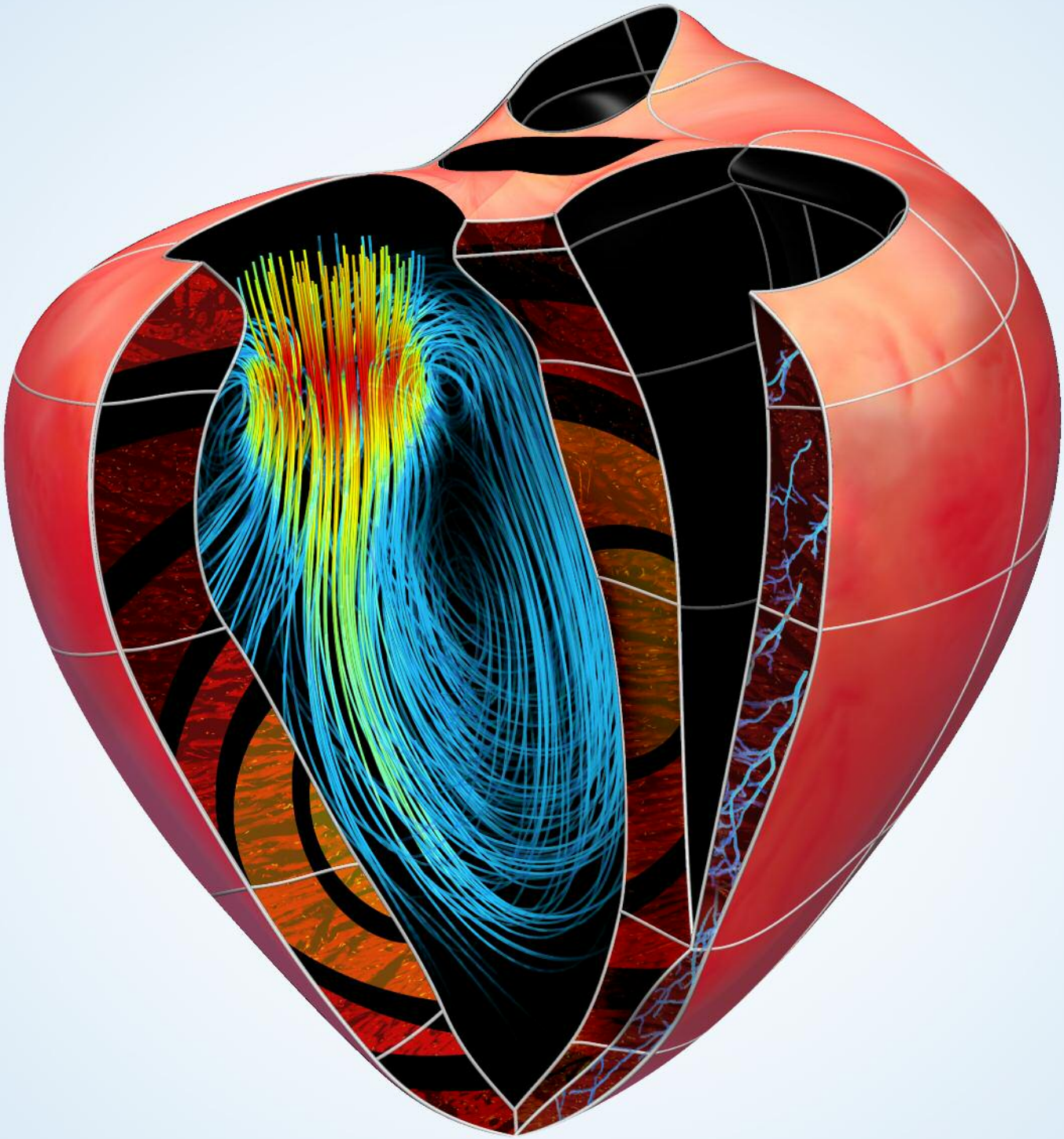
Isaac Newton Institute for Mathematical Sciences

Annual Report 2008–2009



UNIVERSITY OF CAMBRIDGE

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Please note that the following statistical information may be obtained from the Institute on request, or from **www.newton.ac.uk/reports/0809/appendices.html**

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Director's Foreword

David Wallace
Director of the Institute

I am pleased to report that the Governance arrangements put in place last year are working well. The Management Committee is, for the first time, chaired by someone external to the University of Cambridge, and I am very grateful to Howard Covington for taking on this role.

External representation on the Management Committee has been strengthened further with the co-option of the Chair of Correspondents. After consultation with the national network of more than 80 Institute Correspondents, names were forwarded to the five Learned Societies forming the Council for the Mathematical Sciences, who selected Caroline Series for this role. Working with Ben Mestel, the Deputy Director, Caroline has transformed the role of the Correspondents. For example, the Annual meeting this year had a most stimulating and helpful discussion on a ten-year vision for the Institute, which is now being further developed.

There are again three sections in 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 (SSC); Caroline Series for Institute Correspondents; and Howard Covington for the Management Committee (MC).

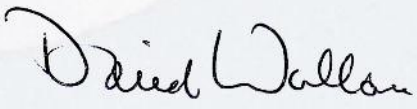
Scientific activities centred around the six main programmes this year: *Mathematics and Physics of Anderson Localisation*; *Design of Experiments*; *The Nature of High Reynolds Number Turbulence*; *Algebraic Lie Theory*; *Discrete Integrable Systems*; and *The Cardiac Physiome Project*. Twenty three workshops were held in conjunction with these programmes, including five satellite meetings, in Glasgow (2), Gregynog, Leeds and Warwick, and an additional workshop in collaboration with the International Union of Theoretical and Applied Mechanics (IUTAM). The Institute also hosted the Institute of Mathematics and its Applications (IMA) Conference on *Dense Granular Flows*, as a follow-up to the 2003 Institute programme on *Particle and Granular-laden Flows*.

During the year, 794 seminars were given, and videos of most are available on the Institute web archive. Highlights included successive seminars by Nobel Laureate Gerard 't Hooft, and Fields Medallist Serguei Novikov in a workshop on *Quantum Discrete Integrable Systems*. A remarkable workshop to celebrate the award of the Abel Prize to John Thompson saw participation by two other Fields Medallists, Jean-Pierre Serre and Laurent Lafforgue (Rothschild Visiting Professor); Thompson and Serre are unique in holding Abel, Fields and Wolf Prizes.

The Institute has also supported a number of other short meetings. The *Open for Business* series, designed to enable senior people from business and industry to engage with the Institute, continued with two meetings, on *Turbulence*, and on *Quantitative Finance*. In a new development, a two-day meeting at Reading to scope a possible proposal to the Institute on *Adaptive Mesh Modelling of the Atmosphere and Ocean* attracted some 80 climate scientists and applied mathematicians.

We report also on the exciting development of the network of friends of the Institute in the City, through dinners hosted by Howard and Veronika Covington in their London home.

Staff have again performed superbly in what has been an extremely busy year. My sincere thanks to them, and to all who, with them, make the Institute such a special place to work: participants, programme organisers, and all involved in overseeing our activities.



Science at the Institute

SJ Wilkinson

John Ball,
Chair of the Scientific Steering Committee

This has been another busy year for the SSC. Six programme proposals were considered in our October meeting and seven in May; two proposals were approved, and six carried forward for resubmission in October 2009.

The table of future programmes is shown opposite. It is very healthy in terms of commitment; a minimum of 18 months' lead time is needed in organising the longer programmes but we must be careful not to over-commit into the future. A second characteristic is the range of both pure mathematics and applications. We are again indebted to referees, who provided us with more than 80 reports in the course of the year, but a significant onus remains on members of the Committee.

It is vital that SSC has a good balance of experienced members and we are very grateful to the Learned Societies and other organisations for their suggestions. In order to give more attention to these suggestions and other possible names, a Nominating Committee has been established. It is chaired by the Chair of SSC with two members appropriate to the vacancies to be filled (Elmer Rees and David Harman in 2007 and Caroline Series and Peter Green in 2008), and is served by the Director. It is a helpful step in strengthening SSC for the future.

My thanks go to Peter Coveney and Caroline Series for their contributions as members, and I am very pleased that David Preiss and Marie-Francoise Roy agreed to join the Committee from 1 January 2009.

Scientific Steering Committee

Membership of the Scientific Steering Committee at 31 July 2009 was as follows:

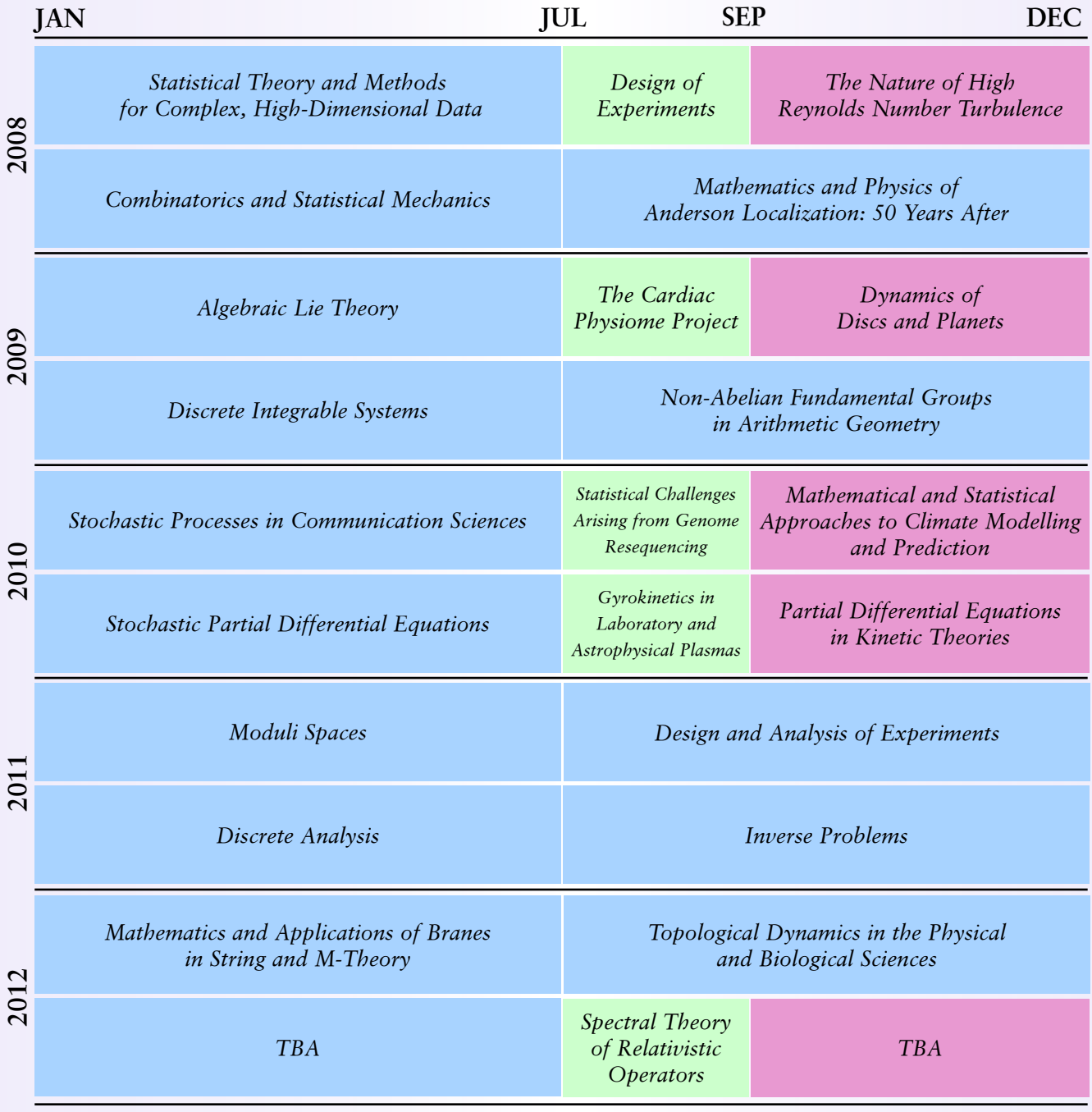
Sir John Ball FRS FRSE (Chair)	University of Oxford
Professor KG Binmore CBE FBA	University College London
Professor M Broué	Institut Henri Poincaré
Professor EK Burke	University of Nottingham
Professor DR Fearn FRSE	University of Glasgow
Professor CS Frenk FRS	University of Durham
Professor É Ghys	École Normale Supérieure de Lyon
Professor PJ Green FRS	University of Bristol
Professor D Preiss FRS	University of Warwick
Professor SR Reid FREng	University of Aberdeen
Professor M-F Roy FREng	Institute of Mathematical Research of Rennes
Professor JF Toland FRS FRSE (*ex-officio*)	University of Bath; ICMS
Professor LN Trefethen FRS	University of Oxford
Professor M Vingron	Max Planck Institute for Molecular Genetics
Sir David Wallace CBE FRS FREng (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**

Future Programmes

The schematic below shows the 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** is emailed in advance to assist us with planning; see page 20 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/** Further information on how to participate in programmes can also be found on the website at **www.newton.ac.uk/participation.html**



Mathematics and Physics of Anderson Localization: 50 Years After

14 July to 19 December 2008

Report from the Organisers:
YV Fyodorov (Nottingham), I Goldsheid (Queen Mary), T Spencer (IAS) and MR Zirnbauer (Institut für Theoretische Physik, Köln)

SGJ Penton

T Spencer, I Goldsheid, YV Fyodorov and MR Zirnbauer

Scientific Background

In his seminal 1958 paper *Absence of diffusion in certain random lattices*, Philip W Anderson discovered one of the most striking quantum interference phenomena: particle localization due to disorder. Cited for the1977 Nobel prize in physics, that paper was fundamental for many subsequent developments in condensed matter theory.

