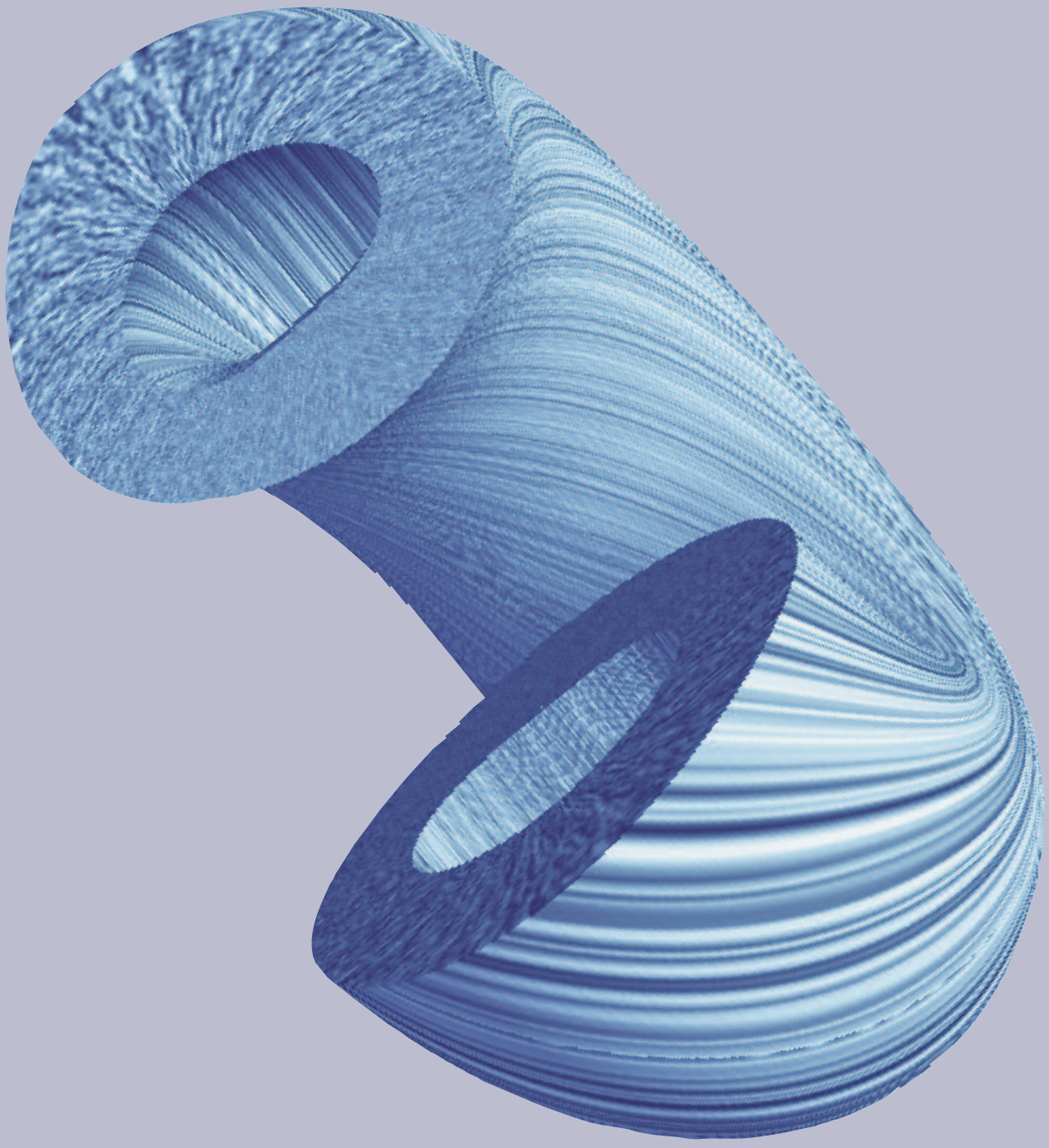
Isaac Newton Institute
for Mathematical Sciences

Annual Report 2010–2011



UNIVERSITY OF CAMBRIDGE

Contents

APPENDICES

Please note that the following statistical information may be obtained from the Institute on request, or from **www.newton.ac.uk/reports/1011/appendices.html**

Director's Foreword

David Wallace
Director of the Institute

The overwhelming feeling at the end of my five years is what an extraordinary place the Newton Institute is.

Almost 20 years on from its opening, the building itself continues to impress newcomers in the way that it facilitates interaction and collaboration. Its location in the stunning environment of the Centre for Mathematical Sciences at the University of Cambridge is both architecturally and intellectually outstanding.

But it is the people associated with the Institute who really make it what it is, and it is to those that my heartfelt thanks go.

The scientific reputation of the Institute is embodied in past and future programmes, and the quality of these is utterly dependent on the organisers of programmes, and the participants in them. Organising a programme is a significant undertaking: it requires preparation of a strong proposal and considerable dedication to make it a success – organisers set scientific direction and ensure that a critical number of visitors of the highest quality participate.

The Scientific Steering Committee is at the heart of the competitive peer review process leading to the selection of programmes and I am indebted to the hundreds of referees who have provided reviews in the past five years. SSC members bring exceptional experience to the breadth of proposals across pure & applied mathematics, and the Chair, Sir John Ball, has ensured that discussions are engaging and decisions exemplary in their balance and integrity. The cross-disciplinary initiative in the Special Call for proposals in June 2011 is opening new areas, as well as new challenges for peer review.

The Management Committee is responsible for the financial and operational well-being of the Institute. Its role has evolved, most importantly through increased external representation reflecting the responsibility of the Institute as a critical part of scientific infrastructure for the UK. Members take that role very seriously. My especial thanks go to Howard Covington, whose exceptional commitment to the Institute goes far beyond chairing the Committee: his lay leadership, in fundraising, in hosting dinners, in personal support for me, and in so many other ways, is outstanding, and I am delighted that he was admitted to Honorary Fellowship this year.

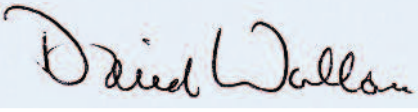
The network of Institute Correspondents was established in 2002. Its role was strengthened in 2008, when the National Advisory Board was disbanded, to enhance engagement with the UK community, and to ensure that the scientific community's views were effectively reflected in Institute policies and activities. The appointment of Caroline Series as Chair of Correspondents and *ex-officio* member of Management Committee has been critical in that change. It was very gratifying that some 50 Correspondents attended the annual meeting in June, more than any previous meeting.

I am grateful to Ben Mestel who returned to his full-time post at the Open University in August for his work as Deputy Director.

The Institute would not exist without financial support and I thank you all: Research Councils, particularly the Engineering and Physical Sciences Research Council, the University of Cambridge, Foundations, learned societies, businesses and philanthropic individuals.

If I have any legacy in the Institute, it is overworked staff. The introduction of Follow-up workshops, of Open for Business meetings, of Scoping meetings, of Case Studies of impact, and of Newsletters has added significantly to their load. I confess to particular pride in the web archive of video lectures of seminars at the Institute. This has developed into a tremendous resource for research; as I write it has attracted more than 450,000 views and 100 Tbytes of downloads, and the competence of the Institute in this area has even greater potential for the future.

The 20th anniversary of the Institute falls in 2012. There will be much to celebrate. I offer my successor John Toland my very best wishes with apologies for any skeletons in cupboards!



Science at the Institute

SJ Wilkinson

John Ball,
Chair of the Scientific Steering Committee

Since its inception in 1992, there have been 222 proposals made to the Scientific Steering Committee, of which 106 have been developed to full proposals accepted by the SSC. Acknowledging that it is always disappointing for those whose proposals are not accepted, this seems a reasonable success rate, particularly in view of the opportunity for constructive feedback informally from the Director prior to submission, and in many cases formally from the SSC in encouraging a resubmission. I echo David Wallace's thanks to referees, without whom our task would be impossible.

I welcome very much the cross-disciplinary initiative of the Institute. This will not diminish the support of the Institute for fundamental mathematics; rather it is aimed at ensuring that interdisciplinary proposals place mathematics at the heart of research in other disciplines. This is exciting in its own right, and a special challenge for the SSC, that will require the co-option to meetings of experts in disciplines which are far from the expertise of SSC members. More than ever meetings will require members to bring the breadth of their impartial expertise to bear.

My thanks go to David Fearn, Etienne Ghys and Stephen Reid for their contributions as retiring members. With input this year from the London Mathematical Society, the European Mathematical Society, the Engineering and Physical Sciences Research Council and the School of Technology at the University of Cambridge, the Nominating Committee (Philippa Hemmings, John Toland, Caroline Series and myself) identified Professor John Lygeros, Professor Sylvia Richardson and Professor Richard Thomas as our preferred nominees, and I am pleased that they have agreed to join the Committee from 1 January 2012.

Finally let me express my own great appreciation, and that of the SSC, for the tremendous work done by David Wallace as Director of the Newton Institute. His dedication, vision and careful attention to the many practical issues involved in running the Institute have been exemplary. The SSC congratulates John Toland on his appointment as David's successor, and looks forward to working with him over the coming years.

Scientific Steering Committee

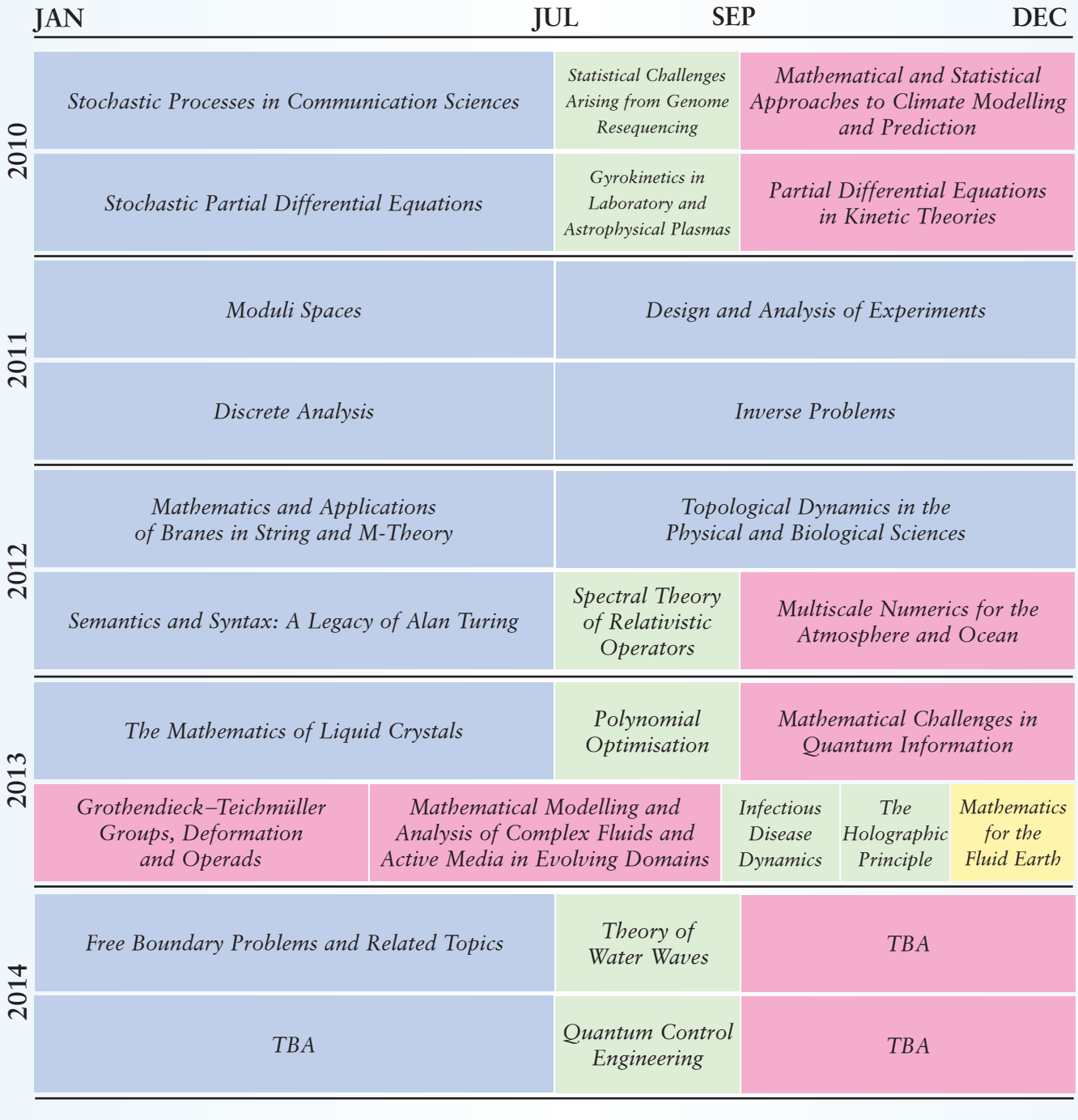
Membership of the Scientific Steering Committee at 31 July 2011 was as follows:

