriate allowance for career breaks), and you must work or study in a UK University or a related research institution. Those wishing to join the scheme should consult the Institute's web site at

[www.newton.ac.uk/junior.html](http://www.newton.ac.uk/junior.html)

Members will receive regular advance information regarding programmes, workshops, conferences and other Institute events. The Institute also makes available some of its general funds specifically to support early career researchers taking part in Institute activities. Members may apply for grants from these funds. Types of involvement supported include attendance at workshops, conferences, etc., and visits of up to two weeks to work or study with longer-stay participants in the Institute's research programmes. The Institute registered 141 new Junior Members in 2009/10; the current total is 776 as at the end of July 2010.

### *Satellite Workshops*

The Institute encourages organisers of 4- or 6-month programmes to cooperate with local organisers in holding 'satellite' workshops at UK Universities and institutions outside Cambridge. Satellite workshops are organised on themes related to an Institute programme, and involve a significant number of the longer-stay overseas participants who are visiting the Institute at the time. They also, crucially, draw in and involve UK mathematicians



*Distribution of Satellite Workshops*

● *Planned*

● *Held*

and scientists who might not otherwise be able to participate substantially in the Institute programme; and they enable the expertise of the Institute's overseas participants to be shared more widely within the UK.

Future satellite workshops are planned at Cardiff, Edinburgh Royal Observatory, Exeter, ICMS, Oxford, Swansea, Wales (Gregynog Hall) and York.

Costs for satellite workshops are shared between the Institute and the host institution and the Institute typically contributes £15,000 (excluding the overseas travel costs of Institute participants, which are covered separately). From mid-2008 the host institution's share has been provided by EPSRC.

The Institute is keen to continue to expand the geographical range of satellite workshop locations. Institutions interested in holding a workshop should contact either the organisers of the relevant programme or the Deputy Director.

Further details on planned Satellite Workshops can be found at

[www.newton.ac.uk/events.html](http://www.newton.ac.uk/events.html)

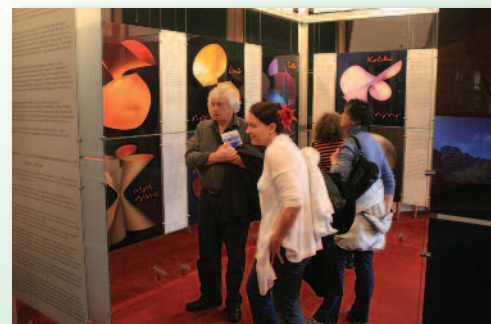
## Institute News

### *IMAGINARY: through the eyes of mathematics*

IMAGINARY is a travelling exhibition created by the Mathematisches Forschungsinstitut Oberwolfach and the Institute hosted the exhibition's first visit to the UK in March 2010. The 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. An online 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 the Harrow School in Beijing. For more information please see [www.imaginary-exhibition.com](http://www.imaginary-exhibition.com)



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### *Women in Mathematics*

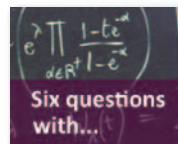
As part of the Institute's gender balance initiative, the Institute hosted a Women in Mathematics two-day meeting on the 15–16 April 2010. Co-sponsored by the London Mathematical Society's Women in Mathematics Committee and the UK Resource Centre for SET women (UKRC), the event attracted 80 participants. The first day comprised the annual Women in Mathematics day which has been successfully run by the LMS for several years. Featuring a mixture of talks from established mathematicians and early career researchers, including PhD students, it both celebrated the mathematical achievements of women mathematicians and gave the opportunity for younger women to present their research. Participants were introduced to the European Mathematical Society Women in Mathematics Committee, which was also meeting at the Institute during the event.

The second day concentrated on career-development for women mathematicians, and in addition to

mathematical seminars, talks on initiatives to support women in their careers were given by the Institute, the LMS and the UKRC. Information on funding opportunities was provided by EPSRC and the University of Cambridge Research Office.