The goal of the programme was to bring together the world leaders in the spectral theory of random Schrödinger operators and theoretical physicists working on Anderson localization, and, thereby to bridge the language gap between the communities and to create an environment conducive to fruitful collaboration between physicists and mathematicians.

Programme Structure

The programme activities were organised around four workshops (three at the Newton Institute, and a satellite meeting at Gregynog Hall, University of Wales). The programme was attended by around 100 Visiting Fellows and Programme Participants. Professors P Anderson, J Fröhlich (Rothschild Visiting Professor), D Thouless, and F Wegner (Microsoft Research Fellow) were among our most distinguished participants. Between the workshops, a seminar schedule of typically two to three seminars per week was run, with the majority of participants presenting their research in that framework. Many participants of the programme used the opportunity to travel round the UK and gave talks at other British Universities including Birmingham, Bristol, Brunel, Edinburgh, Imperial, Lancaster, Manchester, Nottingham, Oxford, UCL, and Warwick, and also Cambridge itself. We also organised joint seminars with the programme on *High Reynolds Number Turbulence*. Those meetings were extremely useful in exposing non-specialists to the present state of research and to outstanding issues in both fields, and for identifying both similarities and differences in questions asked and methods used.

Workshops

Anderson Localization Transition

Workshop, 14–25 July 2008

Organiser: MR Zirnbauer

This training course attracted 61 participants and was mainly directed at early career researchers (typically at postdoctoral level), but a several more mature colleagues, interested to learn more on topics related to Anderson localization, were also present. The audience represented a mixture of mathematicians and mathematical and theoretical physicists. The main goal of the workshop was to introduce the subject by exposing participants to ideas, terminology and analytical techniques both

rigorous and heuristic. Approaches to the study of Anderson localization by mathematicians and by theoretical physicists were reviewed by experts from both communities.

The list of topics covered included: phenomenology of Anderson localization (T Spencer); introduction to supermatrix techniques and the nonlinear σ-model (YV Fyodorov); introduction to the spectral theory of random Schrödinger operators (L Pastur); rigorous techniques for 1D and quasi 1D systems (I Goldsheid); rigorous methods in the statistical mechanics of phase transitions (D Brydges); critical phenomena in two-dimensional disordered systems (A Ludwig). In addition to the scheduled lectures, some of the younger participants were able to present their recent research.

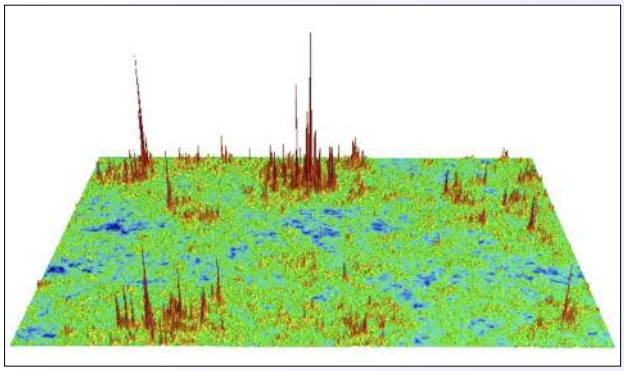
Anderson Localization and Related Phenomena

Workshop, 18–22 August 2008

Organisers: YV Fyodorov, I Goldsheid, T Spencer, MR Zirnbauer

This one-week workshop attracted 60 participants and brought together mathematicians and theoretical physicists who are leaders in mathematical and physical aspects of the theory of random Schrödinger operators, Anderson localization phenomena, and related topics. Presentations were selected to review the current state of the field in the theoretical and mathematical physics communities.

Among the topics that were addressed during the workshop were: the nature of critical phenomena associated with localization-delocalization transitions; the existence and statistical properties of extended states for $D > 2$ and the behaviour in the critical dimension $D = 2$; supersymmetric methods and nonlinear σ-model techniques; the localization-delocalization phenomena associated with the Integer Quantum Hall Effect, including new materials like graphene; localization in the presence of a random magnetic field; asymptotic behaviour of products of random matrices and associated Lyapunov exponents; spectra, localization and delocalization in disordered systems described by non-selfadjoint operators; localization in systems with nonlinearities; and localization-delocalization phenomena in disordered systems of interacting quantum particles.



F Evers, A Mildenberger, and A Mirlin

Intensity profile of a multifractal wave function at the critical point of Quantum Hall-type transition. The intensity in green areas is typical, in blue areas is anomalously low, and in brown areas is anomalously high.

Delocalization Transitions and Multifractality

Workshop, 2–6 November 2008

Organisers: F Evers, YV Fyodorov

As is well known, by changing the disorder potential in a single-particle quantum Hamiltonian, one may induce a transition from localized to extended eigenstates (the Anderson delocalization transition). Precisely at the point of the transition one expects a highly non-trivial intensity pattern reflecting intriguing "multifractal" properties of the critical eigenstates (see figure above). This picture extends to a broader class of quantum systems, including, most prominently, those exhibiting Quantum Hall-type transitions. It also has interesting counterparts beyond quantum mechanics in other disorder-induced critical phenomena.

In recent years considerable effort has been invested in performing large-scale numerical simulations of systems of that kind. This has allowed both the testing of highly non-trivial analytical predictions for various critical statistics, and has provided additional insights and the background for further theoretical understanding. The four-day workshop, co-organised with the Karlsruhe Institute of Technology, Germany, brought together researchers on Anderson delocalization transitions, with emphasis on multifractality and its implications. The talks reviewed the state of the art in both numerical and analytical communities, discussed conceptual as well as technical difficulties, and mapped new directions of research. In addition, a few, more mathematical talks discussed multifractal measures and other probabilistic questions in disordered systems.

Classical and Quantum Transport in the Presence of Disorder

Workshop, 15–19 December 2008

Organisers: YV Fyodorov, I Goldsheid, T Spencer MR Zirnbauer

54 participants attended the concluding workshop of the programme. In addition to describing recent results in quantum localization, the workshop explored some emerging connections between classical and quantum transport. The topics included quantum localization and diffusion, random walks in a random environment, quantum chaos and resonances, and the effects of non-linearity on wave propagation.

Outcomes and achievements

The scope of the problems addressed during the programme not only covered diverse aspects of Anderson localization, but frequently touched on a much broader range of topics in the theory of disordered systems and related fields (e.g. the theory of random matrices). Among the many contributions, we would like to highlight, in particular, the following two:

The work by M Disertori, T Spencer, and MR Zirnbauer, who rigorously analysed a super-symmetric hyperbolic σ-model believed to contain most of the essential features of the Anderson localization phenomenon. In particular, in that framework they proved the existence of a kind of quasi-diffusion in $D = 3$ spatial dimensions. This model is equivalent to a random walk in a highly correlated random environment. These results were presented at an invited talk at the International Congress of Mathematical Physics (Prague, August 2009).

The work by V Chulaevsky and Yu Suhov on multi-particle localization theory presents the first steps towards extending standard mathematical methods to the case of interacting particles. Remarkably, the cumbersome original proofs were considerably simplified and generalised by incorporating ideas and heuristic insights provided by the fellow physicists present on the programme (mainly, B Shapiro).

Of the many other interesting results obtained by Visiting Fellows we would like to mention the works on level repulsion of Wigner matrices (L Erdos, B Schlein, and H-T Yau); on fractal superconductivity close to the delocalization transition (M Feigelman and V Kravtsov); on pre-freezing transition in disorder-induced multi-fractal exponents (Y Fyodorov); on the effects of nonlinearity in 1D random systems (S Fishman); on a new approach to constructive control of Lyapunov exponents (I Goldsheid); on ballistic transport in disordered graphene (A Mirlin and P Ostrovsky); on localization in quantum graphs (S Molchanov); on quantum transport in chaotic cavities (D Savin and B Khoruzhenko); on eigen-vector localization for random band matrices with power law band width (J Schenker); on the capacitance of quasi one-dimensional wires (M Skvortsov and MR Zirnbauer); on colour-flavour transformations and characteristic poly-nomials of real random matrices (Y Wei and B Khoruzhenko); and on the mean density of complex eigenvalues for an ensemble of random matrices with prescribed singular values (Y Wei and YV Fyodorov).

In addition to papers arising from the above, V Chulaevsky and Yu Suhov are working at present on the book *Multi-Particle Multiscale Analysis* to be published by Birkhäuser in 2010. L Pastur and M Shcherbina will publish a book *Eigenvalue Distribution of Random Matrices* (American Mathematical Society), considerable parts of which were written during the programme.

In conclusion, we would like to mention that the main challenge to the coherence of the programme was the diversity of the participants' backgrounds. Judging by participants' responses, the programme indeed succeeded in engaging physicists and mathematicians in a constructive dialogue, with mathematicians particularly appreciative of the opportunities to learn from the physical ideas and heuristic arguments of their physicist colleagues.

Design of Experiments

21 July to 15 August 2008

Report from the Organisers:
RA Bailey (Queen Mary, London), B Bogacka (Queen Mary, London), H Großmann (Queen Mary, London) and D Woods (Southampton)

SGJ Penton

D Woods, B Bogacka, RA Bailey and H Großmann

Background

Both the theory and practice of experimental design have fragmented over the last fifty years. In fact, the design of experiments has been so successful in many areas of application that there are now separate traditions in different applications, such as biology, agriculture, engineering, psychology, and clinical trials. For example, the recent rapid development of microarray experiments in genomics not only poses its own peculiar problems but has often ignored the knowledge base in design of experiments. There was therefore an urgent need for cross-fertilization between the different application areas.

The aim of the programme was thus to synthesize different approaches to the design of experiments, so that people in each area could incorporate what is best from other areas. The programme focussed on three methodological topics and three application areas. The chosen topics were where progress could be made in a short time, bringing together different approaches to tackle some specific problems, both applied and theoretical. The methodological topics were multistratum experiments, multi-tiered experiments, and the design of experiments for non-linear models. Each is already used in several application areas, but often with different vocabulary. The idea was to get together statisticians from the different areas so that they could pool expertise. Because the underlying methodology is the same, it would be possible to learn from one another, incorporate the best from each area and produce a more unified theory.