Sir John Ball FRS FRSE (Chair)	University of Oxford
Professor K Ball (*ex-officio*)	ICMS
Professor M Calder	University of Glasgow
Professor DR Fearn FRSE	University of Glasgow
Professor É Ghys	École Normale Supérieure de Lyon
Professor W Kendall	University of Warwick
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 E Süli	University of Oxford
Professor R Twarock	University of York
Professor C Villani	Institut Henri Poincaré
Sir David Wallace CBE FRS FREng (Secretary)	Director, Newton Institute
Professor T Wooley FRS	University of Bristol

Future Programmes

The schematic below shows recent and forthcoming programmes selected by the Scientific Steering Committee. Long-stay participation in a programme is at the invitation of the programme organisers; anyone interested should contact them directly. One- or two-week workshops are advertised, and applications invited with specific deadlines. Visits of one or two days are always welcome; we ask only that **reception@newton.ac.uk** is emailed in advance to assist us with planning; see page 24 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.**



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

Statistical Challenges Arising from Genome Resequencing

12 July to 6 August 2010

www.newton.ac.uk/programmes/CGR/

Report from the Organisers:
D Balding (UCL), C Holmes (Oxford), G McVean (Oxford) and M Stephens (Chicago)

SJ Wilkinson

G McVean, C Holmes, M Stephens and D Balding

Background

High-throughput genetic and genomic platforms have had a great impact on biomedical research in recent years, and given new impetus to studies of molecular mechanisms of disease, systems biology, and population genetics. Fast and relatively cheap sequencing platforms now allow near-complete genome sequences to be obtained from individual members of species. They also permit rapid sequencing of targeted genomic sequences, gene transcripts and methylation states. The impact of these technological developments is expected to be huge, and the focus is increasingly on efficient and imaginative ways of analysing the new data, to deliver the full benefits of genome sequencing.

The motivation for our programme was to bring together leading mathematical and biological researchers to discuss the statistical and computational challenges presented by high-throughput sequencing. The underpinning mathematical techniques involved are wide-ranging, including statistical and machine-learning techniques for high-dimensional classification and regression, as well as techniques from signal processing and various mathematical models of evolutionary processes.

Programme Structure

The 4-week programme started with a 1-week workshop with 120 participants, followed by three weeks of more intense small-group activities involving only the long-term participants.

In addition to the usual core funding from the Newton Institute, the organisers made successful bids to both MRC and BBSRC for additional funding (£25k each). This meant that we were particularly well placed to invite the best people in the field. We tried to be as international as possible in selecting long-term participants and workshop speakers, but the field is very much dominated by major genome centres in North America and the UK and this was reflected in our invitation list. We were able to give a platform to many younger researchers and our stellar list of speakers and the topicality of the subject meant that the programme was oversubscribed.

We could have moved the workshop to a larger lecture theatre in nearby but we would then have lost the benefits of the excellent video facilities offered by the main seminar room. We reminded unsuccessful applicants of the possibility to view workshop talks via webstreaming and we learned from immediate feedback that this was well used, with remote participants contributing comments and feedback via e-mail.

Workshop

To maximize the opportunity to participate we opened the workshop on Tuesday 13 July with a half-day tutorial focussing on the nature of sequence data and basic methods of analysis. The speakers were:

- M Caccamo (BBSRC, Norwich) *Sequencing Technologies – cheaper, faster and better*
- G Lunter (Wellcome Trust Centre for Human Genetics, Oxford) *From calling bases to calling variants: experiences from the analysis of Illumina sequencing data*
- J Taylor (CSIRO, Canberra) *Looking under the hood; profiling genome function with sequencing*

The tutorial workshop was well attended positively received.

Main Programme

Following the workshop, the pattern for the remaining three weeks was for the long-term participants to continue their research, meeting once a day for an informal seminar/discussion at 11am. The discussion leader was decided each day, on a volunteer basis with no obligation to participate. This worked well with all slots being filled and only a few wishing to present who were unable to do so. Some of the presenters and topics were:

- Nilanjan Chatterjee: GWA SNP effect sizes and missing heritability
- Danielle Witten: Poisson models for RNA sequence data
- Jen Taylor: Plant genomics and *k*-mer editing
- Heather Cordell: Association studies with sequence data; rare variants
- Wally Gilks: Data compression of DNA and RNA sequences: a statistical view
- Paul Fearnhead/Xavier Didelot: Recombination in bacteria
- Tim Massingham: Data format/storage issues
- Gerton Lunter: Inference of demography and migration
- Zam Iqbal: De Bruijn graphs and assembly
- Jon Wakefield: Allele specific expression
- Yun Song: Analytic sampling formulas for the coalescent with recombination
- Chris Holmes: Problems of Bayesian inference
- Phil Green: Some thoughts on SNP detection
- Lachlan Coin: Final wrap up: what did we learn? What are the interesting problems to work on?

The formats of these sessions varied, some being standard seminars with a dialogue with participants throughout, others being more tutorial-like, others presenting open problems or work-in-progress. They were well attended, with typically 10–15 participants.

Open for Business Event

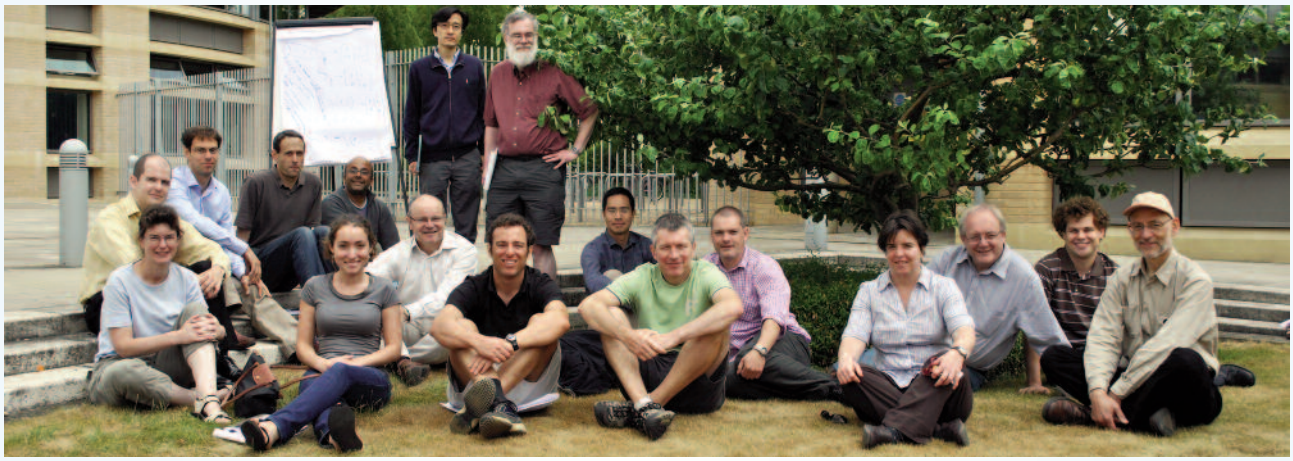
The programme held an *Open for Business* day on 3 August 2010 entitled *Future Developments in Genome Resequencing* which brought together leading mathematical and biological researchers in an interdisciplinary and industrial environment to discuss the mathematical, statistical and computational challenges that lie ahead. The day included the following talks:

- M Nelson (GlaxoSmithKline) *Prospects for pharmacogenetics in a genome-sequencing era*
- N Carter (Wellcome Trust Sanger Institute) DECIPHER *and opportunities and challenges for clinical genetics of next generation sequencing*
- D Bentley (Illumina) *Should I sequence my genome now?*
- G McVean (Oxford) *The 1000 Genomes Project and challenges in population-scale sequencing*

Outcomes and Achievements

Besides the formal talks, the first week of the programme provided an important opportunity for large numbers of researchers from diverse backgrounds (e.g., computing, statistics, mathematics and biology) to exchange ideas about how they are dealing with the immediate practical challenges posed by rapidly-changing sequencing technologies. Although the effects of this are difficult to quantify, anecdotally this type of informal interaction is of considerable benefit, particularly facilitating the sharing of "tricks of the trade" that play a vital role making complex scientific projects work, but which may not get much attention in written papers.

SJ Wilkinson



Programme Participants

Many longer-term attendees provided positive written feedback. Some extracts from participants' reports:

K Albers: I worked mostly on implementing the analysis pipeline for exome resequencing samples, and the ongoing discussions about pitfalls in sequence analysis were useful and inspiring for this work. In addition, the talks provided inspiration and ideas for thinking about extending previous work I did on variant calling from next-generation sequencing data.

W Gilks: The scientific programme for the workshop week at the beginning of the programme was excellent, and the lecture which took place each weekday morning of the following three weeks really broadened my horizons.

J Marioni: The workshop has provided an excellent environment for research, both to take forward on-going projects and also to generate new collaborations. Following my oral presentation in the first week of the workshop, I received very interesting feedback and suggestions from a number of people attending the workshop … one of the sessions (led by Jon Wakefield) was extremely useful in providing new directions in which I can take this aspect of my research … I have had several excellent conversations with Gil McVean and various members of his group about single-cell sequencing. Following these discussions, I am currently in the process of organising (along with Gil) a small meeting …

J Taylor: … I have been exploring the utility of these properties and characteristics to inform the handling and interpretation of NGS data. During this workshop, I had excellent conversations with other participants regarding the interpretation of these characteristics and have several additional lines of investigation to explore.

P Fearnhead: Discussions with Yun Song … have led to a deeper understanding by both of us of the genealogical interpretation of these sampling distributions, which hopefully will be useful when the ideas are applied to 3-locus models.

H Jiang: … the programme was very comprehensive in terms of the problems that were discussed … *de novo* assembly of transcriptomes, SNP detection, inference of population evolution and migration history.

Lectures on the Web

Perhaps one of the most important outputs of the programme has been the availability online of the videos of the workshop presentations. Approximately 20 videos have been viewed more than 100 times and two have been viewed nearly 500 times. The high quality of the videos has been appreciated by users. In May 2011, downloads of these videos are still occurring at the rate of about 5 per day. Many speakers also made their slides available. They are available on the programme website.

There is no doubt that mathematical/statistical/computational models for analysis of large-scale DNA sequence datasets is a field still in the early stages of exciting growth, and there is plenty of potential for exciting and fruitful future research programmes in this area.

Gyrokinetics in Laboratory and Astrophysical Plasmas

19 July to 13 August 2010

www.newton.ac.uk/programmes/GYP/

Report from the Organisers:
W Dorland (Maryland), S Nazarenko (Warwick) and A Schekochihin (Oxford)

SJ Wilkinson

A Schekochihin and W Dorland

Background

The motivation for the programme was the challenge of understanding plasma turbulence (and, more generically, kinetic turbulence). While the problem is long-standing, it is made particularly timely by a number of recent developments: the start of the ITER project for fusion plasmas, the availability of unprecedented amounts of data on small-scale plasma fluctuations from modern measurements in the laboratory and in the solar wind, radical increases in computing power making fully resolved 3D kinetic simulations finally feasible, and substantial progress in understanding due to recent theoretical advances.