A full list of talks is available from

[www.newton.ac.uk/women/WIM/wimw01.html](http://www.newton.ac.uk/women/WIM/wimw01.html)



### *6 Questions with...*

6 Questions with... is an occasional series of interviews with female mathematical scientists. In this series we showcase the achievements of inspirational women from all kinds of backgrounds and at all stages of their mathematical sciences careers. The Institute hopes that the series will help female mathematical scientists to share their experiences and will also encourage women to persist and excel at mathematical sciences research. The interviews are available online at

[www.newton.ac.uk/women/sixquestionswith/](http://www.newton.ac.uk/women/sixquestionswith/)

## Open for Business

### *Energy Systems Week*

Open for Business Event, 24–27 May 2010

Organisers: S Zachary, C Dent, RJ Gibbens, S Foss, R Leese, J Meeson, B Mestel

As part of the Institute's *Open for Business* activities and the *Stochastic Processes in Communication Sciences* programme, the Institute held an *Energy Systems Week*, which focused on mathematical and statistical challenges in the design and management of future energy systems, notably those in networks for the supply and distribution of electrical energy. The event was supported by EPSRC, the Knowledge Transfer Network for Industrial Mathematics and the Council for the Mathematical Sciences.

Adaptation to new, non-fossil-fuel, sources of energy poses many interesting mathematical challenges in the generation and distribution of electrical power. Notably, renewable sources such as wind power produce supplies which are highly variable and often unpredictable even on relatively short timescales. Further, new sources of generation capacity, whether renewable or nuclear, are often located far from the urban and industrial areas they must serve. Thus in the future there will be a need to manage a complex and stochastic system, in which supply and demand need to be managed on a minute-by-minute basis, and in which there are many competing operators each seeking to maximise their own returns.

The first two days of the workshop consisted of tutorials by energy systems experts on the mathematical challenges now posed: B Hobbs (Johns Hopkins), D Ralph (Cambridge) and S Meyn (Urbana-Champaign) addressed issues in the dynamical management of multivariate-player systems; G Vinnecombe (Cambridge), J Bialek (Durham) and D Kirschen (Manchester) spoke about the stability and optimal control of power networks; M O'Malley (Dublin) introduced the statistical and optimization problems in the integration of wind energy into electricity networks. These sessions were all extremely lively and provoked both extensive and intensive exchanges between the mathematicians,



economists and power systems engineers attending the workshop.

The third day of the workshop was an *Open for Business* day and featured presentations on high-level strategy and policy issues for future energy systems. S Meyn spoke on the need for regulation in energy markets; S Smith (Ofgem) spoke on ensuring the adequacy of future energy systems, and J Bialek on their mathematical modelling; C Murray (National Grid) discussed the role of National Grid in balancing future energy security, sustainability and affordability. These presentations were followed by a lively panel discussion in which mathematicians and economists strove hard to understand each other's viewpoints.

The final day focused on some specific problems and challenges. S Riches (EPSRC) introduced the UK Research Councils Energy Programme; A Richards (National Grid) discussed statistical issues in demand forecasting; N Meah (Dept. of Energy and Climate Change) discussed the effective incorporation of uncertainty in economic projection models so as to inform policy makers properly; Mark Tritschler (KEMA) presented mathematical challenges in the control of smart grids.

The workshop proved a highly effective base for identifying these many important research issues and for planning how best academics and industrialists with many different areas of expertise should work together to address them.

# Management and Statistical Reports



Howard Covington,  
Chair of the Management  
Committee

At this time of transition for the university sector, we applaud the government for maintaining research spending in cash terms. In the new, constrained funding environment, it is imperative for the Institute to diversify its funding. The Engineering and Physical Sciences Research Council (EPSRC) is enlightened both in the scale of its funding, and in the scope which it gives the Institute to support cross-disciplinary research. We are grateful to other Research Councils (BBSRC, MRC, NERC and STFC) who have supported specific Programmes in the last 18 months. We await the outcome of a cross-Research Council application to provide core support over the next three years.