The chosen application areas were genomics, computer experiments and clinical trials. Each of these is currently lively, and has interesting problems to be brought to the attention of a wider audience of design researchers. The aim was to make substantial progress simply by getting the application people together with the design people. Not only would specialist design knowledge be used to improve the design of experiments in the application area; particular expertise from the application area might turn out to be useful in the design of experiments in other areas.

Programme Structure

The programme opened with a workshop on Advanced Topics in Design of Experiments, 21–25 July 2008. This had three goals. The first was to introduce researchers in different parts of the design of experiments to parts of the subject outside their own speciality. Three short courses were given: *Multistratum Experiments*, *Optimal Design for Linear and Non-linear Models* and *Multi-tiered Experiments*. The second goal was to introduce three specific application areas where good design is needed. A theme day was devoted to each of *Experiments in Genomics and Proteomics*, *Computer Experiments* and *Clinical Trials*, with both statisticians and scientists explaining the topic. The third goal was to introduce students and other interested people to the subject. This workshop

was attended by 29 invited participants and 10 other researchers.

The middle two weeks had no timetabled activities in order to allow participants to work intensively together, to develop what they had learnt from the first week as well as to continue existing research projects. There were 26 invited participants during this phase.

The final week of the programme was devoted to the workshop *Designed Experiments: Recent Advances in Methods and Applications (DEMA2008)*, 11– 15 August 2008. This was the successor to the DEMA conference which was held in Southampton in 2006. There were plenary talks on randomisation and on design of two-phase experiments; theme days on genomics and proteomics, clinical trials, and computer experiments; and sessions on multistratum experiments, design for correlated data, block designs, designs for non-linear models, and design construction and optimality. There were also two poster sessions, each preceded by a much-appreciated "poster storm". The workshop was attended by 41 invited participants and 64 other researchers. Participants came from the pharmaceutical industry, software houses, engineering companies, an oceanography centre and medical research establishments, as well as mathematics and statistics departments.

Since RA Fisher, one of the pioneers of design of experiments, was a Fellow of Gonville and Caius College, Cambridge, AFW Edwards kindly entertained participants at Caius one evening, showing them the portrait of Fisher and the stained glass window of the Latin square on the cover of Fisher's book *The Design of Experiments*.

Outcomes and Achievements

The short courses in the first week were pitched at just the right level for the audience to engage with the material: this was as true for experts from other specialities as it was for PhD students. Probing questions from people in different areas provoked useful discussion right from the start. The input from the three application areas enabled participants "to focus on the right design problems" (Bogacka). The statisticians working in these areas attended throughout and "found the whole week extremely valuable" (Speed). Many conversations in the middle two weeks were sparked off by this introductory material, and it was clear that participants were seeking information from each other as well as from "the excellent library" (Kunert). Several multi-hour round-table discussions were held with a dozen participants, of whom half shared expertise while the other half learnt. Small tutorials seemed to be in progress all the time. Morgan's comment is typical: "I have made definitive progress on several problems, learned the fundamentals of several design areas in which my knowledge was sorely lacking, and laid the groundwork for future working relationships."

Some of the research achieved during the programme was already underway, and simply needed the calm and supportive environment of the Newton Institute for its completion. Most participants learnt about new areas, and started new work. The talks by Bailey, Bogacka, Challenor, Gilmour, Kunert and Morgan (at least) in DEMA2008 were based on work done during the programme. Most exciting was the fact that over thirty new collaborations were begun.

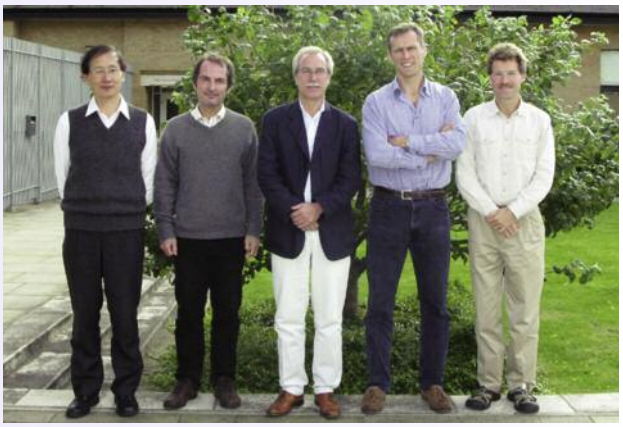
As Gilmour commented: "I am leaving the INI with considerably more unfinished work than I arrived with. I regard this as a sign of a very successful programme." DEMA2008 was "one of the most successful conferences on design of experiments that I had ever attended" (Cheng) and "probably the best organised conference I have attended" (Godolphin). Much useful interaction took place between the workshop participants and the long-term participants. The geophysics group working with A Curtis made contact with mainstream design of experiments. K Baggerly, RA Bailey, SG Gilmour, K Kerr, V Lima-Passos, A Lynch and B Parker discussed the design of experiments in genomics, and have already collaborated on two experiments. As the result of the talks they gave, RA Bailey, TP Speed and C Vivacqua are advising the US National Institutes of Health on a large experiment on the collection and storage of blood. Another outcome was that AC Atkinson organised a session at the 2009 Joint Statistical Meetings in Washington DC with D Woods and B Bogacka as invited speakers. It is likely that most of the research continued or initiated during the programme will lead to publications.

The Nature of High Reynolds Number Turbulence

26 August to 19 December 2008

Report from the Organisers:
P Bartello (McGill), PA Davidson (Cambridge), D Dritschel (St Andrews), Y Kaneda (Nagoya) and R Kerswell (Bristol)

SGJ Penton



Y Kaneda, P Bartello, PA Davidson, R Kerswell and D Dritschel

Scientific Background

Turbulence holds a unique place in the field of classical mechanics. Although the governing equations have been known since 1845, there is still surprisingly little we can predict with certainty. Yet turbulence is of immense importance in engineering, geophysics and astrophysics. It controls the drag on cars, aeroplanes and bridges, and dictates the weather through its influence on large-scale atmospheric and oceanic flows. The liquid core of the earth is turbulent and it is this which maintains the terrestrial magnetic field against the natural forces of decay. Solar flares are a manifestation of turbulence, being triggered by the vigorous motion on the surface of the sun. Physically, turbulence may be regarded as an evolving spatially complex velocity field, containing a very wide range of scales, and chaotic in both space and time. Despite this complexity, turbulence exhibits many near-universal features, particularly at high Reynolds numbers. Near boundaries, for example, the distribution of the mean component of velocity, as well as the fluctuating components of motion, are found to have a near-universal statistical form, being the same on an aircraft wing, in a pipe, or in the atmospheric boundary layer.

Away from boundaries, the way in which energy is distributed among the eddies of different scales is also found to be nearly universal, following (at least approximately) laws proposed by Kolmogorov. Universality is also observed in turbulence subject to a strong background rotation or stratification, and such turbulence is of crucial importance in geophysics and meteorology. Even in magneto-hydrodynamic (MHD) turbulence, so ubiquitous in astrophysics, there are many universal characteristics, the most striking of which is its streaky pattern aligned with the mean magnetic field. Some of this universality was anticipated by the pioneers of the subject, such as Richardson, Prandtl and Kolmogorov, and the theories they developed are still highly influential in our thinking. Although, for a long time turbulence was regarded as a largely unsolved problem, in recent years there has been some room for cautious optimism.

This programme attracted theoreticians and experimentalists from a wide range of backgrounds, including engineering, mathematics, geophysics, meteorology, solar physics and astrophysics, thereby achieving our goal to bring together the world's leading experts to debate the fundamental nature of turbulence, ranging from how it is initially triggered through to its asymptotic state at high Reynolds number.

Programme Structure

Around 240 mathematicians and scientists from 16 countries participated in the programme, including 48 long-stay Visiting Fellows and 41 Programme Participants who stayed for several weeks. There were four workshops, two one-day meetings and an *Open for Business* day.

KR Sreenivasan was the Rothschild Visiting Professor, whose lecture on super-fluid turbulence stretched the capacity of the Institute's largest lecture theatre.

Workshops and Themed Days

Wall Bounded Shear Flows: Transition and Turbulence

Workshop, 8–12 September 2008

Organisers: PA Davidson, RR Kerswell, H Nagib, T Nickels, KR Sreenivasan

This workshop was attended by 95 participants. It brought together experimentalists and theorists interested in high Reynolds (Re) number boundary layers with those working at transitional and low (weakly turbulent) Reynolds numbers in sheared systems. Special efforts were made to introduce and orientate one community to the issues and recent successes of the other through two introductory lectures given on the first day. The participants were roughly split evenly between the two communities and the 60 research talks arranged loosely in themes and interwoven to emphasize the synergies between the communities. Subjects discussed at the workshop included dynamical-system approaches to shear flows, numerical and experimental investigations of the spatiotemporal dynamics of transitional and fully-developed flows (especially the role of coherent structures), near-wall and outer scale interactions, scaling and universality.

Prospects of High Performance Computing in Turbulence Research

Workshop, 26 September 2008

Organiser: Y Kaneda

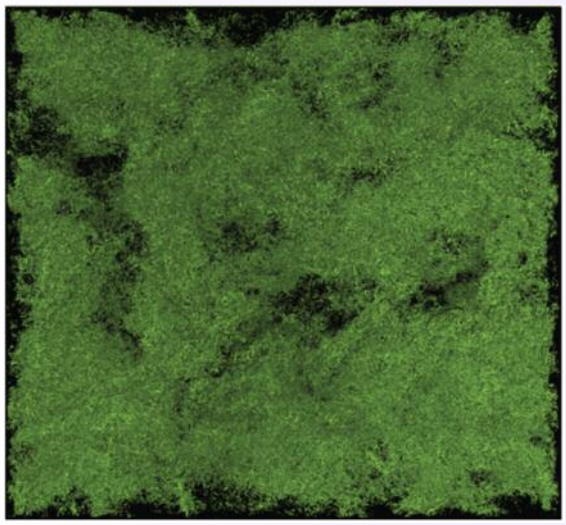
The one-day meeting was attended by 47 participants and promoted the best use of the unprecedented development in computer power, to improve our understanding of the nature of high Reynolds number turbulence. The meeting consisted of four 45-minute invited lectures by leading experts: M Yokokawa and T Zachariah in computer science, and J Jimenez and PK Yeung in turbulence research. There followed an animated discussion session on the future prospects and role of high performance computing in turbulence research.

Inertial-Range Dynamics and Mixing

Workshop, 29 September – 3 October 2008

Organisers: PA Davidson, Y Kaneda & KR Sreenivasan

This workshop brought together researchers in theory, modelling, numerical simulations, laboratory experiments and field-observations communities to discuss and exchange new ideas on fundamental questions of turbulence related to inertial-range dynamics and mixing. The workshop focus was on the near-universal physics of such phenomena as observed in canonical turbulent flows at high Reynolds number. The workshop attracted 105 researchers from 15 countries, of whom 39 were from the UK. The workshop consisted of 56 talks and 12 poster presentations. These presentations covered a wide range of problems of turbulent flows from the quantum to the cosmological scale. Attention focussed on the geometrical structure of turbulence, the energy cascade and dissipation in classical and super-fluid turbulence, the origin and growth of singularities, Lagrangian dynamics and scaling, and scaling in atmospheric turbulence.



T Ishihara and Y Kaneda

The small scale structure of turbulence as computed on the Earth Simulator in Japan

Euler at Newton: The Inviscid Equation

31 October 2008

Organisers: J Gibbon, R Kerr & RR Kerswell

The aim of this one-day meeting, which was attended by 43 participants, was to assess scientific progress one year on from the IUTAM Symposium 'Euler250' which marked the 250th anniversary of the publication of Euler's equations. The meeting consisted of five invited one-hour talks given by M Brachet, P Constantin, K Ohkitani, P Orlandi and A Pouquet which concentrated on detailing recent analytical and numerical advances in understanding how solutions of the (inviscid) Euler equations are related to those of the (viscous) Navier-Stokes equations and, ultimately, turbulence.