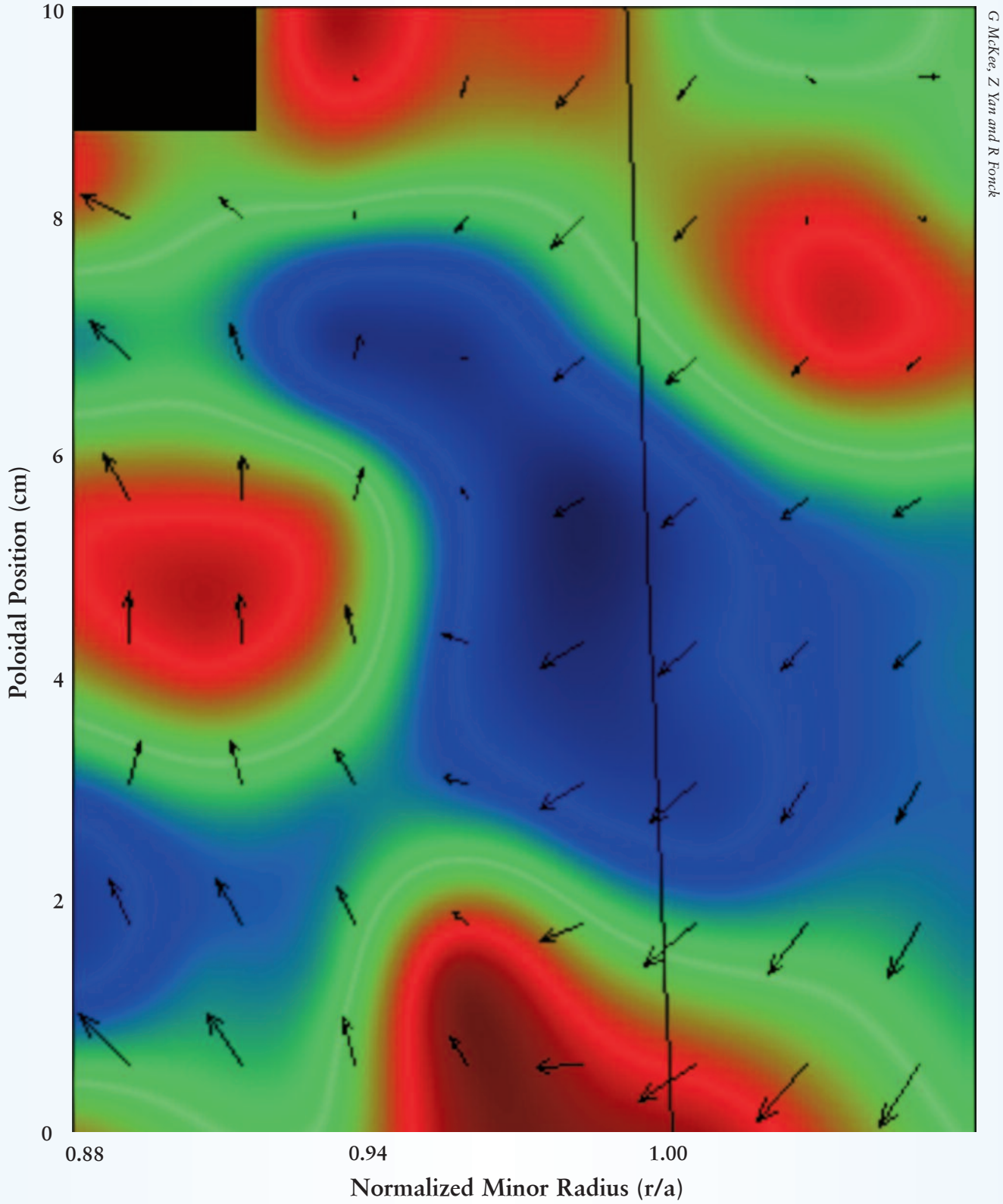
Gyrokinetic theory has emerged as the theoretical framework of choice in both fusion plasmas and, increasingly, in space plasmas, because it offers a rigorous way of reducing the dimensionality of the kinetic phase space and the timescale range that must be handled by mind or computer. The gyrokinetic approximation (especially, as has emerged during the programme, the aspect of it that deals with the coupling between fluctuation scales and transport scales) does, however, pose a number of mathematical problems – ranging from nearly pure mathematical ones (well-posedness of the equations) to very practical (efficient numerical methods). The programme aimed to address the problems of plasma turbulence, its numerical modelling and its gyrokinetic description by bringing together a broad group of interdisciplinary experts: from experimentalists and observers to numerical modellers, plasma theorists and applied mathematicians.

Programme Structure

During the first week of the programme a workshop *Kinetic-scale turbulence in laboratory and space plasmas: empirical constraints, fundamental concepts and unsolved problems* was organised by S Bale, T Carter, W Dorland, S Nazarenko and A Schekochihin. The idea of the workshop was to set the stage by focussing on the range of empirical facts, and the challenges to modelling, that they pose.

In the following three weeks we held two seminars each day and there were six mini-workshops:

- Kinetic reconnection (26 July)
  Organisers: N Loureiro, A Schekochihin and D Uzdensky
- Edge gyrokinetics (27 July)
  Organiser: P Catto
- Drift tearing and microtearing (28 July)
  Organiser: N Loureiro
- Gyrokinetics for simple laboratory plasma configurations (29 July)
  Organiser: P Ricci
- Gyrokinetic phase-space turbulence (2 Aug)
  Organisers: J Krommes and G Plunk
- Approaches to global full-f gyrokinetic simulations (10 Aug)
  Organiser: F Parra



Low-wavenumber density turbulence image obtained with Beam Emission Spectroscopy on DIII-D tokamak near the edge of a low-confinement mode discharge on the verge of transitioning to a high-confinement mode. Reconstructed image obtained from a one microsecond sample window with an 8×8 array of discrete detectors. Red represents positive density fluctuations, blue negative, and green the equilibrium density. Superimposed are the velocity vectors of the local turbulence structures obtained by velocimetry analysis of a sequence of images, showing the interactions and shearing of turbulent eddies. Eddy structure scale lengths are about 10 ion gyroradii.

SJ Wilkinson

Participants at the workshop 'Kinetic-scale turbulence in laboratory and space plasmas: empirical constraints, fundamental concepts and unsolved problems'

The seminars, offline discussions and collaborations were structured around 11 working groups focused on specific problems:

1. Alpha particles, their transport and Alfvenic instabilities (moderator: I Abel)
2. Astrophysical kinetics and gyrokinetics (moderators: S Balbus and G Hammett)
3. Phase-space turbulence, energy flows in gyrokinetics (moderators: J Krommes and G Plunk)
4. Edge gyrokinetics (moderator: P Catto)
5. Global full-*f* simulations (moderator: F Parra)
6. Hamiltonian gyrokinetics (moderator: A Brizard)
7. Kinetic reconnection (moderators: N Loureiro and D Uzdensky)
8. Microtearing and high-beta gyrokinetics (moderators: N Loureiro and C Roach)
9. Sheared gyrokinetic turbulence, interactions between flows and turbulence (moderators: F Casson and E Highcock)
10. Gyrokinetics for simple laboratory plasma configurations (moderator: P Ricci)
11. Tokamak transport (moderator: M Barnes)

Outcomes and Achievements

The programme outcomes are best represented by the publications that were produced. A less directly measurable but no less important outcome is a new network of collaborations that have emerged (from the interdisciplinary selection of the programme participants, for many of whom this was the first time that they had attended the same scientific gathering together). Discussions held during the programme have influenced the thinking throughout the community. Since the programme finished, two other interdisciplinary events of this kind have been organised by the participants of the programme.

- *Dynamics and turbulent transport in plasmas and conducting fluids* (organised by N Plihon *et al.* at Les Houches, February 2011)
- *Vlasov–Maxwell kinetics: theory, simulations and observations in space plasmas* and *Fusion theory working group meeting* (organised by F Califano and A Schekochihin at the Wolfgang Pauli Institute in Vienna, March 2011)

The topics that received particular emphasis and so deserve special mention were:

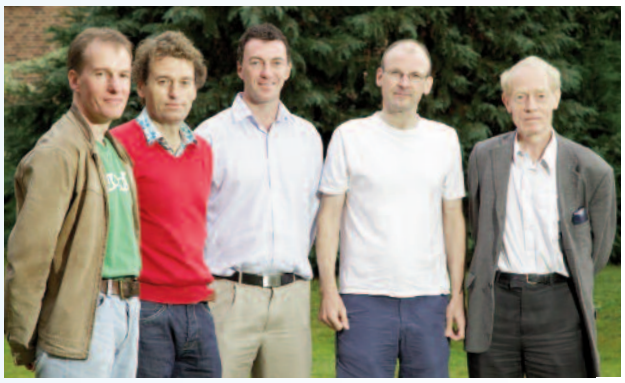
- Transport bifurcations in fusion plasmas and subcritically driven gyrokinetic turbulence
- Fast magnetic reconnection, plasmoid reconnection, gyrokinetic reconnection
- Momentum transport and energy conservation in gyrokinetic formalism and implications for numerical modelling

Mathematical and Statistical Approaches to Climate Modelling and Prediction

11 August to 22 December 2010

www.newton.ac.uk/programmes/CLP/

Report from the Organisers:
R Chandler (UCL), M Collins (Exeter), P Cox (Exeter), K Horsburgh (NOC, Liverpool), JM Huthnance (NOC, Liverpool), JC Rougier (Bristol), DB Stephenson (Exeter) and J Thuburn (Exeter)



L McIlwraith

R Chandler, M Collins, DB Stephenson, JC Rougier and JM Huthnance

Background

The Earth's climate system is complex with a multitude of spatial and temporal scales and although some aspects are well understood, others are not easily represented in computer models (simulators) and it is not feasible to represent smaller-scale processes in global climate models (GCMs). Transfers between scales are often best regarded as stochastic at resolved and unresolved scales. Thus uncertainties in GCMs lead to uncertainties in climate projections, as do uncertainties in initial conditions and forcing (e.g., volcanic aerosols and especially greenhouse gases). Against this background, the programme had two main themes: (a) stochastic parameterisation schemes and statistical implications, and (b) probabilistic climate prediction.

Programme Structure

During the programme there were three workshops and an *Open for Business* event. In addition, there were 49 other seminar presentations which participants were encouraged to deliver early to foster interaction. Dispersed throughout the programme there were organised discussions on particular themes.

Methods in Climate Modelling

Workshop, 23–27 August 2010

Organisers: P Cox, K Horsburgh and J Rougier

This workshop produced several new insights into the use of simple (phenomenological) models related to recent advances in statistics that allow these models to be carefully fitted to measurements and an opportunity for this expertise to be transferred to stochastic schemes for sub-grid-scale processes.

Probabilistic Climate Prediction

Satellite Meeting at the University of Exeter, 21–23 September 2010

Organisers: DB Stephenson, M Collins, JC Rougier and R Chandler

This satellite meeting led to the following research challenges being identified.

1. The need for statistical frameworks for multi-model ensembles (MMEs) that lead to reliable predictions of societally-relevant variables, taking account of process information (physical metrics) and complex biases (non-linear, time-dependent etc), leading to design of MMEs that include climate models with varying complexity and resolution.

2. Rigorous evaluation of probabilistic climate predictions and their assumptions.

3. Recognition of sources of uncertainty in probabilistic climate predictions.

4. Reconciliation of operational and conceptual probabilistic definitions of climate and climate trend.

Uncertainty in Climate Prediction: Models, Methods and Decision Support

Workshop, 6–10 December 2010

Organisers: R Chandler, JM Huthnance

This workshop combined the programme's two themes and emphasised user needs. Presentations,

including "stakeholder" contributions from outside the programme, identified the programme's achievements in addition to challenges and future directions for climate science.