We are making a concerted effort to raise funds from the private sector. The work of the Institute inspires all those who value the mathematical sciences, both as an intriguing and fundamental part of human culture and as the essential underpinning for so much of modern life. I am deeply grateful to all the donors who have helped as this year and to the Development Board for their advice and guidance.

At the end of 2010, Peter Johnstone and Tim Gowers step down as member of the Management Committee, and I thank them personally for their contributions. We are delighted to welcome Joan Lasenby and Nick Manton.

## Management Committee

Membership of the Management Committee at 31 July 2010 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 WT Gowers FRS	<i>Trinity College</i>
Mr D Harman	<i>EPSRC</i>
Professor PH Haynes	<i>Head of Department, DAMTP</i>
Professor JME Hyland	<i>Head of Department, DPMMS</i>
Professor PT Johnstone	<i>St John's College</i>
Professor R Langley	<i>Council of the School of Technology</i>
Professor PB Littlewood FRS	<i>Council of the School of the Physical Sciences</i>
Dr B Mestel (Secretary)	<i>Deputy Director, Newton Institute</i>
Professor C Series	<i>Chair of Correspondents</i>
Sir David Wallace CBE FRS FREng	<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 fund-raising 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 2197 visitors was recorded for 2009/10.

This includes 303 Visiting Fellows and 127 Programme Participants. Within the four programmes during the year there were 17 workshops (periods of intense activity on specialised topics) which attracted a further 484 visitors (i.e., those not already attending the programme).

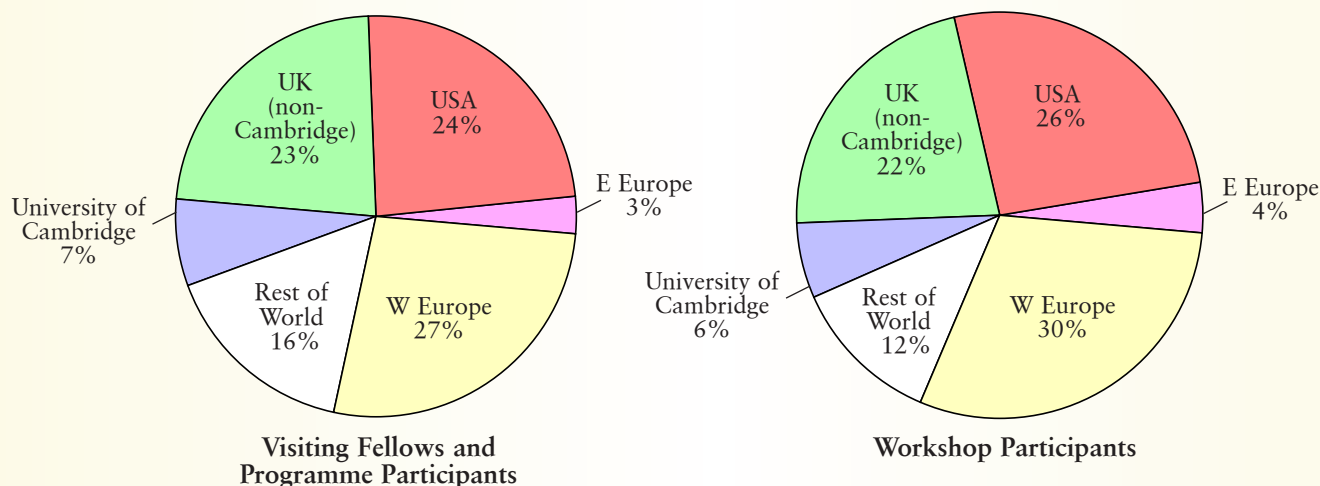
In addition to workshops, which serve to widen UK participation in programmes, the Institute from time to time arranges less formal special academic

meetings as well as talks for the general public, so further opening up the activities of the Institute. More than 1283 visitors attended such events and took part informally in Institute activities or satellite events and follow-up meetings.