Structures and Waves in Anisotropic Turbulence

A Satellite Meeting at the University of Warwick, 3–7 November 2008

Organisers: S Nazarenko, C Connaughton, P Bartello, PA Davidson, A Schekochihin

This workshop was a Newton Institute Satellite Meeting and also a follow-up to the activities of the Warwick Turbulence Symposium. The workshop focussed on fundamental effects in turbulence arising from the presence of waves or structures in anisotropic media.Turbulence anisotropy may be caused by an externally applied magnetic field (plasma and MHD systems), or by rotation and stratification. The talks covered a range of applications, from astrophysical to geophysical to laboratory systems, with the main emphasis on finding common features in these different flows, as well as identifying their fundamental differences.

Turbulence in Fluids

Open for Business Day, 17 November 2008

Organisers: DG Wallace, RA Leese, PA Davidson

This meeting attracted 17 leading people from industry, government agencies and finance. After a key-note talk by KR Sreenivasan (Director, ICTP, Trieste), there was a wide-ranging discussion coordinated by a panel of experts, which included Lord Hunt (UCL), TA Hutton (Airbus), T Palmer (ECMWF), and A Purnell (FIA). The discussion centred on the importance of turbulence for the wider community, including commerce and government agencies.

Rotating Stratified Turbulence and Turbulence in the Atmosphere and Oceans

Workshop, 8–12 December 2008

Organisers: D Dritschel, P Bartello, P Davidson, R Griffiths, HK Moffatt, J Sommeria, K Winters, S Yoden

This workshop/symposium, jointly supported by the IUTAM, attracted 86 participants. It focussed on the fundamental structure of atmospheric, oceanic and planetary circulations, and in particular on the way in which small-scale turbulence collectively organises such flows on large scales. Themes included the emergence of 'jets' or currents and 'eddies' or spinning coherent masses of fluid (vortices), the 'equilibration' of turbulence through the saturation of fluid dynamical instabilities, possible routes to turbulence via natural instability processes, the effect of rotation and stratification on scale cascades, gravity-wave emission in turbulent flows, 'balance' or the proximity of geophysical flows to a gravity-wave-free state, state-of-the-art numerical methods for the simulation of turbulent geophysical flows, statistical properties of turbulent mixing and the role of mixing in the formation of coherent vortices, and the energetics of ocean dynamics, as well as turbulence in magnetised fluids. Speakers included world-leading experts and altogether there were 60 presentations (40 talks and 20 posters).

Outcome and Achievements

The four workshops were an important part of our programme and they allowed leading researchers to exchange ideas and younger people to meet older, established figures. Two workshops brought together quite different communities. In the first workshop, researchers in transition and dynamical systems mixed with the high-Reynolds number turbulence community, while the third workshop had equal numbers of participants from astrophysics and geophysics. In both cases the result was a spectacular success, with the different communities interacting in a lively fashion. The INI/IUTAM workshop was the first major international conference devoted specifically to the nature and role of turbulence in geophysical (atmospheric and oceanic) flows. The workshop highlighted the importance of ageostrophic fronts at the surface of the ocean for coastal circulations, the dominant role played by coherent structures and their interactions, and highly-anisotropic behaviour resulting from stratification and rotation, effects not present in classical homogeneous turbulence.

Three books inspired by the programme will be published by Cambridge University Press: *The Nature of Turbulence* edited by PA Davidson, Y Kaneda and KR Sreenivasan, *Geophysical and Astrophysical Turbulence* by PA Davidson and JJ Riley, and *Twelve Chapters in the History of Turbulence* edited by PA Davidson, Y Kaneda, HK Moffatt and KR Sreenivasan. A fourth book, entitled *Turbulence in the Atmosphere and Oceans,* edited by DG Dritschel, will be published by Springer–Verlag.

Algebraic Lie Theory

12 January to 26 June 2009

Report from the Organisers:
M Geck (Aberdeen), A Kleshchev (Oregon) and G Röhrle (Ruhr-Universität Bochum)

SJ Wilkinson

M Geck, G Röhrle and A Kleshchev

Theme of the Programme

Lie theory has profound connections to many areas of pure and applied mathematics and mathematical physics. In the 1950s, the original analytic theory was extended to an algebro-geometric context so that it also makes sense over arbitrary algebraically closed fields, in particular, fields of positive characteristic: thus giving rise to "Algebraic Lie Theory". The central theme is understanding the study of fundamental objects such as finite and infinite dimensional Lie algebras, reductive groups, quantum groups and Hecke algebras of various kinds, as well as their representation theories.

A driving force has always been the abundance of challenging, yet very basic problems, such as obtaining explicit character formulae for representations. An indication of the complexity and the difficulty of the problems is that even the representations of the symmetric group (that is, the Weyl group of an algebraic group or a Lie algebra of type A) in positive characteristic are not fully understood!

The introduction of geometric methods in the 1970s revolutionised the field. It led to a flow of new ideas between several disciplines, and produced spectacular advances. Outstanding problems are understanding categories of representations (especially in positive characteristic) in geometric terms. The ideas of "geometrization" and "categorification" now play a fundamental role in the development of the subject. New structures continue to arise from connections with other areas of mathematics and mathematical physics, like the emerging theory of W-algebras.

Given the wide spectrum of background motivations, the aim of the programme was to provide a forum for the discussion, the interaction and the further development of the various recent methods, advances and applications of Algebraic Lie Theory.

Programme Structure

The programme intentionally involved a broad variety of research areas connected by the general theme "Algebraic Lie Theory". Apart from day-to-day informal discussions, there were regular seminars ranging from two to four talks each week (organised by P Achar).

Due to the diversity of topics, a core feature of the programme was the organisation of workshops and special lecture series with a focus on particular aspects of current research, to be detailed below.

Instructional Workshop

12–23 January 2009

Organisers: M Geck, A Kleshchev and G Röhrle

This initial, two-week long meeting attracted 71 participants, among which a large portion of early career researchers. The workshop consisted of 10 introductory mini-courses (3–5 lectures each) which were given by leading experts.

There was a mixture of classical-style lectures and informal discussions/problem sessions, which allowed for close interaction between the speakers and the participants. This workshop also formed part of the activities supported by the EPSRC network grant *Representation Theory Across The Channel* (held by M Geck and I Gordon).

Algebraic Lie Structures with Origins in Physics

Workshop, 23–27 March 2009

Organisers: P Etingof, A Kleshchev, M Nazarov and A Premet

The idea of the workshop was to bring together mathematicians and mathematical physicists working in such (overlapping) areas as W-algebras, Yangians, vertex algebras, characteristic-p Lie theory, conformal algebras, chiral algebras, quantum groups, Hecke algebras, Cherednik algebras, infinite dimensional Lie algebras, as well as related representation theory, geometry, combinatorics, and applications. The meeting provided rare and very important opportunities, especially for young researchers and the 23 invited one-hour lectures were attended by over 100 participants. A special feature of the workshop was that it was held concurrently with the *Quantum Discrete Integrable Systems* workshop run by the parallel programme in the Institute. This has increased already high "cross-pollination" opportunities. As a result, several high profile talks were extremely well attended by participants of both workshops.

Categorification and Geometrization from Representation Theory

A Satellite Meeting at the University of Glasgow, 14–17 April 2009

Organisers: K Brown, I Gordon, U Kraehmer, N Reshetikhin, R Rouquier and C Stroppel

This meeting attracted over 100 participants and was made up of two separate events: a two-day introductory workshop with three introductory mini-courses (three lectures each) and a workshop with 18 invited one-hour lectures. The idea of "categorification" goes back to Crane and Frenkel, motivated by mathematical physics, and in particular by the hope to construct higher dimensional topological quantum field theories. It is becoming increasingly clear that this notion is the connecting principle behind a number of new developments in both Lie theory and topology.

This was the first conference on "categorification" in a broad sense and brought together people from quite different areas of mathematics (representation theorists, topologists, algebraic as well as symplectic geometers, mathematical physicists), all either working on "categorification" from their own perspective, or interested to learn more about developments in this relatively new field.

Automorphic Forms and the Langlands Programme

Spitalfields Day, 13 May 2009

Throughout May, Professor Laurent Lafforgue, the Rothschild Distinguished Visiting Professor of the programme, gave a series of lectures (8 hours in total) explaining part of his research work on Langlands' functoriality principle, in which he attempts to construct explicitly kernel functions for Langlands' transfer of automorphic representations. As a complement to this high-profile lecture series, and with the help of the London Mathematical Society, we organised a Spitalfields Day with four invited one-hour lectures by internationally leading experts, centering around recent developments in the theory of automorphic forms, the Langlands Programme and related areas. A highlight was Gerard Laumon's talk about Ngo Bao-Chau's work on the so-called "Fundamental Lemma", a celebrated result in the theory of automorphic forms conjectured by Langlands, Shelstad and Waldspurger. The workshop was attended by 60 participants.

Group Theory, Geometry and Representation Theory: Abel Prize 2008

Workshop, 27–29 May 2009

Organisers: M Geck, G Röhrle and J Saxl

This short meeting, organised jointly with the Department of Pure Mathematics and Mathematical Statistics at the University of Cambridge, was designed to celebrate the award of the 2008 Abel Prize, jointly to John Thompson and Jacques Tits, "*for their profound achievements in algebra and in particular for shaping modern group theory*". In view of the classification of finite simple groups, the theory of abstract finite groups essentially relies on the theory of reductive algebraic groups over fields of positive characteristic. The twelve invited one-hour talks covered a broad area deeply influenced by Thompson and Tits. The large assembled audience, of approximately 80 participants, appreciated in particular the lectures by Serre and Thompson.

Representation Theory and Lie Theory

Workshop, 22–26 June 2009

Organisers: M Geck, A Kleshchev and G Röhrle

This was the concluding workshop of the programme. It attracted over a 100 participants and consisted of 23 invited one-hour talks covering a wide spectrum of topics ranging from classical Lie theory to the modern use of geometric methods in representation theory. The goal was to review the state of the art and to map out new directions. From all the feedback we received, the workshop was perceived as a major success.

Outcome and Achievements

The programme attracted 103 Visiting Fellows and Programme Participants researchers overall with approximately 70% coming from overseas. We were particularly pleased about the large number of early-career researchers from all over the world attending the various workshops. Participants gave 83 invited talks at universities throughout the UK.

A major achievement of the programme was to provide a forum for presenting and discussing new ideas and developments, by bringing together as many researchers as possible from as wide a variety of areas as possible. We believe that a highly significant part of the outcome of the programme will be in the long term, as a result of newly established collaborations and the focussing on new research directions. Here are some of the major themes which are bound to play a dominant role:

• Rouquier's vast programme to develop a "higher" representation theory of Kac–Moody Lie algebras. A special case was essential in the proof of Broué's abelian defect group conjecture for symmetric and general linear groups (Chuang, Rouquier). The general version leads to categorifications of fundamental objects like canonical bases of quantum groups. It also gives rise to a new class of associative algebras defined independently by Khovanov and Lauda. Rouquier himself gave a series of lectures at the instructional workshop and a talk at the final workshop.

• The study of perverse sheaves with coefficients in positive characteristic, initiated and currently being developed by a generation of young mathematicians (Fiebig, Juteau, Mautner, Williamson). This is leading to a new attack on classical and long-standing open problems in the modular representation theory of finite and algebraic groups including, for example, the representations of the symmetric group in positive characteristic (Juteau). One of the issues is to understand the failure of the "Decomposition Theorem" in the theory of perverse sheaves in positive characteristic. As a possible way around it, Juteau, Mautner and Williamson initiated the study of so-called "Parity Sheaves".

• One of the declared aims of the programme was to achieve progress on the open problem of understanding the relations between representations in characteristic zero and in positive characteristic, where major examples are given by Lusztig's character formula for representations of algebraic groups in positive characteristic or James' conjectures on modular representations of Hecke algebras. Up to now these problems have resisted solution but the work of Fiebig, Juteau, Mautner, Williamson and others may lead to a better understanding of the difficulties involved and hopefully to new ways of looking at them.

• The study of a new class of associative algebras, defined independently by Khovanov and Lauda (by diagrammatical methods) and Rouquier (see above), the original motivation being the "categorification" of quantized enveloping algebras. Among exciting new applications, these algebras provide natural gradings on various classical objects (Hecke algebras, Specht modules) and currently form the subject of extensive study (Ariki, Brundan–Kleshchev, Brundan–Stroppel, Rouquier, Varagnolo–Vasserot).