At the highly successful *Open for Business* event, *Climate Change Question Time* in London on 24th November, a presentation by the Rothschild Visiting Professor Tim Palmer to over 250 participants was followed by two panel discussions: *The Scientific Uncertainties and Their Implications* and *Policy in the Face of the Uncertainties*.

Outcomes and Achievements

A success of the programme was to demonstrate that pressing challenges in climate science, including policy and investment decision-making, can be addressed by better collaboration between mathematicians/statisticians and climate scientists, taking the debate beyond the traditional deterministic paradigm of climate modelling. Many advances were made and new collaborations, between two and five per participant, were initiated. Many papers and books were written and the proceedings of the August workshop will appear in a theme issue of *Philosophical Transactions of the Royal Society of London A*. The programme outcomes will influence IPCC AR5.

Framework for Handling Uncertainty

The programme produced significant developments in the analysis and interpretation of ensemble experiments including the weighting of simulators, handling deficiencies, decision-relevant probabilities, and phenomenological models for studying complex systems, data assimilation, approximation with emulators for large problems and Bayesian methods to reconstruct palaeoclimates.

Progress was made on extending ensemble-based data assimilation to non-Gaussian schemes. Initial studies were done on Gaussian mixture models.

The state of the climate system is modelled as a probability distribution function (pdf) for which assimilation of observations should lead to best estimates. Assimilation involves an ensemble of pdfs, each with a certain probability. This "pdf of pdfs" should be governed by some kind of infinite-dimensional Fokker–Planck equation. This approach is being pursued.

Probabilistic Projections

The "ASK" method applies to scaling factors (based on "detection and attribution") for simulator output to adjust space-time patterns associated with forcing. It was agreed that the resulting climate projections need to make clear the methods and assumptions.

Observation-based stochastic models using Linear Inverse Modelling (LIM) showed that the trend in the most energetic sea-surface-temperature pattern is improbable based on natural variability alone. Future collaborations will evaluate trends relative to internal variability in IPCC models using LIM-based techniques. LIM provides information on patterns of variability and forcing as possible diagnostics for climate model performance.

Optimal trade-off for finite computing has been analysed: ensemble (spanning key sources of uncertainty to assess uncertainty, risk or extreme events) versus refinement (improving simulator parameterisations and/or spatial resolution).

Emulators

An emulator is first fitted to a designed set of simulator runs, before being used for statistical inference on the simulator outputs. A "toy" example showed emulator utility even for very nonlinear functions. Emulation of extremes allowing for uncertainty in the model inputs was investigated. The role of experimental design was developed and Bayesian neural net emulators were extended to account for uncertainty within a large-scale calibration exercise. Multivariate emulation of HadCM3 and other output was demonstrated, including use of emulators to learn about simulators (structure). Emulator-based palaeoclimate reconstructions, synthesising GCM evaluations and proxy reconstructions, and including a structured assessment of uncertainty, was presented by programme participants at the 2010 AGU Fall Meeting.

Paleoclimate and Proxy Data

Reconstructing past climates from proxy data is a complex statistical problem because the climate and proxies are multivariate and observations are sparse. A chronological scale is wanted, but each proxy type responds to climate distinctively and translates time to a depth scale differently. Statistical methods

R Wooding

One of the panel discussions during 'Climate Change Question Time'

for chronology building in palaeoclimate reconstructions were investigated.

Tipping Points

Significant numbers of climate states during the last ice age have been inferred. Indicators via variability have been analysed temporally and spatially, devising algorithms for the more novel spatial aspect for GCMs.

A theoretical model of rainfall, related land cover and terrestrial carbon was developed to investigate Amazon forest die-back. Predictions based on HadCM3LC climate are being compared with major vegetation changes in HadCM3LC.

GCMs

Proofs that the semi-geostrophic equations can be solved rigorously in spherical geometry supports their use as a simple model of large-scale atmospheric circulation. Recent results improve understanding of blocking climatology: blocking is likely to be more frequent with a smaller radius of deformation, which in turn is influenced by stratospheric winds.

The commonly-used filter for leap-frog time-stepping had been modified recently to give much improved accuracy; the simple improvement was extended to semi-implicit schemes.

Progress was also made on a new semi-implicit semi-Lagrangian dynamical core, specifically on convergence of the iterative nonlinear solver.

The Hamiltonian Particle Mesh method (HPM) guarantees exact transport and conservation of mass. Tests show that HPM can represent atmospheric flows and preserves energy accurately in long-term simulations. Current work concerns orography forcing gravity waves, moist processes and convective parameterisation due to diabatic heating.

Stratospheric processes and chemistry affect tropospheric processes and climate. Programme discussions resulted in the setting up of a UCL project, with Leverhulme Trust funding, to calibrate chemistry parameterisations in the NCAR Whole Atmosphere Community Climate Model.

Stochastic Parameterisations and Turbulence Spectrum in GCMs

Processes too detailed for direct GCM simulation might be represented by an emulator of the process model, deterministic or stochastic. A new collaboration was begun to explore emulators for superparameterisation in relation to clouds. A stochastic parameterisation of convective clouds, hitherto applied in single-column models and ensemble weather forecasting, will now be tried out for NCAR's next climate model. Progress was made in modelling convection out of equilibrium yet still accounting for its stochastic nature. Work was planned to resolve cumulus convection by taking into account the distribution of variability in the atmospheric layer and to use stochastic models to represent atmospheric dispersion through city streets. Following the programme, NCAR is running fine- and coarse-resolution twin experiments for stochastic potential vorticity flux from sub-grid to resolved scales.

Reduced stochastic modelling methods were discussed in relation to climate modelling. The aim is to find equations of motion which sample the distribution and allow for evaluation of temporal quantities, e.g. auto-correlation functions. Two approaches were linked for first time with a proof that the Nosé–Hoover–Langevin equations reduce to the Langevin equation in the limit of large stochastic variance.

Although the role of Maximum Entropy Production (MEP), which was the subject of several presentations and discussions, is not yet clear, surprisingly good estimates often result from its use with simplified models or sub-models. Whether MEP holds for land-sea temperature contrast posed in MEP terms is being studied.

Partial Differential Equations in Kinetic Theories

16 August to 22 December 2010

www.newton.ac.uk/programmes/KIT/

Report from the Organisers:
JA Carrillo (Barcelona), S Jin (Wisconsin) and PA Markowich (Cambridge)

SJ Wilkinson

S Jin and PA Markowich

Background

Kinetic equations occur naturally in the modelling of the collective motion of large individual particle ensembles such as molecules in rarefied gases, beads in granular materials, charged particles in semiconductors and plasmas, dust in the atmosphere, cells in biology, or the behaviour of individuals in economic trading. Although such a variety of applications seems at first sight overwhelmingly broad, there are important common mathematical features in the kinetic theories of all these applications. Generally, huge interacting particle systems cannot efficiently be described by the dynamics of individual particles due to complexity, but clearly some input from the microscopic behaviour is needed in order to bridge from microscopic dynamics to the macroscopic world, typically described in terms of averaged quantities. This leads to classical equations of mathematical physics: the Boltzmann equation of rarified gas dynamics, the fermionic and bosonic Boltzmann equations and the relativistic Vlasov–Maxwell system of particle physics, the quantistic Wigner–Poisson system, to name just a few.

As a spin-off kinetic theory has produced many new mathematical tools in the last 20 years: renormalized solutions of transport equations by R DiPerna and PL Lions, averaging lemmas by the French kinetic school, and entropy dissipation tools which have been extended methodologically and used far beyond kinetic theory, are just some highlights of new analytical PDE methods stemming from kinetic theory. Another landmark in this field was the recognition of the hydrodynamic limit of renormalized solutions of the Boltzmann equation as (weak) Leray solutions of the Navier–Stokes equations by F Golse and L Saint-Raymond. On the other hand, kinetic theory has different scientific viewpoints, ranging from applied mathematical and physical modelling to stochastic analysis, numerical analysis of PDEs and, in many important cases, extensive numerical simulations.

While modern computers are still inadequate in simulating dynamics in micro- and nano-technologies, kinetic equations provide models that can capture important features of microscopic or quantum phenomena with a computational cost that is manageable by today's computing facilities. Indeed, the mesoscopic kinetic theory, connecting the microscopic and even quantum scale to the hydrodynamic scales, plays a central role in developing these modern computational methods.

Main Objectives

The main objective of this programme was to advance Partial Differential Equations (PDEs) research in kinetic theories and to develop its impact in the applied sciences, highlighting selected modern application areas. This effort was made from a global perspective of research in PDEs, bringing together mathematical modelling, analysis, numerical schemes and simulation in a feedback loop of synergies. Therefore, the main goal was to foster a mathematical understanding of Boltzmann and

S Greenham

Fields Medallist Cédric Villani and programme organiser José A Carrillo

Vlasov-type models which is accessible to scientists who apply them in specific application areas.

For this programme we chose three exemplary newly emerging areas of application of kinetic theories. This choice was made to facilitate the embedding of our programme into UK (and Cambridge) scientific strengths in fluid dynamics, mathematical modelling of biological flows and quantum mechanics. These three topics represented and still do very active and fast-paced growing areas of kinetic research.

The three selected emerging application areas of kinetic theories were:

Kinetic Modelling in Biology

Various kinetic models have been proposed for the description of chemotaxis, collective motion of individuals (swarming), blood coagulation, tumour growth and neuroscience. They include running & tumble kernels, Keller–Segel equations, and coagulation-fragmentation models to name just a few. From a more mathematical analysis viewpoint they are modelled through nonlinear drift-diffusion or Fokker–Planck equations. The main questions treated were long-time asymptotics, free-energy functionals, probability tools and refined estimates for mathematical fluid equations.

Coupled Fluid–Particle Models

Fluid-kinetic coupling appears naturally in many applications such as: motion of swimming bacteria in a fluid, polymers, and aerosols/sprays with applications ranging from Diesel engines to drug delivery by means of aerosols in human lungs.

Their analysis includes tools related to core mathematical techniques in general kinetic theory such as: entropy estimates, scaling limits, simplified asymptotic equations, closures and approximated models.

PDE Models for Quantum Fluids

Quantum fluid modelling attracts lots of attention, mainly due to the phenomenon of Bose–Einstein condensation. Kinetic equations, relying mainly on the Wigner transformation, can also be applied to quantum fluid dynamics. Recently hybrid kinetic-quantum mechanical models, coupling the Gross–Pitaevskii equation to the boson Boltzmann equation, became a hot topic.

Outstanding problems in general kinetic theory that remained to be clarified at the time of the programme: convergence and equilibration rates in inhomogeneous Boltzmann-type problems, mean-field limits, weakly inhomogeneous situations, weak relaxation for Vlasov-models related to Landau damping, asymptotic preserving schemes, Bose–Einstein condensation modelling and Bohmian measures for Wigner–Poisson.

Programme Structure

With the initial help of the Scientific Advisory Committee, formed by Y Guo (Brown, USA), R Illner (Victoria, Canada), B Perthame (Paris VI, France), A Stuart (Warwick), JF Toland (Bath) and G Toscani (Pavia, Italy), the organisers co-ordinated long-stay visits for more than 120 invited researchers. These included many of the prominent researchers in kinetic theory worldwide. At the beginning of the programme (25 August to 3 September 2010) we organised a series of lectures and tutorials in specific areas of current interest for kinetic theory practitioners, to trigger collaborations between established and newly arrived participants, and junior researchers.

Fluid-Kinetic Modelling in Biology, Physics and Engineering

Workshop, 6–10 September 2010

Organisers: JA Carrillo, A Jüngel

This workshop included general talks on the role of Partial Differential Equations in kinetic theories and on new applications of kinetic modelling in the fields of mathematical biology, mathematical physics and engineering. Some of the application fields covered were swarming, coagulation processes and biological flows.