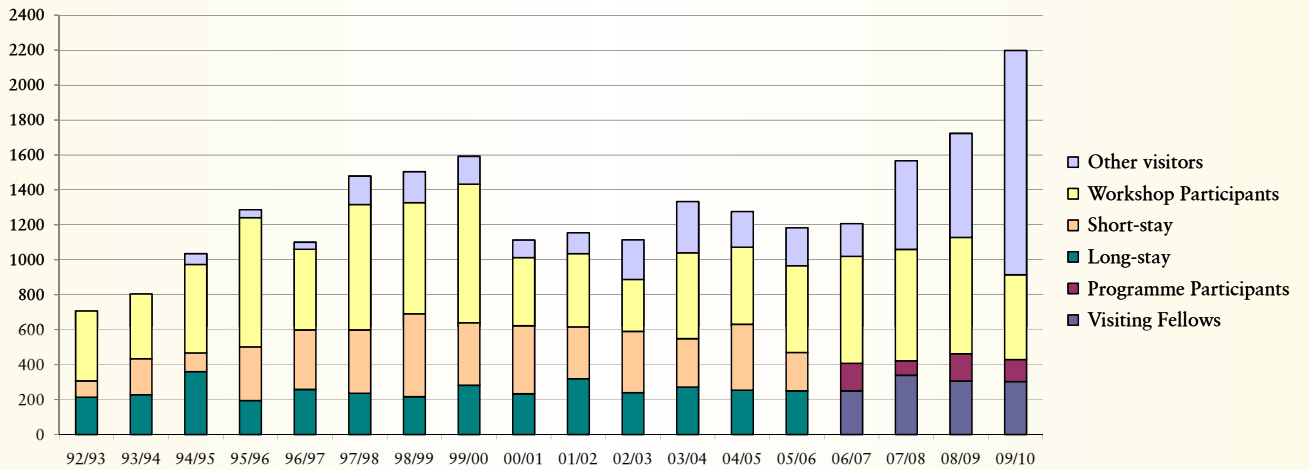
Within all the programmes, workshops and other activities, 562 seminars were given in total at the Institute during the year. The Institute also funds visits by overseas programme participants to other UK institutions to give seminars (see page 18), and 215 such seminars took place this year.

Programme	Visiting Fellows	Mean stay (days)	Programme Participants	Mean stay (days)	Workshop Participants
<i>Non-Abelian Fundamental Groups in Arithmetic Geometry</i>	69	43	13	45	74
<i>Dynamics of Discs and Planets</i>	64	49	24	56	130
<i>Stochastic Partial Differential Equations (SPDEs)</i>	81	42	65	31	93
<i>Stochastic Processes in Communication Sciences</i>	89	38	25	80	187
<b>Totals</b>	<b>303</b>	<b>43</b>	<b>127</b>	<b>47</b>	<b>484</b>

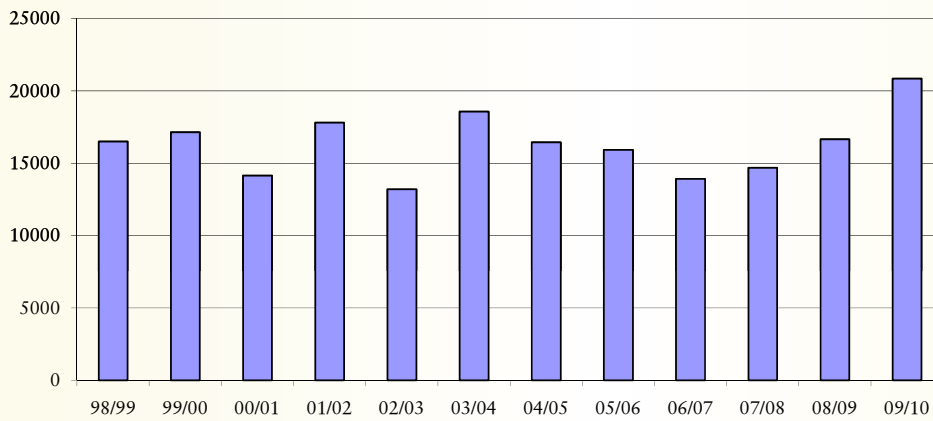
The pie charts below show the percentages of Visiting Fellows, Programme Participants and Workshop Participants broken down by country of residence:



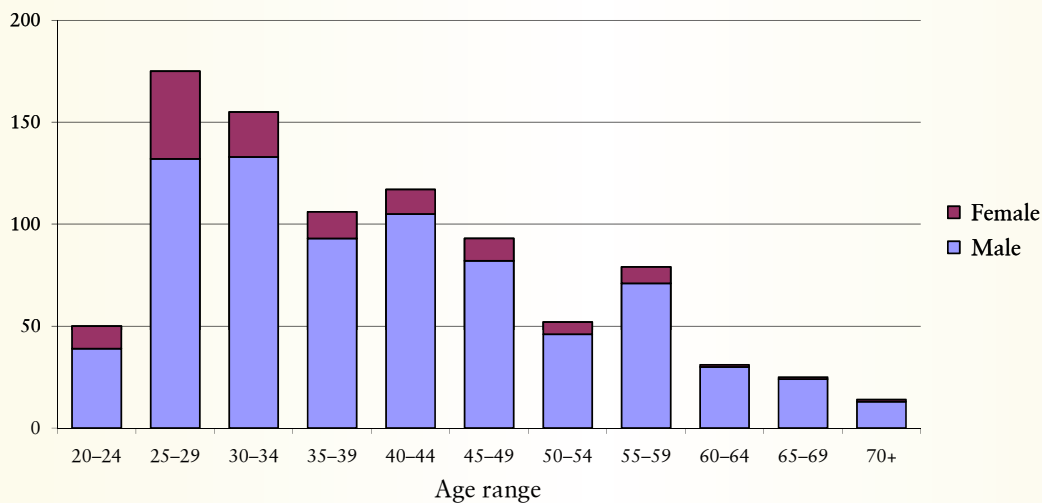
The following chart summarises the total participation figures since the Institute began:



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

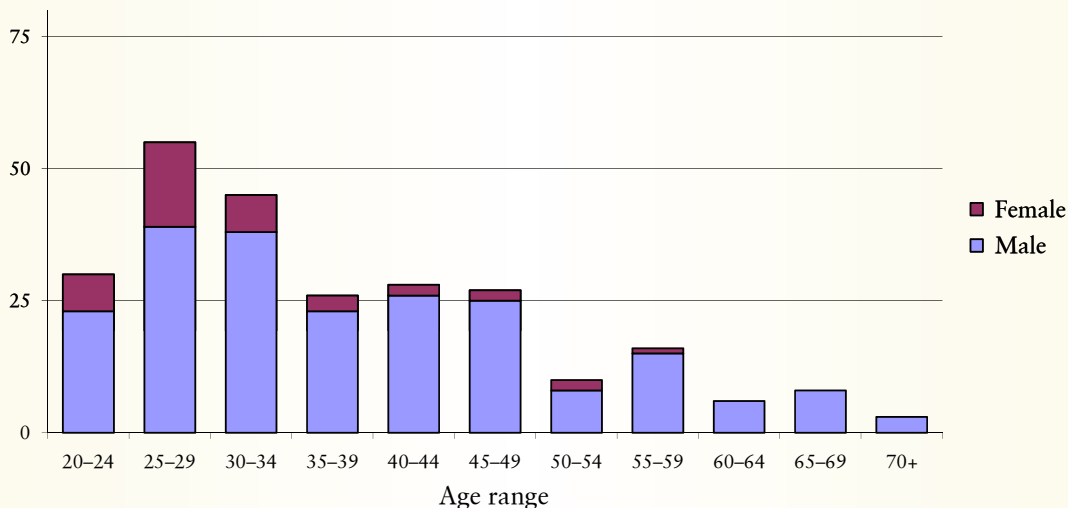


The numbers of all Visiting Fellows, Programme Participants *and* Workshop Participants combined in 2009/10 are shown below, by age and gender:

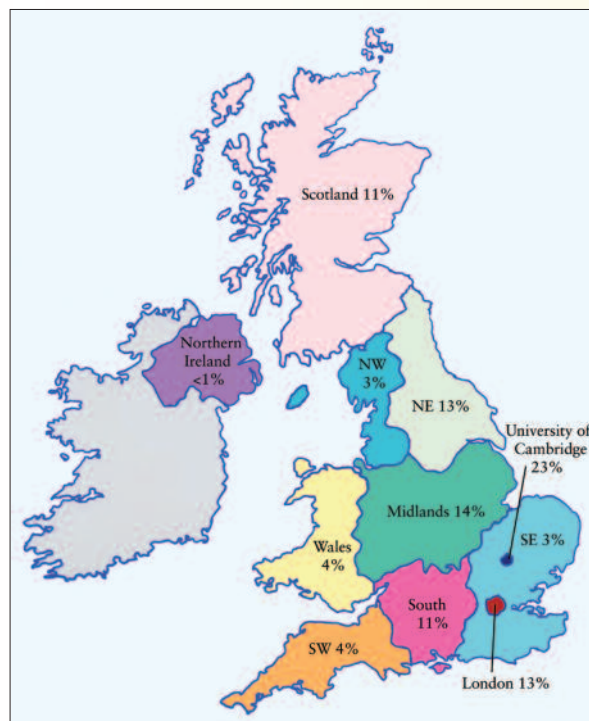
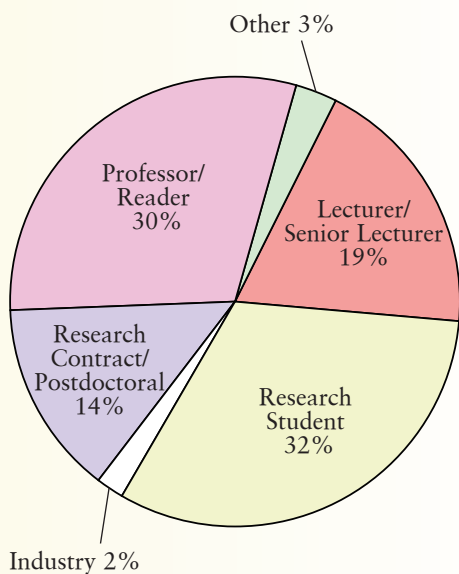


The statistics presented on this page relate only to visitors whose home institutions are in the UK: overseas visitors have been excluded.

The age range and gender balance of all Visiting Fellows, Programme Participants and Workshop Participants from UK institutions in 2009/10 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 2009/10:



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/0910/appendices.html](http://www.newton.ac.uk/reports/0910/appendices.html)

## Finances

### *Accounts for August 2009 to July 2010 (Institute Year 18)*

	2008/09 Year 17 £'000	2009/10 Year 18 £'000
<b>Income</b>		
Grant Income – Revenue <sup>1</sup>	1,310	1,289
Grant Income – Workshop	182	111
Grant from the University of Cambridge	77	68
NM Rothschild and Sons Trust Funds <sup>2</sup>	128	117
Investment Income <sup>3</sup>	141	135
Donations, Reimbursements and Other Income <sup>4</sup>	47	42
Net FEC contribution from Estates and Indirect Costs <sup>5</sup>	137	106
<b>Total Income</b>	<b>2,022</b>	<b>1,868</b>
<b>Expenditure</b>		
Scientific Salaries <sup>6</sup>	443	253
Scientific Travel and Subsistence <sup>7</sup>	525	605
Scientific Workshop Expenditure	331	246
Other Scientific Costs <sup>8</sup>	36	42
Staff Costs	417	499
Net Housing Costs <sup>9</sup>	71	40
Computing Cost	54	130
Library Costs	7	5
Building – Repair and Maintenance	9	12
Non-FEC Estates and Indirect Costs <sup>5</sup>	19	16
Consumables	19	36
Equipment – Capital	4	2
Equipment – Repair and Maintenance	2	2
Publicity	2	5
Recruitment Costs	3	1
<b>Total Expenditure</b>	<b>1,942</b>	<b>1,894</b>
<b>Surplus / (Deficit)</b>	<b>80</b>	<b>(26)</b>