• The theory of finite W-algebras, which have their origin in mathematical physics. It is related to a number of classical subjects around algebraic groups and Lie algebras, such as the geometry of the nilpotent cone, Slodowy slices etc. Connections with the related concept of generalised Gelfand–Graev representations of finite reductive groups remain to be investigated. Various problems concerning the representation theory of finite W-algebras (highest weight theory, existence of finite-dimensional or even 1-dimensional representations) have recently formed the subject of intensive study (Brundan–Kleshchev–Goodwin, Losev, Premet, Goodwin–Röhrle–Ubly).

Discrete Integrable Systems

19 January to 3 July 2009

Report from the Organisers:
R Halburd (University College London), F Nijhoff (Leeds), M Noumi (Kobe), R Quispel (La Trobe) and O Ragnisco (Roma TRE)

SJ Wilkinson

R Halburd, R Quispel, F Nijhoff and M Noumi

Scientific Background

Many physical processes are mathematically described by differential equations, reflecting the smoothness of macroscopic natural phenomena. However, there are also many inherently discrete physical processes, and these are better described by *difference equations*. In particular, at the subatomic scale (where quantum mechanics takes over), the assumption of a space-time continuum may no longer be adequate because it has been speculated that a coherent theory of quantum gravity requires an inherently discrete description of the fundamental interactions in physics. To describe these discrete phenomena we need to develop the mathematical theory of difference equations much farther than hitherto.

Difference equations are essentially nonlocal, which is one reason why their theoretical development (in spite of the numerous applications e.g. in numerical analysis, control theory, mathematical biology and economics) has lagged behind that of differential equations, as this nonlocality renders such systems both richer as well as more difficult to treat. Furthermore, several distinct difference equations may reduce to the same differential equation after a continuum limit, which adds to the difficulty of singling out a preferred difference equation as a model for a specific physical phenomenon. It is here that the notion of *complete integrability* is crucial, since it often implies the exact solvability of the equations and the presence of a rich algebraic and geometric structure. One expects that it is exactly these properties that explain why integrable equations, in spite of their rareness, appear frequently in applications.

In recent years a number of intriguing connections has emerged between the field of discrete integrable systems and other areas of mathematics such as algebraic geometry, number theory, differential geometry and representation theory.

From these connections a host of new insights has been gained and new mathematical objects have been defined. The coming together of these various strands of research made the programme very timely, and by focussing strongly on these new trends and developments, bringing together the most prominent researchers active on the interface of the various disciplines, it has endeavoured to foster new breakthroughs in the field.

Programme Structure

The programme ran over five and a half months and a large number of visiting fellows, programme participants and workshop participants, with a healthy mixture of high-profile experts in the field as well as promising early-career researchers. There were 67 visiting fellows and 28 programme participants. To date, 39 programme preprints have appeared in the Institute's Preprint Series. As well as

regular talks given as part of the programme, participants gave invited seminars at Cambridge, Glasgow, Imperial, Kent, Leeds, Loughborough, Open University, Oxford, Queen Mary and University College London (UCL).

There was a schedule of two formal seminars each week, interlaced with informal seminars that were organised on an ad-hoc basis, often by "popular demand". Among these were several mini-lecture series, such as those by the Rothschild Visiting Professor, JJ Duistermaat, on *QRT Maps and Elliptic Surfaces*, and those given by M Noumi on *Point Configurations and the Elliptic Painlevé Equation*. A number of seminars aimed at a wider audience were given, e.g. by JJ Duistermaat, SP Novikov and N Joshi.

Apart from these ongoing activities, the programme included four workshops, of which two took place at the Isaac Newton Institute, and two were Satellite Meetings at the University of Glasgow and the University of Leeds respectively. A brief description of these workshops follows.

Quantum Integrable Discrete Systems

Workshop, 23–27 March 2009

Organisers: O Ragnisco, J Avan, A Hone, R Quispel

This workshop brought together mathematicians and physicists working on discrete models of space-time, and discrete integrable systems in the quantum setting, both theoretically and applied to quantum field theory and statistical mechanics. The workshop concluded with a special one-day meeting on discrete aspects of space and time, including talks by the Nobel Lauteate G 't Hooft, and the Fields medallist SP Novikov.

The wide range of talks in the workshop revealed the enormous potential for further dialogue between mathematics and physics in the realm of discrete descriptions using lattices and iterated maps. In particular, using a lattice description of space-time may be the only way to avoid the problems due to divergences that usually arise in attempts to create a quantum theory of gravity.

Key talks were given by L Amico, V Bazhanov, A Bobenko, G 't Hooft, C Korff, SP Novikov and S Sergeev.

C Mercat

z^3-discrete conformal map of the portrait of Isaac Newton and the University of Cambridge Shield

Geometric Aspects of Discrete and Ultra-Discrete Integrable Systems

Satellite Meeting, 30 March–3 April 2009

Organisers: C Gilson, C Korff, J Nimmo, O Ragnisco

This meeting focussed strongly on connections with tropical geometry and with discrete Painlevé equations and the corresponding algebraic geometry. Since this area is strong in Japan, there was substantial Japanese representation, made possible through funding from a PMI2 Japanese/British Research Cooperation Award, the Sasakawa Fund, the Daiwa Foundation, and the Glasgow Mathematical Journal Trust.

The workshop has led towards a comprehensive understanding of the present status of discrete and ultra-discrete integrable systems. Topics covered include lattice equations and Yang–Baxter maps, geometric crystals and combinatorics of crystal bases, box-ball systems and tropical geometry.

Key talks were given by A Veselov, S Kakei, F Nijhoff, T Takenawa and Y Yamada.

Algebraic Theory of Difference Equations

Satellite Meeting, 11–15 May 2009

Organisers: A Pillay, A Fordy, A Mikhailov, J-P Ramis, FW Nijhoff

This meeting was supported by the LMS. It involved three usually separate communities: integrable systems, differential and difference Galois theory, and model theory in mathematical logic. There were over 50 participants, and among them there were

prominent experts from all three fields, such as G Casale, M Gekhtman, C Hardouin, SP Novikov, J-P Ramis, T Scanlon, M Singer, M van der Put, H Umemura and L di Vizio. Tutorial talks were given by R Halburd, T Scanlon, M Singer and J-P Ramis. The meeting included the following subjects: the Galois theory of difference and q-difference equations; isomonodromic deformation problems and Painlevé difference equations; integrability of analytic difference equations; difference algebraic geometry; dynamics of rational maps; and connections with the model theory of difference fields.

Discrete Systems and Special Functions

Workshop, 29 June – 3 July 2009

Organisers: P Clarkson, A Olde Daalhuis, M Noumi, R Halburd

This final workshop attracted 66 participants and continued a recent fruitful trend of bringing together researchers from integrable systems, special functions and orthogonal polynomials. There are deep connections between these fields.

Connections between the discrete Painlevé equations and orthogonal polynomials were presented in talks by W van Assche and A Its. K Kajiwara clarified the relationships between the hyper-geometric solutions of the symmetric and asymmetric q-Painlevé equations. EM Rains gave a monodromy interpretation of Sakai's elliptic Painlevé equation. S Ruijsenaars described the application of special Hilbert–Schmidt operators to elliptic Calogero– Moser quantum N-particle systems of non-relativistic and relativistic type. The talks by W Hereman, E Hubert and E Mansfield described advances in symbolic computation for discrete systems.

Outcomes and achievements

The overall success of the programme was that it drew together experts and early-career researchers from different disciplines including complex analysis, algebraic geometry, representation theory, Galois theory, spectral analysis, the theory of special functions, graph theory, difference and differential geometry, mathematical physics, and naturally, integrable systems. The main theme being the crossroads of these and other fields, the programme allowed new synergies to emerge and new collaborations to develop.

We list here a number of highlights that deserve special mention:

• The development of a novel variational formalism for integrable lattice systems based on Lagrangian multiforms (Lobb, Nijhoff, Quispel).

• The establishment of the full soliton solutions to the celebrated ABS lattice equations and the first construction of elliptic solutions of the latter equations (Atkinson, Hietarinta, Nijhoff).

• Full classification of octahedral lattice equations in three dimensions, leading to an exhaustive list of such equations in the scalar case (Adler, Bobenko, Suris).

• Development of a generalized symmetry method for discrete equations, which allows for a classification of difference equations beyond the cases considered so far (Levi, Yamilov, Hydon, Viallet).

• Development of the theory of singular finite-gap operators, which applies in particular to the case of real but singular potentials which violate self-adjointness (Novikov, Grinevich).

• Nevanlinna theory and difference equations. The extension of results for the difference operator to Cartan's value distribution theory for meromorphic functions from $\mathbb{C}$ into $\mathbb{C}P^n$ (Halburd, Korhonen).

• A systematic approach to periodic initial value problems on the two-dimensional lattice. The discovery of elegant closed-form expressions for all integrals of the resulting maps in the integrable case has opened novel avenues of proving the Liouville–Arnold integrability of these maps (van der Kamp, Tran, Quispel).

• New uses of Okamoto's space of initial conditions for Painlevé equations, including a new and elegant proof that the Painlevé equation has the Painlevé property. The methods of Okamoto and Boutroux were combined to obtain asymptotic information (Duistermaat, Joshi).

• Several new collaborations have started to find discrete geometric interpretations of discrete Painlevé equations, to explore higher dimensional integrable mappings and also to clarify possible links between discrete integrable hierarchies and discrete Painlevé equations (Doliwa, Hone, Nimmo, Noumi, Viallet).

The Cardiac Physiome Project

29 June to 24 July 2009

Report from the Organisers:
RH Clayton (Sheffield), P Hunter (Auckland), N Smith (Oxford) and S Waters (OCIAM)

SJ Wilkinson

P Hunter, S Waters, N Smith and RH Clayton

Theme of the Programme

The Cardiac Physiome project is an international effort to build biophysically based multi-scale mathematical models of the heart. Effective methods for analyzing model complexity are an important and fundamental mathematical requirement for the success of this project. Specifically, techniques are needed for determining the appropriate level of detail, exploiting model inheritance and defining standards for the constituent electrical, mechanical and vascular classes of the cardiac model.

Our overall goal for the four-week programme was to facilitate the development and application of modelling and algorithmic expertise to cardiac physiological problems, and to establish new ways of contributing to the Physiome framework. To do this we aimed to promote interactions between mathematically focussed scientists seeking to work at the life sciences interface, multi-scale modellers and selected experimental specialists. Within particular classes of cardiac model, the goal was to outline a specific set of criteria for the model elements. Examples of criteria included enforcement of conservation laws, parameter sensitivity that is consistent with experimental observations, and establishing the level of model complexity that is supported by the data and is required to capture function. Using these criteria we used the environment of the workshop to review collectively the current techniques and outline the opportunities and needs for novel mathematical techniques to assess models. Within this overarching framework the following issues for the Cardiac Physiome project were addressed:

1. Where are the computational bottle-necks in multi-scale simulations, and what numerical analysis and visualisation tools will improve the throughput and interpretation of computational simulation for the Physiome?

2. Which mathematical tools are most appropriate to quantify stability and parameter sensitivity in increasingly complex models of physiological systems?

3. How much complexity is required at a given level (e.g. cell) to integrate into simulations of function at higher level (e.g. tissue), and what sort of analysis can be used to establish the level of complexity required for a specific simulation?

4. What are the mathematical and computational criteria that models or sub-groups of models should conform to for different functions? How can these be promoted and enabled within the community?

5. What should be the form and function of model databases and ontologies for different model classes? How can they enable robust model testing and accelerate the iterative refinement within the research community?

Programme Structure

To address these issues within the multi-scale and multi-physics framework, each of the first three weeks was organised to focus on a particular scale/physics relevant to the theme of the workshop.

The specific focus and goal of each of these weeks was:

Focus Week 1 Sub-cellular Modelling: to review the characterisation of subcellular measurement with biophysically based models of subcellular components including: channel and exchanger functions, signalling and transduction pathways. These discussions and presentations for this week were based on questions 2, 3 and 4 above.