PDEs in Kinetic Theories: Kinetic Description of Biological Models

Satellite Meeting at ICMS, Edinburgh, 8–12 November 2010

Organisers: N Bournaveas, E Tadmor

The main objective of this satellite workshop at the ICMS (Edinburgh) was to bring together leading researchers to review recent developments in research on mathematical modelling, analysis, numerical schemes and simulation of kinetic equations in general and of models in biology in particular.

PDE Models for Quantum Fluids

Workshop, 13–17 December 2010

Organisers: S Jin, PA Markowich

Recent advances in the mathematical understanding of Bose–Einstein condensation were the main theme of this workshop. Quantum fluid modelling in vortex dynamics, mixing of scales in random phase approximations, lattice and multi-component condensates modelled by coupled systems of nonlinear Schrödinger equations and Wigner-like kinetic equations were also treated.

During the programme a weekly seminar working group was organised so that participants who had not had an opportunity to give a talk during a workshop could participate.

At the beginning of the programme we were thrilled to hear that Cédric Villani, a leading researcher in kinetic theory, received the Fields Medal. He gave a well-received talk at the Centre for Mathematical Sciences at the University of Cambridge sponsored by our programme, and he also participated in our weekly seminar. His recent work mentioned in the laudation of the Fields Medal in collaboration with C Mouhot (Cambridge) was the object of special attention during the programme, since C Mouhot gave us a 10-hour course on Landau damping, explaining the details of this landmark work.

Outcomes and Achievements

As we expected, the programme was important in creating significant critical mass in events and brainpower. Research visits of interested junior and senior scientists improved the visibility of UK research in PDE analysis as requested by recent international reviews. We encouraged visits by PhD and postdoctoral researchers in order to attract talented, early career researchers from all over the world. We also focussed on attracting researchers in related areas such as fluid dynamics (JL Rodrigo), mathematical analysis (J Bennet) or applied PDEs and asymptotics (J King). Finally, the thematic programme attracted 97 Visiting Fellows, 34 Programme Participants and 4 Affiliated participants.

The long-term effects of highlights such as the two talks by C Villani in attracting good students to PDE analysis are hard to measure, but certainly they will contribute to it, particularly in the steadily-growing local group of PDEs in Cambridge. As mentioned already the course on Landau damping in kinetic theory by C Mouhot was another highlight of the programme.

Many scientific developments were initiated by this programme; some of them already reported as Newton Institute preprints and others will emerge in the near future. We are aware of a large number of collaborations through the individual scientific reports of each long-stay participant. The mixture of scientists of different origins and backgrounds, such as applied mathematicians in mathematical biology problems, mathematical and numerical analysts of PDEs and designers and developers of numerical schemes and simulations, is an achievement that we are pleased to have facilitated. We expect that the synergies obtained from this mixture will be reflected in the large impact of the publications obtained or initiated from the discussions at the Institute.

Moduli Spaces

4 January to 1 July 2011

www.newton.ac.uk/programmes/MOS/

Report from the Organisers:
L Brambila-Paz (CIMAT, Mexico), O García-Prada (CSIC, Madrid), PE Newstead (Liverpool), and R Thomas (Imperial College London)

SJ Wilkinson

PE Newstead, L Brambila-Paz, R Thomas and O García-Prada

Scientific Background

Algebraic geometry has strong connections with many areas of mathematics and with theoretical physics. Moduli theorists study how objects in algebraic geometry vary in families in order to understand the objects themselves. Although the theory goes back at least to Riemann, moduli spaces were first rigorously constructed in the 1960s by Mumford and others and developed, notably with an infusion of ideas from physics, after 1980.

This programme focussed on three topics: stability in derived categories; the relationship of moduli spaces to topology, Teichmüller theory and hyperbolic geometry especially in the context of Higgs bundles; and moduli of bundles and coherent systems on algebraic curves.

Programme Structure

The intention was to allow maximum time for discussion and for interactions across subject boundaries. There were four workshops, one of which was an introductory school, a Spitalfields Day and a one-day meeting on vector bundles and coherent systems. There were periods of concentration on stability of complexes and of varieties, representations of surface groups and Higgs bundles, and vector bundles and coherent systems.

Workshops

Introductory School

Workshop, 5–14 January 2011

Organisers: L Brambila-Paz, O García-Prada, PE Newstead, R Thomas

This introductory workshop consisted of thirty-two hours of lectures that covered the foundations and some major developments in the field and introduced tools for studying moduli. There were 134 highly enthusiastic graduate students, postdocs and others in attendance. A book based on the courses from this introductory school is in preparation.

Representations of Surface Groups and Higgs Bundles

Satellite Meeting at the University of Oxford, 14–18 March 2011

Organisers: O García-Prada, W Goldman, T Hausel, NJ Hitchin, PE Newstead

This meeting concentrated on the relationship of moduli spaces to topology, Teichmüller theory and hyperbolic geometry in the context of representations of surface groups. Higgs bundle theory, bounded cohomology, Anosov systems, cluster varieties and tropical algebraic geometry are involved. There were 61 participants.

Derived Categories

Workshop, 11–15 April 2011

Organisers: T Bridgeland, J Stoppa, R Thomas

Preceded by a week of informal talks, this workshop focussed on derived categories of coherent sheaves

and the interactions with moduli, stability, invariants, mirror symmetry, string theory, geometric representation theory and knot theory. There were 117 participants.

Closing Conference

Workshop, 27 June–1 July 2011

Organisers: PE Newstead, L Brambila-Paz, O García-Prada, R Thomas

This event incorporated the 2011 workshop of the Research Group Vector Bundles on Algebraic Curves with 13 invited talks, 9 contributed talks and posters on the theory of moduli. There were 116 participants.

Outcomes and Achievements

Many new results emerged, collaborations were consolidated and new projects launched. *Asterisks below indicate Preprints of the Newton Institute.

Derived Categories

In moduli space theory the definition of invariants of 3-folds using derived categories of sheaves is a highly active area where significant progress was made during the programme.

To extract moduli spaces from the derived category a notion of stability is needed. This has been done only in special cases (for the abelian category of sheaves, rather than the whole derived category, or for certain types of stable pairs) using *ad hoc* methods and geometric invariant theory. A celebrated general theory of stability in derived categories has been developed by Bridgeland. During the programme Bayer, Bertram, Macri and Toda** made and reported a breakthrough in constructing Bridgeland stability conditions on 3-folds, making an unexpected link with Fujita's conjecture in Mori theory. Maciocia, Yoshioka and Smith all reported progress including exciting physics-inspired work with Bridgeland and work by Maciocia and Meachan*on Bridgeland stability on principally polarised abelian varieties.

The world's experts in ways of extracting invariants from such moduli spaces (Behrend, Fantechi, Joyce, Kiem, Li, Lieblich) explained recent work and new perspectives. Kiem and Li made substantial progress on wall-crossing formulae using Kirwan blow-ups, and the state of the art was changed by the programme. More powerful motivic and categorified versions of the numerical invariants are now defined in some cases and calculations reported by Bryan, Davison, Nagao, Szendröi and Reineke suggest a beautiful theory.

Where moduli spaces can be constructed, the emphasis is on how the resulting invariants relate to other invariants, such as Gromov–Witten and the long-conjectured BPS invariants of Gopakumar–Vafa from string theory. Leading figures such as Bryan, Diaconescu, Göttsche, Pandharipande, Shende and Toda worked intensively with Thomas, and Toda completed two papers on generalised Donaldson–Thomas invariants**. By the end there was a complete understanding of how these theories match perfectly for plane curves in Calabi–Yau 3-folds (*A Support Theorem for Hilbert Schemes of Planar Curves*, Migliorini and Shende, arXiv: 1107.2355). Göttsche also developed a new and deeper motivic version of his famous conjecture, motivated by Kool–Shende–Thomas' recent proof. In discussions with Shende he also made a remarkable discovery about its link to Welshinger invariants counting real curves. This could be a big topic of research for the next decade.

The interaction of moduli and physics seemed particularly successful when Diaconescu's physical insights into BPS invariants influenced the mathematicians' approaches, and vice-versa. Garcia-Fernandez started collaborating with Ross on stability conditions for pairs with applications in theoretical physics. Huge numbers of graduate students were interested in this area, and commented on how helpful it was to interact with the leaders in the field.

Most of the world's experts on derived categories of quiver representations and their invariants participated, from Nakajima in mathematics to Hanany in physics. Hanany announced a generalisation of Nakajima's famous construction of hyperkähler spaces. Cautis and Nakajima explained beautiful categorifications of Nakajima's algebra actions on cohomology of quiver moduli. Reineke completed work on quantized Donaldson–Thomas invariants for m-loop quivers.

Understanding the 20-year-old mirror symmetry conjecture is a major challenge about which Gross,

SJ Wilkinson

Participants in the Introductory School

Iritani, Keel, Pantev, Soibelman and Zaslow explained substantial progress. Linked and unified proofs from a number of different perspectives may soon emerge, yielding a proper understanding of this remarkable phenomenon.

Higgs Bundles and Character Varieties

Logares, Muñoz and Newstead completed work* involving discussions with Hausel and Thomas on Hodge polynomials of character varieties. Joint work*of García-Prada, Heinloth and Schmitt on the computation of the motive of the moduli space of rank-4 Higgs bundles confirmed conjectures of Hausel and Rodriguez-Villegas with progress on the generalization to higher rank.

Pantev and Simpson settled the compatibility of pushforward for morphisms of relative dimension one in the functoriality of the ramified non-abelian Hodge theory correspondence.

Joint work by Balaji with Seshadri on parahoric bundles was completed following discussions with García-Prada, Biquard, Mundet and Narasimhan. Substantial progress was made by Biquard, García-Prada and Mundet on parabolic G-Higgs bundles and representations of the fundamental group of a punctured surface. Balaji, Biquard, García-Prada, Heinloth and Mundet compared algebraic and analytic approaches to parahoric bundles. García-Prada and Ramanan worked on involutions on the moduli space of Higgs bundles and real forms of a complex semi-simple Lie group, García-Prada and Schaffhauser worked on real Higgs bundles over a real curve, and Bradlow, Biquard, García-Prada and Rubio worked on Higgs bundles for Lie groups of Hermitian type. Work by Goldman and Toledo on relative character varieties was completed*.

Research by Franco, García-Prada and Newstead on Higgs bundles on elliptic curves and by Alvarez-Consul, Garcia-Fernandez and García-Prada on coupled Yang–Mills equations and Kähler metrics was completed*.

Vector Bundles and Coherent Systems

The primary object of work on rank 2 stable bundles with 4 sections on algebraic curves is to determine the smallest degree for which such bundles exist and hence to settle the rank 2 case of a conjecture of Mercat. Recent work was sparked by a paper of Grzegorczyk, Mercat and Newstead (building on work by Voisin). Following this, Farkas and Ortega produced a series of counter-examples, later extended by Lange and Newstead*, to Mercat's conjecture. During the programme, following discussions with Farkas, questions posed in Grzegorzcyk, Mercat and Newstead's paper were answered and included in a postscript.*

Osserman completed a paper on Brill–Noether loci for fixed determinant*. Earlier Teixidor had shown the expected result for determinant of large degree and during the programme, following discussions with Osserman and Teixidor, Grzegorczyk and Newstead showed that in certain cases where the determinant has smaller degree the corresponding moduli spaces of coherent systems possess a (sometimes unique) component of the expected dimension and Osserman's bound is sharp.

Newstead discussed coherent systems with Tommasini, and Gieseker–Petri divisors on the moduli spaces of curves with Lelli-Chiesa. There were many other discussions on the moduli of stable bundles.

Other Work

Work by Hulek and Grushevsky on intermediate Jacobians of cubic threefolds*, by Lange and Ortega on the Prym map for non-cyclic triple coverings* and by Mukai on the Igusa quartic and Steiner surfaces* was completed. Pratoussevitch had new ideas on higher spin bundles and Gorenstein quasi-homogeneous surface singularities, which she discussed with Bayer, Giansiracusa, Newstead and Nitsure. Nitsure continued his collaboration with Neumann and obtained new results on gerbal stratifications of moduli stacks and Lange's universal extensions.