## Notes to the Accounts

<b>1. Grant Income – Revenue.</b>	<b>2008/09</b>	<b>2009/10</b>
The income breaks down as follows:	<b>Year 17</b>	<b>Year 18</b>
	<b>£'000</b>	<b>£'000</b>
EPSRC Salaries	510	341
EPSRC Travel and Subsistence	441	497
EPSRC Workshop income	163	157
EPSRC other costs	18	120
STFC	0	30
Microsoft Research Cambridge	18	0
Leverhulme Trust	80	81
PF Charitable Trust	53	37
London Mathematical Society	25	24
Cambridge Philosophical Society	2	2
<b>Total</b>	<b>1,310</b>	<b>1,289</b>

**2. NM Rothschild and Sons Trust Funds.** The amounts received break down as follows:

Rothschild Visiting Professorships (drawdown)	30	19
Rothschild Mathematical Sciences (income)	98	98
<b>Total</b>	<b>128</b>	<b>117</b>

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

**3. Investment Income.** Income received from the Newton Trust Fund, the Anonymous Donation Endowment, Reprovision moneys and deposits.

**4. Donations, Reimbursements and Other Income.** A total of £160k received via the Cambridge University Development Office (CUDO) was capitalised and is not included in this figure. Sponsorship was received from Adrian Weller, Howard Covington, DFG Bielefeld, RCUK, and the Science Museum. This figure also includes net income received from publications and sale of merchandise.

**5. Estates and Indirect Costs.** The figure for expenditure was calculated under the University's standard costing methodology for activity not included under Full Economic Costs (FEC). The figure for income reflects grants made under FEC.

**6. Scientific Salaries.** This includes stipends paid to EPSRC Fellows, Rothschild Visiting Professors, the Director and the Deputy Director.

**7. Scientific Travel and Subsistence.** Expenditure incurred by programme visitors including junior members.

**8. Other Scientific Costs.** These costs relate to the *Imaginary* Exhibition and *Open for Business* activities as well as the 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. The figure also includes City fundraising dinners which are funded from CUDO receipts.

**9. Net Housing Costs.**

Income	399	385
Expenditure	470	425
<b>Total</b>	<b>(71)</b>	<b>(40)</b>

## *Grants and Donations August 2009 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, Le Centre Nationale de la Recherche Scientifique, 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: the Biotechnology and Biological Sciences Research Council, the David Harding Foundation, Deutsche Bank, Deutsche Forschungsgemeinschaft, GLC Charitable Trust (with special thanks to Lawrence and Rosemary Staden), the Medical Research Council, Microsoft Research Cambridge, the National Environmental Research Council, the National Science Foundation (USA), Research Councils UK, Schlumberger Limited, the Science Museum and the Science and Technology Facilities Council.

Individuals gave generously in support of our activities: Dr Iain Bratchie, Geoff Chapman, Richard Clarke, Howard & Veronika Covington, Professor Thomas W Cusick, Gilbert Dunlop, Mrs Ann and the late Professor Roy Garstang, Patrick Hawke-Smith, Dr Jonathan Hodgson, Peter Kiernan, Professor Armando Majorana, the late David Malcolm and his family, Duncan McInnes, Steve Mobbs, Andrew Nason, Andrew Parry, Richard Saldanha, Ian Simm, Hitesh Thackrar, David & Elizabeth Wallace, Adrian Weller, Michael Wilson as well as donations from individuals who prefer to remain anonymous.

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

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

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Front cover: *Still Life: 5 Glass Surfaces on a Tabletop*. One of the wonderful visualisations taken from algebraic geometry which was part of a special exhibition entitled *IMAGINARY: Through The Eyes of Mathematics*. This travelling exhibition was created by Mathematisches Forschungsinstitut Oberwolfach and it visited the Institute in March 2010. (Image courtesy of Richard Palais and Luc Benard)

Editor: Dr Ben Mestel

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