Focus Week 2 Excitation and Contraction: to investigate frameworks and methods used to couple models of excitation and mechanics at both cell (ODE) and tissue scales (PDE). The influence and interdependence of these two phenomena were discussed along with mathematical and computational tools. Specific issues covered were:

- Modelling: models of excitation (cell and tissue), phenomenology of excitation propagation during normal beats and arrhythmias, and models of force development and tissue deformation. Influence of tissue mechanics on activation during normal beats and arrhythmias. Potential for patient specific models.

- Mathematics and computation: parameter identification and parameter sensitivity in models of excitation and contraction. Relative merits of different numerical schemes.

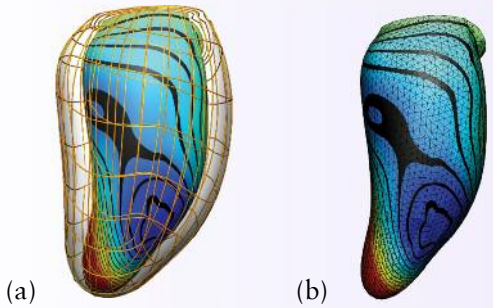
Focus Week 3 Coronary Vascular Fluid Dynamics: to investigate frameworks and methods to describe the flow and transport properties of the coronary vasculature, and to consider how these models link to the cell and tissue models considered in weeks 1 and 2. Areas discussed and presented were:

- Physiology: coronary vascular mechanical structure and topology

- Vascular mechanics and transport: mechanos-transduction, mass transport processes, regulation, angiogenesis and vascular remodelling

- Modelling from large vessels through to microvasculature, fluid-structure interactions. A particular focus was given to the level of complexity that should be incorporated at each level of modelling.

- Mathematics and computation: lumped parameter models, network models, continuum models with a focus on homogenisation, coupling at different scales (large vessels to microvasculature).



D Nordsletten, D Kay and N Smith (University of Oxford)

Pressure contours on the endocardial surface of the left ventricle of the heart mapped onto a solid mechanics mesh (a) and fluid mechanics mesh (b), as part of a coupled fluid mechanical simulation

The fourth week was run as a much larger workshop with approximately 140 participants presenting research findings from their own work in the form of talks and posters. Many of the questions and discussion topics developed during the first three weeks were echoed in both the formal and informal discussions during the meeting. This final week covered the full spectrum of cardiac physiome research topics, scales and experimental-mathematical approaches.

Outcome and Achievements

The programme succeeded fully in our overall goal to facilitate the development and application of modelling to cardiac physiology. Comments that were fed back through scientific reports, and also informally during the programme, have been uniformly positive. Participants have indicated several new collaborations are expected. Some specific examples include Secomb (collaboration with Oxford), Sherwin (expanding fluids research to electrophysiology), Niederer with Young (data sources for cardiac models), and Smith with Van de Vosse (validation of fluid mechanical cardiac models).

The collective input and contributions of attendees throughout the meeting will be published as articles in a special issue of *Progress in Biophysics and Molecular Biology,* which is expected to be published in March 2010. Significant progress was made on writing these articles while at the Institute.

Serving the UK Community

Caroline Series, Chair of Correspondents

It is with great pleasure that I welcome you to the "Serving the UK Community" section of this *Annual Report*. In the following pages you will find key information and statistics on how the Isaac Newton Institute serves the UK Mathematical Sciences community and on how every UK researcher, from beginning PhD student to emeritus professor, can take part in its activities. With over 360 visitors from all over the country, the Institute is a vital national resource for mathematics and its interface with other scientific disciplines, not least because of the exceptional strength of international participation.

Providing this resource is a core part of the Institute's mission. It maintains close links with the UK's higher education and research institutions via an extensive network of Correspondents who receive regular postings on Institute events and who are charged with passing on relevant details to colleagues at their various institutions.

As Chair of Correspondents my role is to represent the UK Mathematical Sciences community on the Management Committee, ensuring that the Institute continues to be responsive to Mathematical Sciences priorities within the UK, and that Institute activities are fully embedded in the community. I also chair the Annual Meeting of Correspondents which takes place every June in Cambridge.

This year's Meeting focussed on two important issues: a Ten-Year Vision for the Institute and the Gender Balance Action Plan (see page 25). The meeting was organised in a new format in which participants split up into smaller groups for discussions on the main topics. This provided much lively interaction and significantly raised the level of the meeting, providing useful feedback to the Institute and being warmly welcomed by the Correspondents present.

Public funding for all UK higher education and research will be challenging in the next few years, and the close connection between the Institute and the wider community will be increasingly important. Please do feel free to contact me to discuss any aspect of the Institute and its role within the UK.

UK Correspondents

The Newton Institute has for several years maintained a list of Correspondents in UK Universities to act as a channel of communication between the Institute and the mathematical sciences community in the UK. This list has in recent years been extended to include relevant learned societies, commercial organisations and institutions not attached to Universities. All Correspondents are regularly informed about activities of the Institute, and it is their responsibility to ensure that the information is disseminated 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 held at the Institute. The names of all Correspondents as at 31 July 2009 can be found opposite.

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** 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**

Newton Institute Correspondents (as at 31 July 2009)

Newton Institute Correspondents act as a channel of communication between the Institute and the UK mathematical sciences community (see page 20). 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	SW Ellacott	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	CS Elsholtz
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 Brzeziński
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	Microsoft Research Group	CM Bishop
British Computer Society	I Horrocks	National Oceanography Centre	M Srokosz
Edinburgh Mathematical Soc.	TH Lenagan	OR Society	R Hibbs
EPSRC	M Bambury	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
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 many did so during 2008/09. 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

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 on the web at

www.newton.ac.uk/webseminars/

For most past seminars, audio files together with accompanying transparencies or PowerPoint files, etc., can be downloaded. Starting from September 2007, however, full video of every seminar has been available for either streaming or download. In time the library of online seminars should build into a substantial national resource. At current rates over 600 seminars are being added *per annum*.

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

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 116 new Junior Members in 2008/09; the current total is 671 as at the end of July 2009.

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.

The *Logic and Algorithms* programme (January to July 2006) held a follow-up event as a one-week Satellite Meeting at the International Centre for Mathematical Sciences in Edinburgh, 21–25 July 2008. There were a total of 90 participants, of which 12 were funded by the Institute. Further details can be found at

www.icms.org.uk/workshops/logicalg

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 on themes related to an Institute programme, and involve a significant number of longer-stay overseas participants from the Institute. They also, crucially, draw in and involve UK mathematicians 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.

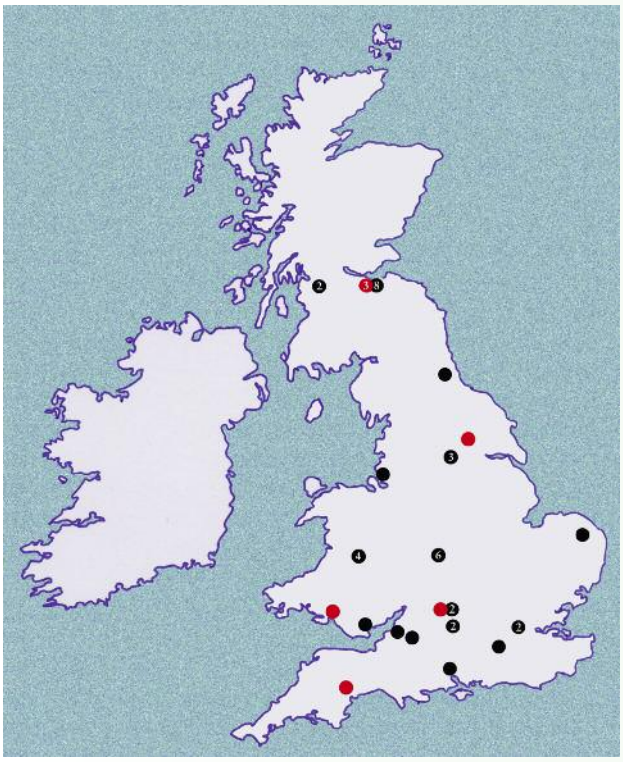
Satellite workshops have been held at Bath, Bristol, Brunel, Cardiff, Durham, East Anglia, Edinburgh, Glasgow, ICMS, Leeds, Liverpool, London, the National e-Science Centre in Edinburgh, Oxford, Reading, Southampton, Surrey, Wales (Gregynog Hall) and Warwick. Future workshops are being planned at Edinburgh Royal Observatory, Exeter, ICMS, Oxford, Swansea and York.

Costs for satellite workshops are typically approximately £15,000 (excluding the overseas travel costs of Institute participants, which are covered separately) and are shared between the Institute and the host institution. 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, Dr Ben Mestel (B.Mestel@newton.ac.uk).

An Inspirational Model

Several aspects of the Institute attract visits and enquiries, apart from researchers interested in the scientific programmes. The building remains very fit for purpose and is an icon for those interested in how a building can stimulate and support interaction. This aspect of the Institute has attracted visitors world wide, including from the University of California at San Diego, Kyoto University, Kobe University, Beijing and Singapore, as well as influencing developments at Edinburgh, Oxford, Strathclyde and York in the UK.



Distribution of Satellite Workshops

● *Planned* ● *Held*

Visits by the Director and the Deputy Director

Over the course of the year, Sir David Wallace and Dr Ben Mestel have made a number of visits to institutions in the UK, to talk about the Institute, stimulate proposals, encourage participation, and gain feedback on its work and potential. Trips in conjunction with other activities enabled useful visits to overseas institutions. In the course of the year, these were: BAMC (Nottingham), BMC–IMS (Galway), ICMS - Edinburgh, Institut Henri Poincaré, Institut des Hautes Études Scientifiques, Mathematisches Forschungsinstitut Oberwolfach, Mittag-Leffler Institut, University College London (De Morgan Dinner), University of Durham (Annual Particle Theory Meeting), University of East Anglia, University of Reading (adaptive mesh Scoping Meeting), University of St Andrews, University of Surrey and the University of York.

If you are interested in arranging a visit to your institution please contact Sarah Fendt (s.fendt@newton.ac.uk).

Institute News

More Blackboards at the Institute

In a most generous and welcome gesture, a friend of the Institute has given a significant donation which will enable us to provide Visiting Fellows with mugs which double as blackboards – a fun, useful and personal gift for them, and who knows what flash of inspiration they might capture! We are very grateful to Barbara Keyfitz, former Director of the Fields Institute, for making this contact for us.

The Newton Institute in the City

Last year we reported on the initiation of a series of dinners at the London home of the Management Committee Chair, Howard Covington and his wife Veronika. These give senior business people, mainly from the City, the opportunity to engage with leading researchers. The object is to develop a network of friends of the Institute, who enjoy the informal interaction, and who value science and what the Institute does to support it.

It would be difficult to overstate the enthusiasm for these events. By July 2009, nine had been held, including a reception and dinner at the Smith Centre of the Science Museum in London, where a packed audience of more than 30 were privileged to hear special guest Stephen Hawking. Six more are planned before Christmas 2009, including an evening hosted by Credit Suisse and a dinner at the Royal Society with special guest Roger Penrose. We are very grateful to them and other scientists for their willing participation: John Barrow, Val Gibson, Michael Green, Ray Goldstein, David MacKay, Andy Parker, Chris Rapley, Martin Rees, Emily Shuckburgh, David Spiegelhalter, David Tong and Neil Turok. Please contact David Wallace (david.wallace@newton.ac.uk) if you would like to engage with the Institute through these events.

Tribes of Science

The Newton Institute was the location for a BBC Radio 4 programme entitled *The Mathematicians*, recorded in June and broadcast in August. Part of a series on *The Tribes of Science*, the programme featured interviews with participants, organisers, the Director and Administrator.