Discrete Analysis

10 January to 8 July 2011

www.newton.ac.uk/programmes/DAN/

Report from the Organisers:
K Ball (UCL), F Barthe (Toulouse), B Green (Cambridge) and A Naor (New York)

SJ Wilkinson

F Barthe, B Green, K Ball and A Naor (inset)

Aims and Background

During the past decade there have been dramatic developments in the interaction between analysis, combinatorial number theory and theoretical computer science: in particular between harmonic analysis and combinatorial number theory and between geometric functional analysis and the theory of algorithms.

The purpose of this programme was to bring together researchers in these diverse areas of mathematics, to encourage more interaction between these fields, and to provide an opportunity for UK mathematicians to engage with an important part of the mathematical computer science community.

The programme was attended by around 125 participants in addition to those who came solely for workshops. Participants gave some 60 seminars during the programme (again in addition to workshop lectures). The "cross-fertilisation" element of the programme meant that the seminars played a very important role in introducing people to one another and their research problems.

The programme was unusual in that there was a smaller programme on "Algorithms and Groups" at the Institut Henri Poincaré run at the same time, about half of which (in terms of topics) overlapped with some 20% of this one. This had some benefits in terms of travel costs for participants from the US. The Newton Institute streamed the lectures of the first workshop to Paris so that participants there could take part interactively. It seems likely that in future, scientists will consider video-conferencing as a normal way to take part in research conferences once the necessary equipment is sufficiently widely distributed. However, this is no substitute for face-to-face discussion

Workshops

Embeddings

Workshop, 10–14 January 2011

Organisers: A Andoni, T Austin, A Naor

The workshop was devoted to all aspects of metric embeddings: the general theory of non-linear functional analysis, links between embeddings and geometric group theory and applications of embeddings within theoretical computer science. The workshop featured around 25 lectures with speakers including Noga Alon, Subhash Khot, Nati Linial, Assaf Naor and Laurent Saloff-Coste. Khot and Saloff-Coste gave particularly accessible survey lectures on the Unique Games Conjecture and Random Walks on Groups, respectively.

For many participants, two of the most intriguing talks were those by Guoliang Yu and Goulnara Arzhantseva on the relationship between coarse embeddings of metric spaces and the Novikov Conjecture for higher signatures.

SJ Wilkinson

Participants at the 'Embeddings' workshop

The questionnaire responses were uniformly positive: all respondents rated the scientific content of the workshop high or above and more than three-quarters rated it excellent. It is always difficult to persuade diverse groups to talk to one another even when they share mathematical techniques and some participants said they would have liked a few more overview lectures, but the general feeling was that the workshop succeeded in making connections between researchers in three different branches of mathematics.

Discrete Harmonic Analysis

Workshop, 28 March–28 April 2011

Organisers: I Dinur, K Oleszkiewicz, F Barthe

The goal of this workshop was to bring together researchers interested in harmonic analysis in a discrete setting: in particular, properties of Fourier–Walsh expansions, influences of variables, Sobolev type inequalities and isoperimetry or concentration estimates. Such analysis plays a role in many fields and has applications to combinatorics, theoretical computer science, probability theory, statistics and number theory. Several talks were devoted to the interplay between the continuous and discrete settings (for example the implementation of log-concavity or curvature methods in the discrete case, geometric properties of Gaussian measures and so on). The workshop announcement was met with an extremely enthusiastic response and 100 participants attended. The speakers included Gowers, Håstad, Kalai and a lecture by the Rothschild Distinguished Visiting Fellow, Avi Wigderson. Among these, the lecture by Wigderson described opposite must count as a highlight, but the most important effect of the workshop was to make it clear to participants how very closely related are the methods being used in the several different fields referred to above. The questionnaires gave the workshop an 86% excellent rating for scientific content.

Groups and Additive Combinatorics

Satellite Meeting at Gregynog Hall, Wales
27 June–1 July 2011

Organiser: B Green

The theme of this workshop had been decided in 2010, following a sharp upturn of interest in topics at the interface of group theory and additive combinatorics sparked by a remarkable paper of Hrushovski and subsequent work of Pyber–Szabó and Breuillard–Green–Tao. An aim was to introduce group theorists to the new developments, in the hope that they might bring new insights or suggest new directions.

Many of the talks at the workshop concerned approximate groups and their connection with expansion and rapid generation in finite groups. Almost all of the main players in this area were present, gave presentations, and continued their collaborations. Hrushovski gave an admirable account for this non-specialist audience of his model-theoretic approach. Pyber spoke on his work with Szabó on approximate linear groups, Breuillard spoke on his new (2011) work with Green, Sanders and Tao on approximate groups in general, and Salehi–Golsefidy/Varjú and Guralnick all discussed their ongoing work on expansion phenomena.

Other talks at the workshop amply illustrated the diversity of phenomena that one may hope to study using a combination of group theoretic and additive combinatorial methods. For example, Elon Lindenstrauss discussed his deep work with Bourgain, Mozes and Furman on orbits of $\mathrm{SL}_n(\mathbb{R})$ on the torus.

The workshop concluded with an open problems session in which a variety of intriguing questions were presented. The questionnaires gave a 96% excellent rating for scientific content.

Rothschild Distinguished Visiting Fellow Lecture

The Rothschild Distinguished Visiting Fellow for the programme was Avi Wigderson from the Institute for Advanced Studies, Princeton who is perhaps the world's leading expert on the theory of algorithms. He delivered his lecture on *The power and weakness of randomness, when you are short on time*. The lecture was screened simultaneously in a second room since the main lecture room was unable to accommodate all attendees.

The lecture was a brilliantly clear and inspiring account of the way in which randomisation has been used to produce polynomial-time algorithms to solve a host of computational problems for which there is no deterministic algorithm. Professor Wigderson discussed the apparently paradoxical fact that if (as everyone believes) the class of NP-hard problems cannot be solved with algorithms that run in a time that is less than exponential as a function of the input size, then it must in principle be possible to remove the randomness: to find algorithms that are actually deterministic. He went on to describe the astonishing applications to probabilistically checkable proofs and zero knowledge proofs. He gave the example of a mathematician who wishes to demonstrate to others that s/he possesses a proof of a mathematical theorem without revealing anything about what the proof actually says. The true applications are very much more serious: you wish to demonstrate to retailers that you possess your credit card without revealing anything that would enable the retailer or eavesdroppers to demonstrate that they possess it.

Outcomes and Collaborations

At least half the participants described specific collaborations that they had begun or continued at the Institute. The following is a selection of some of the collaborative or individual work that has already resulted in articles.

Breuillard, Green, Sanders and Tao proved the nonabelian Freiman conjecture of Helfgott and Lindenstrauss. This is now being written up as a major article in additive combinatorics.

Oleszkiewicz and Sen (a postdoctoral researcher in Cambridge) found a way to relate their work on hypercontractivity for the discrete cube to the study

SJ Wilkinson

Participants at the 'Discrete Harmonic Analysis' workshop

of queues (a topic which has many applications in communications). This will be published in a joint article with Mossel.

Bennett, Bez and Gutierrez completed two articles on geometric estimates for transforms of Radon type.

Naor completed an article on the Grothendieck constant. This quantity arose in a seemingly very abstract problem in functional analysis but in the last few years has been found to be equal to the gap between classical versus quantum computation for a standard communication model. Naor has shown that the long-held belief as to the value of this quantity is false. Another participant, König, has been the expert on this quantity for many years and he and Naor have begun a collaboration.

Arzhantseva collaborated with C Drutu (who was not a programme participant) on the rapid decay property for word hyperbolic groups.

Braverman, Hatami and Gowers used results on quasi-random groups to improve the best available bounds on a problem in communication complexity. This was a striking example of two different parts of the programme interacting very successfully.

Bulatov, Dyer, Goldberg and Jerrum established a connection between log-supermodular functions and constraint satisfaction problems in computing.

Solymosi and Tao established a higher-dimensional versions of the famous Szemerédi–Trotter theorem, concerning point-line incidences.

Follow-up Meetings

The Institute is constantly seeking ways to extend and add value to its programmes. To this end, follow-up meetings are short events which compliment full programmes that were held some years earlier. These are proving increasingly popular with programme organisers because of how they provide an effective way to strengthen collaborations started during the original programmes and are particularly beneficial because the true implications of results may emerge from developments only years after a programme has finished. Follow-up meetings take place either at the Institute or at suitable venues anywhere in the UK.

During 2010/11 the Institute held four Follow-up Meetings and brief details are included here.

SJ Wilkinson

Participants at the 'Highly Oscillatory Problems: From Theory to Applications' Follow-up Meeting in September 2010

Highly Oscillatory Problems: From Theory to Applications

Isaac Newton Institute, 12–17 September 2010,

This event was sponsored by the European Science Foundation in partnership with the European Mathematical Society and the organisation of European Research Centres on Mathematics. It was chaired by Arieh Iserles as a follow-up to the six-month programme on *Highly Oscillatory Problems: Computation, Theory and Applications* which took place at the Newton Institute from January to July 2007.

Historically research into high oscillation phenomena has been distributed across many areas of pure and applied mathematics, with little cross-disciplinary communication and interaction. The original programme considered the notion of high oscillation as a central theme around which concerted inter-disciplinary research effort could be organised. Following upon the success of the original programme the follow-up event continued to foster the knowledge base of mathematical research into high oscillation across different disciplines and subject areas, with particular emphasis on computational issues. Cross disciplinarity here is not just a convenient optional extra, it is in the very nature of the underlying subject matter. Through forging a shared language between communities, the aim of the original meeting was to develop a comprehensive and unified theory of high oscillation and its computation. This confluence of theory and application was further developed in the follow-up meeting where issues addressed included electromagnetic and acoustic scattering, wave mechanics, multiscale problems, homogenisation, symplectic algorithms, computational asymptotics, Riemann– Hilbert techniques, and the theory of highly oscillatory partial differential equations.

There were lectures by distinguished speakers, short talks by young and early career researchers, poster sessions, and round table discussions. The meeting was attended by 89 participants.

Computational Challenges in Partial Differential Equations

University of Swansea, 4–8 April 2011

This event was following up on the six-month programme *Computational Challenges in Partial Differential Equations* which took place at the Newton Institute from January to July 2003. It was a collaboration with the Wales Institute of Mathematical and Computation Sciences and organised by Mark Ainsworth, Charles Elliot, Kenneth Morgan and Endre Süli.

The meeting concentrated on areas that are currently attracting significant interest. Sessions were held on multiscale modelling, interface modelling, PDE's on surfaces and geometric evolution problems, biomedical applications

including new modelling techniques and patient-specific applications, computational rheology, atomistic-to-continuum passage, density functional theory and quasi-continuum methods, low-order modelling and reduced bases and uncertainty modelling.

Pitched at a high scientific level, this was a successful scientific event including lectures by leading figures and outstanding young researchers in the field of numerical analysis of partial differential equations, scientific computing and computational engineering at the cutting edge of research. The result was an extremely productive interaction between engineers and mathematicians attended by 85 participants.

Phylogenetics: New Data, New Phylogenetic Challenges

Isaac Newton Institute, 20–24 June 2011

This event followed upon the highly-successful and popular *Phylogenetics* programme at the Newton Institute from September to December 2007. It was organised by Vincent Moulton, Mike Steel and Tandy Warnow and covered various mathematical and computational topics, in areas such as combinatorics, algebraic geometry and Bayesian statistics, that underly the theory of phylogenetic trees and networks. These structures are central to modern molecular evolutionary biology, and their applications, from understanding the origin of mammals and measuring biodiversity to the analysis of environmental metagenomics data, were also showcased. Several new results presented at the follow-up meeting were established in response to challenges raised during the original programme. Some of these results will appear in a special issue of the journal *Algorithms for Molecular Biology*.

Talks were delivered by 11 UK and international keynote speakers who set the scene for 32 short talks from participants invited by the organisers. Early stage researchers also had the opportunity to present their results in a poster session.