Cambridge Science Festival

On the 21 March 2009 Professor Franco Vivaldi (Queen Mary, University of London) gave a talk entitled *The Arithmetic of Chaos* as part of the Cambridge Science Festival. During his talk Professor Vivaldi looked at various systems whose future is hard to predict (think of the weather). Looking at the heart of this phenomenon - called chaos - he showed how unpredictability ultimately stems from the properties of numbers. The talk was given to a packed lecture theatre and many people had to be turned away.

Video Conferencing and Web Streaming

With funding from the Royal Commission for the Exhibition of 1851, the Institute has augmented its video recording facilities to include web streaming and video conferencing. The three camera, microphone array and data projector system in the main seminar room is edited in real time. Information on forthcoming talks is available from the homepage **www.newton.ac.uk**. Subject to speaker permission, streamed seminars can be viewed at **rtsp://video.newton.ac.uk/broadcast/live.rm**

Gender Balance Action Plan

The Isaac Newton Institute is committed to equal opportunities in all our activities. This commitment is founded not just on principles of fairness and justice but on the recognition that the Institute has a pivotal role in utilizing, encouraging and supporting the whole spectrum of mathematical research talent.

As part of this commitment, the Institute has formulated a *Gender Balance Action Plan*. The Plan has been written after consultation with Institute Correspondents, Management Committee and Scientific Steering Committee, as well as with the London Mathematical Society's Women in Mathematics Committee, the UK Resource Centre for Women in Science, Engineering and Technology, and the European Women in Mathematics Committee. Our aim is to increase the percentage of women participating in Institute programmes by 20% over the coming years. This will be achieved by a series of measures including:

(i) encouraging programme organisers to aim for at least 20% participation by women;

(ii) removing barriers to women's participation and ensuring the Institute supports women's involvement in Institute events;

(iii) showcasing the achievements of women mathematical scientists in the Institute;

(iv) developing special funds to support women mathematical scientists to visit the Institute;

The Institute is grateful for the support of the UK Resource Centre for Women in Science Engineering and Technology (via a grant held jointly with the London Mathematical Society) and the Thriplow Trust in their generous support for Institute's work in this important area.

The *Gender Balance Action Plan* can be found at

www.newton.ac.uk/women/gbap.html

Open for Business

As part of our mission to foster links between academic research and the business world, the Institute has established a series of *Open for Business* events. Organised in partnership with the Knowledge Transfer Network for Industrial Mathematics, and supported by the Higher Education Innovation Fund (HEIF4) of the University of Cambridge, these meetings bring together mathematical sciences researchers and practitioners from business and industry, enabling formal and informal discussion and networking.

In 2008–09, the Institute organised two, highly successful *Open for Business* meetings. The first, *Turbulence in Fluids,* was held on 17 November 2008, in conjunction with the *High Reynolds Number Turbulence* (HRT) programme. The meeting featured a keynote address by Professor Katepalli Sreenivasan (Director, ICTP, Italy), followed by presentations by Lord Julian Hunt (UCL), Dr Tony Hutton (Airbus; and Centre for Fluid Mechanics Simulation, CFMS Ltd), Dr Tim Palmer (ECMWF) and Dr Tony Purnell (FIA), who together formed the panel for a discussion session chaired by Sir David Wallace. The meeting was attended by 18 invited guests – in addition to HRT programme members.

The second meeting, a follow-up event to the 2005 Institute programme *Developments in Quantitative Finance*, was held on 2 June 2009 and was supported by the Cambridge Endowment for Research in Finance. Billed *The Future of Quantitative Finance*, the meeting was attended by 57 guests from outside the Institute. The first session (led by Management Committee Chair, Howard Covington) consisted of presentations by Professor Hashem Pesaran (Cambridge): *The Limits to Rational Expectations Equilibrium and Market Efficiency*, Marek Musiela (BNP Paribas): *How Are Practitioners Dealing with the Issues Now?*, Professor Xavier Vives (IESE, Barcelona): *How Can We Deal with Herding and Other Behavioural Issues?* and Professor Doyne Farmer (Santa Fe Institute): *The Regulation of Risk and the Risk of Regulation.* A lively discussion followed, chaired by Lord John Eatwell (Director, Cambridge Endowment for Research in Finance). Bill Janeway (Warburg Pincus) joined the speakers in the panel.

Management and Statistical Reports

Howard Covington,
Chair of the Management Committee

As well as its regular business of budget approval, commitment of resources, overseeing management, and recommendation of Rothschild Visiting Professors for appointment by the University of Cambridge, the Management Committee plays a particularly important role in reviewing fundraising.

Since the Institute does no regular teaching, and gains no income through the Research Assessment Exercise, its support for visiting researchers is dependent on competitively won research grants and on philanthropy. Core funding is provided by the Engineering and Physical Sciences Research Council, and we are deeply grateful that EPSRC takes responsibility for 85% of the activities of the Institute. A major challenge is to secure external support for multidisciplinary programmes which span astronomy to zoology, and we hope to address this through a cross-Research Council proposal in the coming year.

Stability of funding for the longer term is likely to depend increasingly upon philanthropy, and I offer personal thanks to the many friends, listed on page 32, who have donated to the Institute because they enjoy informal interactions with researchers, and value the cultural and practical impact of their research.

It is a pleasure to thank particularly Sir Evelyn de Rothschild, for his continuing interest in the Institute, and for his most recent support for flexibility in the deployment of Rothschild Visiting Professor funds, which can now be used to support also Rothschild Distinguished Visiting Fellows.

It is a privilege to be associated with an organisation like the Newton Institute which plays such a significant international role, and I am grateful for the opportunity to contribute to it.

Management Committee

Membership of the Management Committee at 31 July 2009 was as follows:

Sir John Ball FRS FRSE	*Chair of the Scientific Steering Committee*
Professor JW Bruce	*London Mathematical Society*
Mr H Covington (Chair)	*General Board*
Professor N Dorey	*Faculty of Mathematics*
Professor WT Gowers FRS	*Trinity College*
Mr D Harman	*EPSRC*
Professor PH Haynes	*Head of Department, DAMTP*
Professor JME Hyland	*Head of Department, DPMMS*
Professor PT Johnstone	*St John's College*
Professor R Langley	*Council of the School of Technology*
Professor PB Littlewood FRS	*Council of the School of the Physical Sciences*
Dr B Mestel (Secretary)	*Deputy Director, Newton Institute*
Professor C Series	*Chair of Correspondents*
Sir David Wallace CBE FRS FREng	*Director, Newton Institute*

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 1723 visitors was recorded for 2008/09.

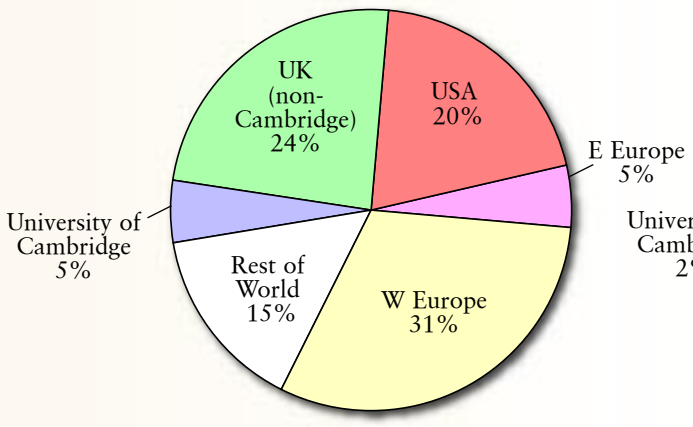
This includes 306 Visiting Fellows and 157 Programme Participants. These new categories for visitors replace the 'long-term' and 'short-term' categories of previous years which were determined simply by the duration of the visit; a Visiting Fellowship instead reflects *total* contribution to the programme in terms of international reputation and importance in the field as well as the length of stay.

Within the six programmes during the year there were 18 workshops (periods of intense activity on specialised topics) which attracted a further 665 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 580 visitors attended such events and took part informally in Institute activities or satellite events and follow-up meetings.

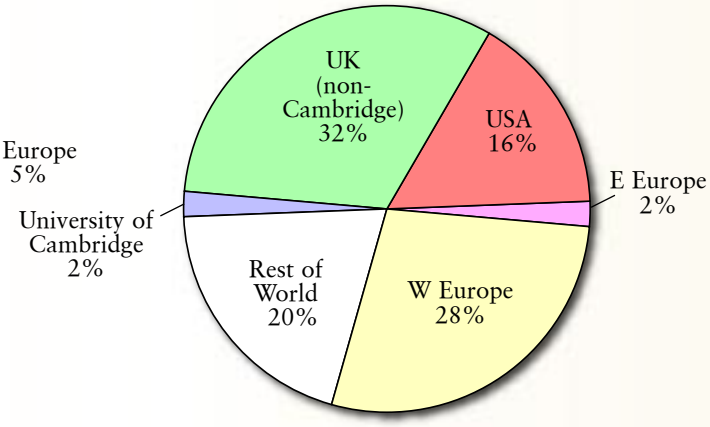
Within all the programmes, workshops and other activities, 1,372 seminars were given in total at the Institute during the year. The Institute also funds visits by overseas programme participants to other UK institutions to give seminars (see page 22), and 268 such seminars took place this year.

Programme	Visiting Fellows	Mean stay (days)	Programme Participants	Mean stay (days)	Workshop Participants
Mathematics and Physics of Anderson Localization: 50 years and after	74	37	26	25	81
Design of Experiments	26	20	9	18	81
Nature of High Reynolds Number Turbulence	48	40	41	37	149
Algebraic Lie Theory	62	38	41	45	143
Discrete Integrable Systems	66	52	27	26	104
Cardiac Physiome Project	30	18	13	13	107
Totals	**306**	**37**	**157**	**32**	**665**