As with the original Phylogenetics programme, there was a great deal of enthusiastic informal discussion and existing and new interactions between participants at various stages in their careers were driven forward.

SJ Wilkinson

Participants at the 'Phylogenetics: New Data, New Phylogenetic Challenges' Follow-up Meeting which took place at Merton College Oxford in June 2011

In summary, the follow up meeting successfully delivered on all of its original objectives and produced several novel ideas and directions in what is still a rapidly evolving area of mathematical biology. The meeting was attended by 66 participants.

Cardiac Physiome Workshop

Merton College, Oxford, 8–10 July 2011

This event followed up on the *Cardiac Physiome Project* programme that took place at the Institute from June to July 2009. It built on the momentum generated from the Newton Institute programme and previous Cardiac Physiome Workshops held in Oxford (2006) and Auckland (2008). Modelling developments since then have provided potential for analysing complex cause and effect relationships and have facilitated an improved understanding of a whole range of physiological systems. The follow-up meeting continued the theme of combining both experimental and modelling research in order to understand functions across physiological scales in the heart.

Plenary talks were given by Don Bers, Nicholas Ayache and Yoram Rudy. Early career researchers had the opportunity to present a poster during the session and 39 interesting posters were displayed. The event was attended by 116 participants.

Serving the UK Community

Caroline Series, Chair of Correspondents

The Newton Institute is part of the infrastructure supporting scientific research in the UK. This section of the Annual Report summarises how it fulfils this role through serving the UK Mathematical Sciences community, through stimulating links with business, and through engaging with the wider public.

The involvement of the community is one of the Institute's major strengths, and the network of Correspondents listed opposite plays a key role in acting as a two-way channel of communication between the Institute and UK researchers. Correspondents receive regular electronic bulletins about ongoing activities at the Institute which they forward to colleagues not only in mathematics, but also in all those interdisciplinary fields for whom Institute programmes may be of interest. The Institute welcomes suggestions for extending the network into other institutions and disciplines.

As Chair of Correspondents, it is my role to represent the mathematics community on the Institute's Management Committee. Please do contact me to discuss any aspect of the Institute's work about which you have ideas or concerns.

More than 50 Correspondents attended this year's meeting, representing universities and a variety of other research institutes from across the UK.

The meeting was opened with a very stimulating talk by Robert May (Oxford), Stability and complexity in model banking systems. After brief presentations of some of the ongoing issues of concern to the Institute, participants split into smaller groups for focussed discussion which as usual resulted in some invaluable feedback: on the Institute's cross-disciplinary initiative; on the impact of mathematics, both what this should mean and the Institute's role in delivering it; and on how the Institute can improve its communications both with the mathematical community and with a wider public. A summary of a survey of women mathematicians in the UK, undertaken as part of a joint project with the London Mathematical Society and supported by the UK Resource Centre, illuminated several issues to take forward. The meeting closed with a talk by Assaf Naor (NYU), one of the organisers of the *Discrete Analysis* programme, on *Quantitative Geometry and Efficient Classification Procedure*.

Finally, I would like to express my thanks to the outgoing Deputy Director, Ben Mestel for his key role in organising the several Correspondents meetings I have chaired. I have enjoyed working with him on this and other items such as the Institute Gender Balance initiative, and I would like to wish him every future success.

UK Correspondents

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

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 2011)

The table below shows the current list of Newton Institute Correspondents both in UK HEI's and in learned societies, commercial organisations and research institutes.

Aberdeen	A Sevastyanov	Loughborough	AP Veselov
Aston	D Saad	LSE	M Luczak
Bath	J Faraway	Manchester (Mathematics)	M Prest
Birmingham	CW Parker	Manchester (Physics)	AJ McKane
Bradford	A Vourdas	Napier	T Muneer
Brighton	PJ Harris	Newcastle	CF Barenghi
Bristol	F Mezzadri	Nottingham	D Hawker
Brunel	A Rawlins	Open	UG Grimm
Cambridge	N Dorey	Oxford	S Lauritzen
City	O Kerr	Plymouth	C Christopher
Dundee	G Hornig	Portsmouth	AD Burbanks
Durham	WJ Zakrzewski	Queen Mary, London	PJ Cameron
East Anglia	S Stevens	Queen's, Belfast	AW Wickstead
Edinburgh	A Olde Daalhuis	Reading	S Langdon
Essex	DB Penman	Royal Holloway, London	J Crampton
Exeter	A Gilbert	St Andrews	DG Dritschel
Glasgow	C Athorne	Salford	RD Baker
Greenwich	K Parrott	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	E Burman
Kent	PA Clarkson	Ulster	M McCartney
King's College London	K Rietsch	University College London	ER Johnson
Lancaster	S Power	Wales (Aberystwyth)	R Douglas
Leeds	A Pillay	Wales (Cardiff)	KM Schmidt
Leeds Metropolitan	E Guest	Wales (Swansea)	T Brzeziński
Leicester	F Neumann	Wales (WIMCS)	T Lyons
Liverpool	V Goryunov	Warwick	C Series
Liverpool John Moores	PJG Lisboa	West of England	K Henderson
London Metropolitan	P Calay	York	N MacKay

ATM	P Andrews	Mathematical Association	C Ogden
British Computer Society	B Mitchell	Met Office	MJP Cullen
British Geological Survey	RM Lark	Microsoft Research Group	CM Bishop
Edinburgh Mathematical Soc.	TH Lenagan	Nat. Ocean. Centre, Liverpool	J Polton
EPSRC	M Bambury	Nat. Ocean. Centre, Southampton	M Srokosz
European Bioinformatics Institute	C Brooksbank	OCISB	R Baker
ICMS	K Ball	OR Society	R Hibbs
Institute for Animal Health	D Schley	Rutherford Appleton Laboratory	N Gidopoulos
IMA (Academic)	P Glendinning	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
John Innes Centre	S Maree	Schlumberger	J Sherwood
LMS	NS Manton	Smith Institute	T Armour

Institute Activities

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**.

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 112 new Junior Members in 2010/11; the current total is 888 as at the end of July 2011.

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 104 visitors did so during 2010/11 delivering a total of 157 seminars in 45 different institutions. To promote this activity, the Institute covers on request the travel costs within the UK for any overseas Fellow.

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

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

Seminars on the Web

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

Starting from September 2007, however, full video of every seminar has been available for either streaming or download subject to speaker permission. In time the library of online seminars should build into a substantial national resource. During 2010/11 within the six programmes covered by this report and including other events an additional 592 seminars were added.

Follow-up Events

As discussed in pages 22–23 and 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.

B Bogacka

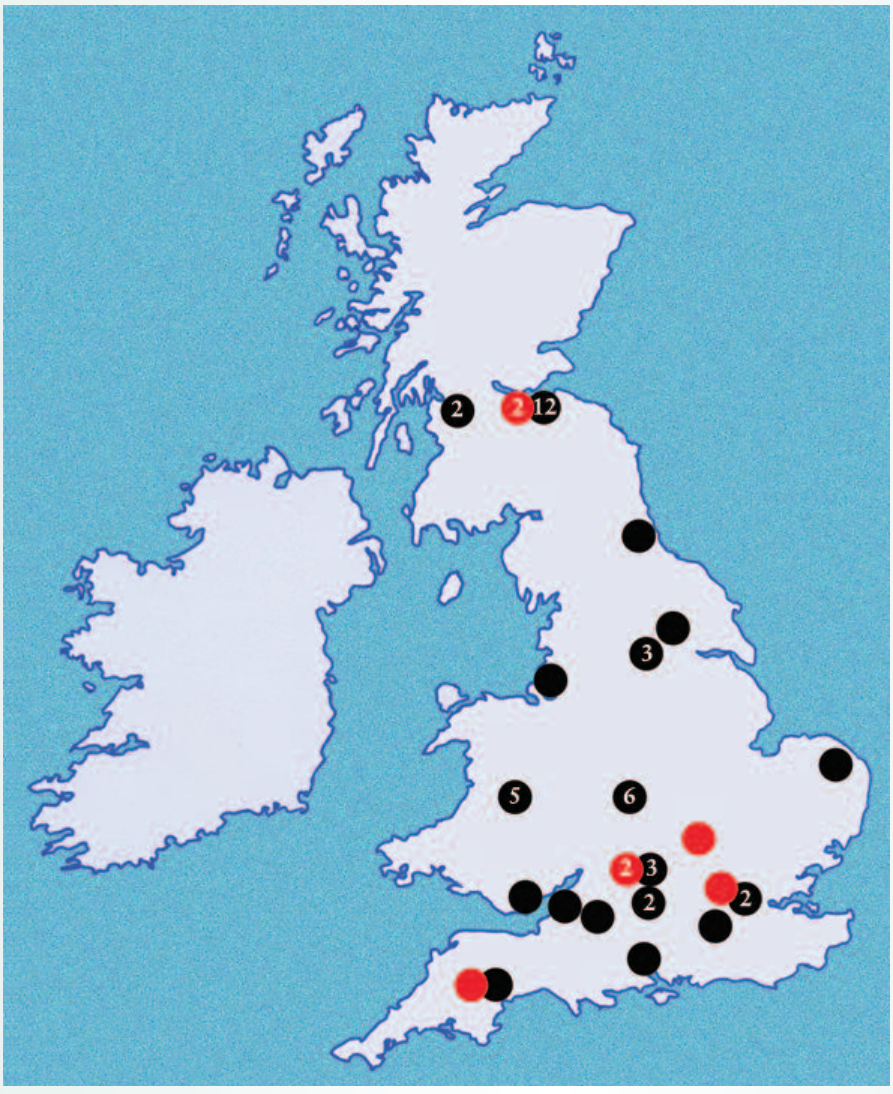
Satellite Workshops

The Institute encourages organisers of 4- or 6-month programmes to cooperate with local organisers in holding 'satellite' workshops at UK Universities and institutions outside Cambridge. Satellite workshops are organised on themes related to an Institute programme, and involve a significant number of the longer-stay overseas participants who are visiting the Institute at the time. They also, crucially, draw in and involve UK mathematicians and scientists who might not otherwise be able to participate substantially in the Institute programme; and they enable the expertise of the Institute's overseas participants to be shared more widely within the UK.

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

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

Future satellite workshops are planned at ICMS (Edinburgh), London, Met Office (Exeter), Newport Pagnell and Oxford. Further details can be found at **www.newton.ac.uk/events.html**.



Planned

Held

Numbers indicate the quantity of events held or planned where greater than one.

Distribution of Satellite Workshops

Institute News

SJ Wilkinson

John Toland takes over as Director

In October 2011, John Toland FRS became the fifth Director of the Institute and was elected a fellow of St John's College. While a professor at Bath, John held an EPSRC Senior Research Fellowship and a Royal Society/Wolfson Research Merit Award. A past-President of the London Mathematical Society he was Director of the International Centre for Mathematical Sciences in Edinburgh and is the Chair of the Mathematical Sciences Research Excellence Framework panel. He belongs to the Executive Committee of the International Mathematical Union, the non-governmental body for the promotion of co-operation in mathematics world wide.

Christie Marr appointed as Deputy Director

The Institute looks forward to welcoming Dr Christie Marr who takes up the post of Deputy Director from January 2012. Christie studied Mathematics at Oxford before taking a PGCE at Kings College London after which she returned to Oxford and studied for a DPhil in Computer Science. She was the founding Director of the Mathematics Support Centre in St Andrews and won the 2010 SIGMA prize for outstanding contributions to mathematics support.

Cross-Disciplinary News

During his last week in office Sir David Wallace learned that the Institute's cross-council bid submitted some fifteen months earlier had been successful and as a result the Institute now has formal liaison officers in BBSRC, EPSRC, ESRC, MRC, NERC and STFC. This level of cross-council support is appropriate recognition of the fact that mathematics relates to all of science (physical and social) and technology. This policy of supporting and embracing excellence wherever it is to be found sits comfortably with the founding principles of the Institute. Indeed, in the first Annual Report, the then Director, Sir Michael Atiyah, commended the "interdisciplinarity" of the programmes which then included computer vision and the mathematical modelling of the AIDS epidemic.