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

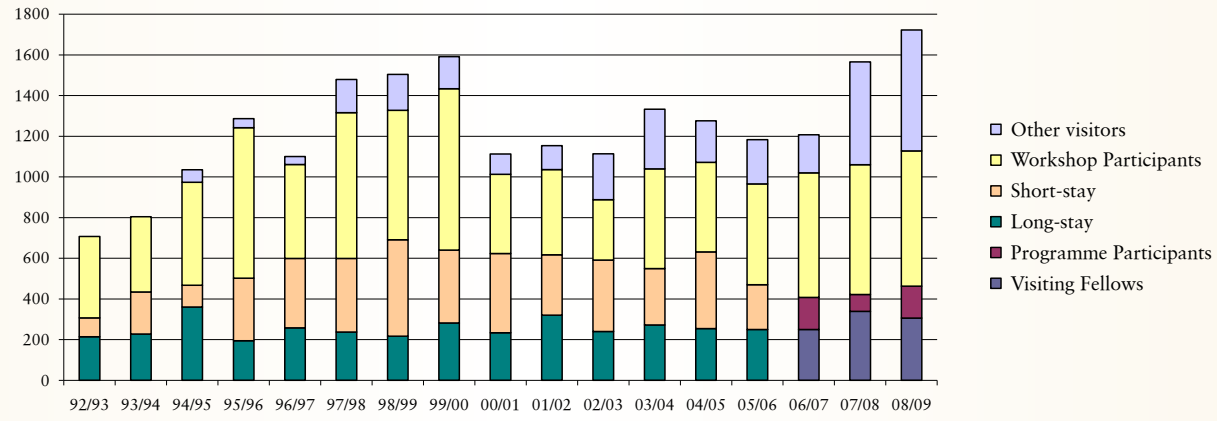


Visiting Fellows and Programme Participants

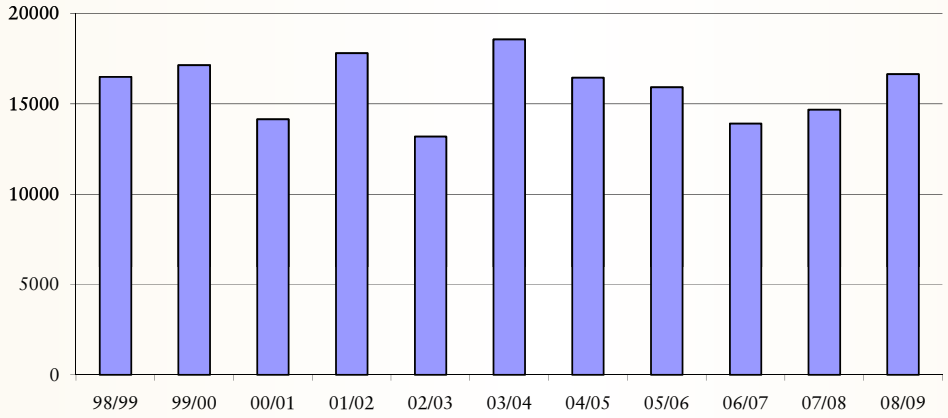


Workshop Participants

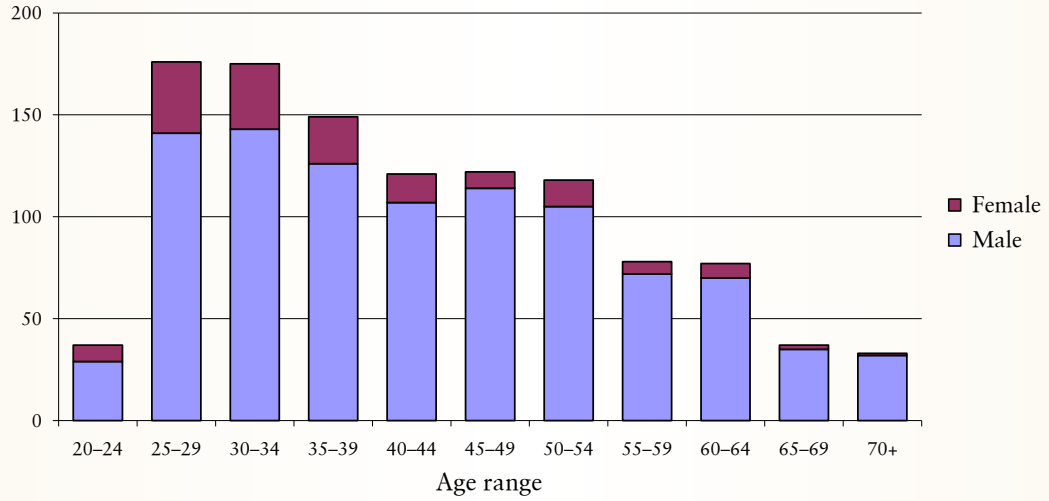
The following chart summarises the total participation figures since the Institute began:



The chart below summarises the total number of person-days for Visiting Fellows and Programme Participants combined (or long-stay and short-stay combined prior to 2006/07; see page 27), *excluding* Workshop Participants.

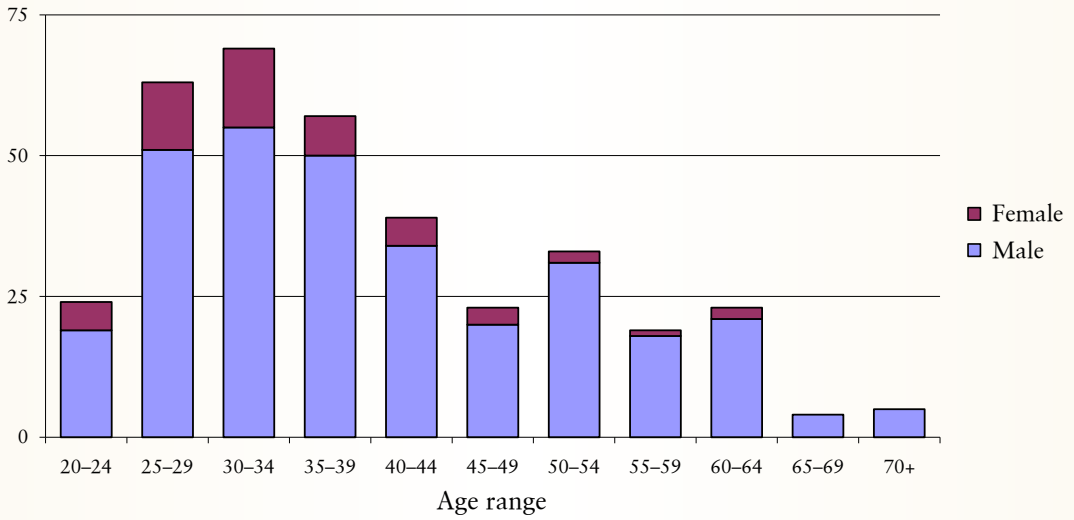


The numbers of all Visiting Fellows, Programme Participants *and* Workshop Participants combined in 2008/09 are shown below, by age and gender:

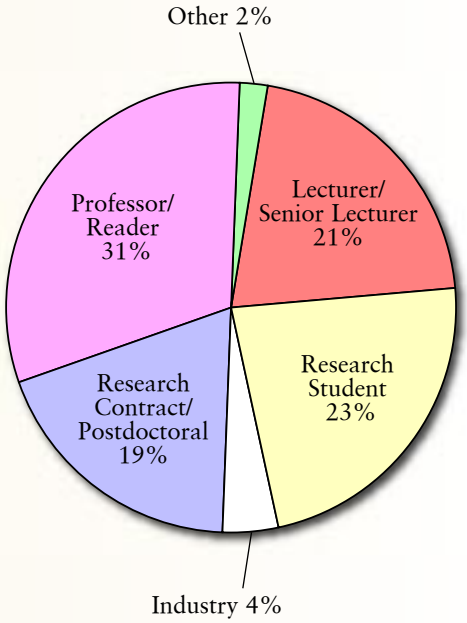


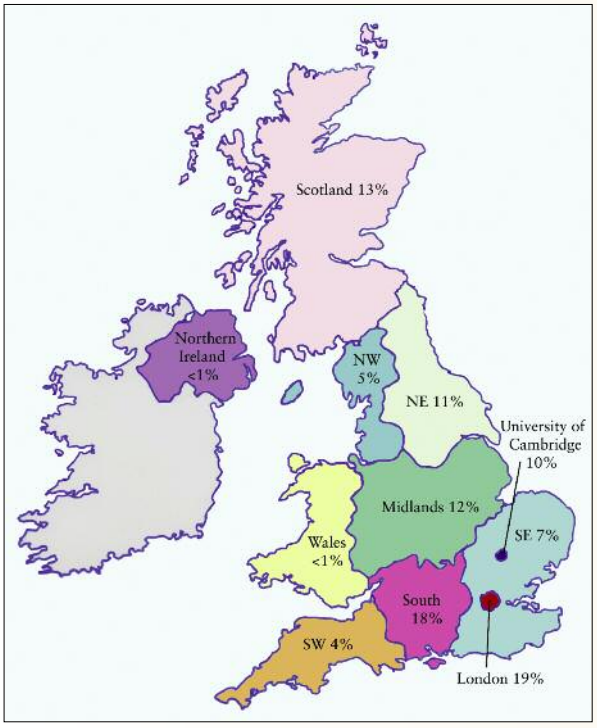
The statistics presented on this page relate only to visitors whose home institutions are in the UK: overseas visitors have been excluded.

The age range and gender balance of all Visiting Fellows, Programme Participants and Workshop Participants from UK institutions in 2008/09 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 2008/09:





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/0809/appendices.html

Finances

Accounts for August 2008 to July 2009 (Institute Year 17)

	2007/08 Year 16 £'000	2008/09 Year 17 £'000
Income		
Grant Income – Revenue[1]	1,113	1,310
Grant Income – Workshop	135	182
Grant from the University of Cambridge	107	77
NM Rothschild and Sons Trust Funds[2]	117	128
Investment Income[3]	141	141
Donations, Reimbursements and Other Income[4]	10	47
Net FEC contribution from Estates and Indirect Costs[5]	12	137
Total Income	**1,635** [5]	**2,022**
Expenditure		
Scientific Salaries[6]	413	443
Scientific Travel and Subsistence[7]	432	525
Scientific Workshop Expenditure	216	331
Other Scientific Costs[8]	18	36
Staff Costs	426	417
Net Housing Costs[9]	17	71
Computing Cost	80	54
Library Costs	9	7
Building – Repair and Maintenance	10	9
Non-FEC Estates and Indirect Costs[5]	68	19
Consumables	18	19
Equipment – Capital	4	4
Equipment – Repair and Maintenance	3	2
Publicity	2	2
Recruitment Costs	2	3
Total Expenditure	**1,718** [5]	**1,942**
Surplus / (Deficit)	**(83)**	**80**

Notes to the Accounts

1. Grant Income – Revenue. The income breaks down as follows:	**2007/08 Year 16 £'000**	**2008/09 Year 17 £'000**
EPSRC Salaries	482	510
EPSRC Travel and Subsistence	449	441
EPSRC Workshop income	60	163
EPSRC other costs	11	18
PPARC/STFC	11	0
Microsoft Research Cambridge	33	18
Leverhulme Trust	21	80
PF Charitable Trust	20	53
London Mathematical Society	25	25
Cambridge Philosophical Society	2	2
Total	**1,113**	**1,310**

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

Rothschild Visiting Professorships (drawdown)	27	30
Rothschild Mathematical Sciences (income)	90	98
Total	**117**	**128**

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

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

4. Donations, Reimbursements and Other Income. A total of £65k received via the Cambridge University Development Office (CUDO) was capitalised and is not included in this figure. Sponsorship was received from Howard and Veronika Covington, IUTAM, BBSRC, the Royal Commission for the Exhibition of 1851 and Microsoft Research Cambridge. 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. The total income and expenditure figures shown here differ from those published in the 2007/08 *Annual Report* due to the net position being reported in 2007/08.

6. Scientific Salaries. This includes stipends paid to Microsoft Research and 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. This includes costs relating to meetings of the Institute's committees, Institute Correspondents' expenses, programme organisers' expenses and entertainment, as well as the travel expenses of overseas participants for their visits to other UK institutions to give seminars (see page 22). The figure also includes City fundraising dinners which are funded from CUDO receipts.

9. Net Housing Costs. Costs include legal fees for rent renewals and overdue rent from 2007/08 totalling £10k.

Income	358	399
Expenditure	375	470
Total	**(17)**	**(71)**

Grants and Donations August 2008 to date

In addition to substantial funding from the Engineering and Physical Sciences Research Council, the Institute is indebted to 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 for continuing support. We are very grateful to the following organisations for their specific support during this period: Deutsche Forschungsgemeinschaft (SFB-TR 12 programme); the Fisher Memorial Committee; Genstat/VSN International; GlaxoSmithKline; GLC Charitable Trust (with special thanks to Lawrence and Rosemary Staden); the International Union of Theoretical and Applied Mechanics (IUTAM); JMP; the Karlsruhe Institute of Technology; Microsoft Research Cambridge; the National Centre for Atmospheric Science; the National Science Foundation (USA); the National Security Agency (USA); the Royal Commission for the Exhibition of 1851; the Royal Meteorological Society; the Royal Statistical Society; the Science and Technology Facilities Council (through a grant to Queen Mary University of London); the Science Museum, London; the UK Resource Centre for Women in Science, Engineering and Technology (through a grant to the London Mathematical Society); and the Thriplow Trust.

Individuals gave generously in support of our activities: Dr Iain Bratchie, Geoff Chapman, Howard and Veronika Covington, Professors David and Miriam Donoho, Professor Roy and Mrs Ann Garstang, Dr Jonathan Hodgson, the late David Malcolm and his family, Steve Mobbs, and David Wallace. We are also very grateful to a friend of the Institute for a donation for blackboard mugs for Visiting Fellows.

Cumulative Financial Grants and Donations above £10,000

(listed in order of cumulative value)

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

Isaac Newton Institute for Mathematical Sciences

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Front cover: A finite element model of the heart with embedded coronary vessels, tissue microstructure and stress contours in the heart wall, and velocity stream lines of flow within the left ventricular chamber, calculated from a coupled fluid-mechanical simulation. This was one of the topics studied during the *Cardiac Physiome Project* programme held at the Institute from 29 June to 24 July 2009.

Image courtesy of Jack Lee, David Nordsletten and Nic Smith (University of Oxford).

Editor: Dr Ben Mestel
Design, production and typesetting: Sara Wilkinson