As ever, communication is paramount, and to this end the Institute's network of Correspondents will be enlarged to include representatives from departments and institutes in other disciplines. Additionally, a Cross-Disciplinary College is being developed to advise the Scientific Steering Committee on current proposals and on novel and challenging questions which other disciplines pose to the mathematical sciences. Moreover, the Institute supports scoping meetings, short workshops designed to initiate cross-disciplinary discussions and to investigate the possibility of a full proposal.

Development Board

The Development Board, under the chairmanship of Howard Covington and supported by the Cambridge University Development Office (CUDO), continues to nurture support for the Institute's activities in the world of business and finance through a programme of City Dinners (see opposite) and other fund raising events. Since 2008, £720k has been raised and the Board is actively planning activities in 2012 to celebrate the Institute's twentieth birthday. Three members have recently joined the Board, Sir David Wallace (retiring Director), Mr John Barker (a London businessman) and Ms Madeleine Langford-Allen (Associate Director CUDO), all of whom have been approved by the Institute's Management Committee.

Open for Business

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

Future Developments in Genome Resequencing

Isaac Newton Institute, 3 August 2010

This meeting was chaired by Chris Holmes and was run in conjunction with the Institute programme on *Statistical Challenges Arising from Genome Resequencing*.

Climate Change Question Time

Willis Building, London, 24 November 2010

This meeting was opened with an excellent talk by Tim Palmer and featured two panel discussions chaired by Jonathan Leake and Oliver Morton.

Energy Systems Day

Isaac Newton Institute, 17 March 2011

This event was chaired by Stan Zachary and discussed mathematical challenges arising in the management and control of future energy systems.

R Wooding

Lord Adair Turner, Chairman, Financial Services Authority and Committee on Climate Change responding to a question during a panel discussion at 'Climate Change Question Time'

City Dinners

The Chair of the Management Committee, Howard Covington, hosts a series of informal dinners which give senior people, primarily in financial services, the opportunity to engage with leading scientific researchers. These have included Martin Rees, Stephen Hawking, Roger Penrose and James Lovelock. It would be difficult to exaggerate the enthusiasm for these occasions – the network now extends to more than 85 individuals. As well as establishing a group of generous donors, the dinners have built a potentially influential network of individuals who understand the importance of the mathematical sciences, and who value fundamental science. Talks given at City Dinners during 2010/11 were as shown in the adjacent table.

City Dinners 2010/11

September 2010: **John Shepherd** on geo-engineering

November 2010: **Rob Kennicutt** on astronomy

December 2010 (at the Royal Society): **Martin Rees** on the universe from birth to the present day.

February 2011: **Tim Gowers** on mathematics today and tomorrow

April 2011: **Simon Tavaré** on genomics and susceptibility to disease

June 2011: **Andy Parker** and **Val Gibson** on results from the Large Hadron Collider

July 2011: **Gordon Ogilvie** on formation of planets

Management and Statistical Reports

Howard Covington, Chair of the Management Committee

As for all UK research institutions, two issues currently dominate: impact and funding. I am pleased that the Institute is progressing well in both areas.

Tracking peer-reviewed publications and claiming credit by association for an ephemeral visitor population whose research might have begun long before participation in a programme at the Institute, or be concluded long after, is little more than an exercise in numerology. Of much greater value are responses to questionnaires on how the Institute helps open new areas of research and collaborations and case studies of their long-time impact. The Institute is doing well on these measures. It is having a significant long-term impact on the mathematical sciences in the UK and internationally and contributing fundamentally to research areas with direct economic, technological and social benefit. It is also opening new horizons for individual participants. The Institute's on-line archive of seminars has become one of Cambridge University's most visited web-sites. Follow-up meetings and *Open for Business* occasions for a wider audience are well received and much in demand.

Core funding for the Institute comes from a generous and enlightened grant from the Engineering and Physical Sciences Research Council (EPSRC). The priority for fundraising is to broaden our funding base and a concerted effort is underway to do so. We are seeking funding from other research councils and agencies, foundations, companies and individuals.

The Institute's fundraising efforts have already met with some success and I am deeply grateful to all our donors. These efforts must now be taken to a new level to ensure that the Institute can continue to fulfil its international role in facilitating transformative research in mathematics and across all the many disciplines that mathematics underpins.

David Wallace, whose term as Director concluded at the end of September, has brought to the Institute an enormous amount of energy and enthusiasm. The Institute has gone from strength to strength under his stewardship. I thank him sincerely on behalf of all associated with the Institute and the mathematical sciences community it serves.

John Toland succeeded David Wallace as Director on 1 October 2011. John brings great experience, as a Professor in Mathematics for close to 30 years and as Scientific Director of the International Centre for Mathematical Sciences for 8 years. I welcome John warmly and look forward to working with him.

Membership of the Management Committee at 31 July 2011 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 PH Haynes	*Head of Department, DAMTP*
Dr P Hemmings	*EPSRC*
Professor JME Hyland	*Head of Department, DPMMS*
Professor R Langley	*Council of the School of Technology*
Dr J Lasenby	*Trinity College*
Professor N Manton	*St John's College*
Dr B Mestel (Secretary)	*Deputy Director, Newton Institute*
Professor C Series	*Chair of Correspondents*
Professor J Stirling CBE FRS	*Council of the School of Physical Sciences*
Sir David Wallace CBE FRS FREng	*Director, Newton Institute*

Programme Participation

A total of 2,029 visitors was recorded for 2010/11.

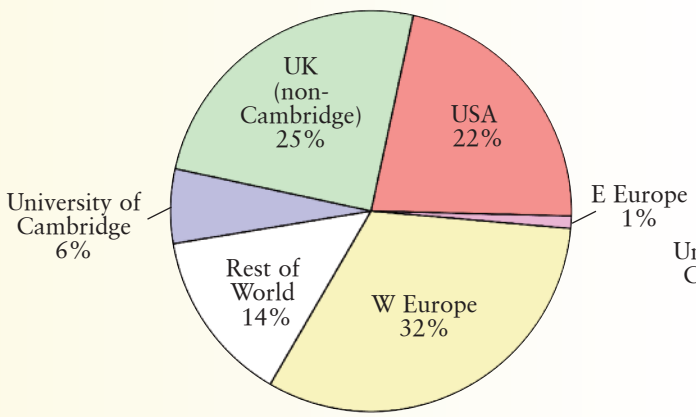
This includes 409 Visiting Fellows and 142 Programme Participants. Within the six programmes during the year there were 20 workshops (periods of intense activity on specialised topics) which attracted a further 613 visitors (i.e., those not already attending the programme).

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 865 visitors attended such events and took part informally in Institute activities or attended satellite events and follow-up meetings.

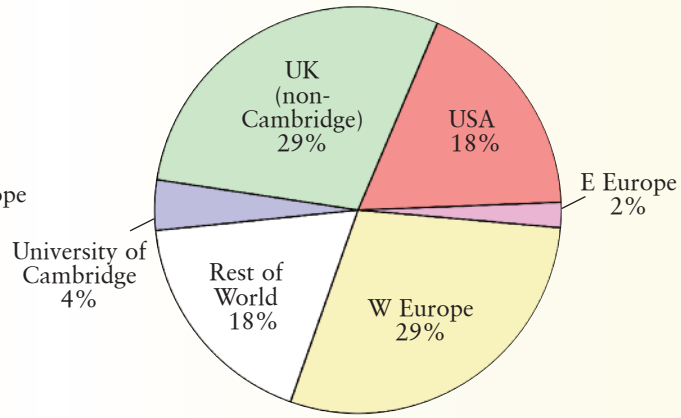
Within all the programmes, workshops and other activities, 625 seminars were given at the Institute during the year. The Institute also funds visits by overseas programme participants to other UK institutions to give seminars (see page 26), and 157 such seminars took place this year.

Programme	Visiting Fellows	Mean stay (days)	Programme Participants	Mean stay (days)	Workshop Participants
Statistical Challenges Arising from Genome Resequencing	26	20	9	21	90
Gyrokinetics in Laboratory and Astrophysical Plasmas	38	15	14	17	34
Mathematical and Statistical Approaches to Climate Modelling and Prediction	74	38	21	41	71
Partial Differential Equations in Kinetic Theory	96	23	34	31	53
Moduli Spaces	76	48	46	52	269
Discrete Analysis	99	32	18	113	96
	409	**32**	**142**	**48**	**613**

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

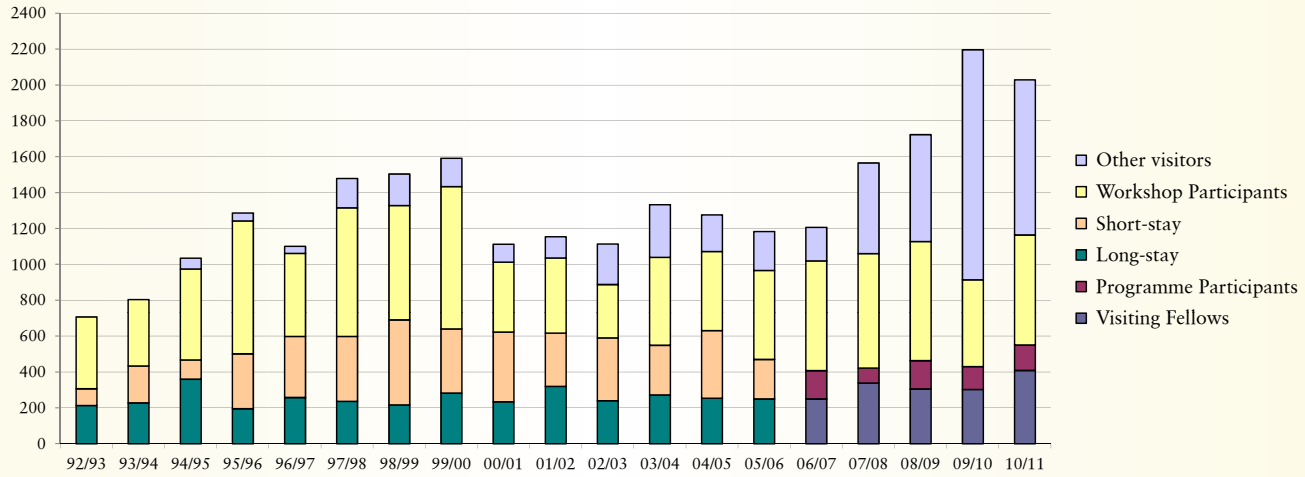


Visiting Fellows and Programme Participants

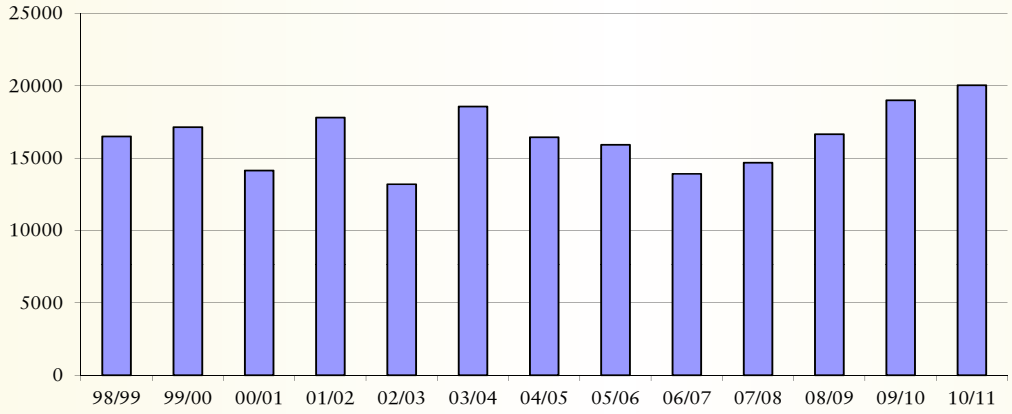


Workshop Participants

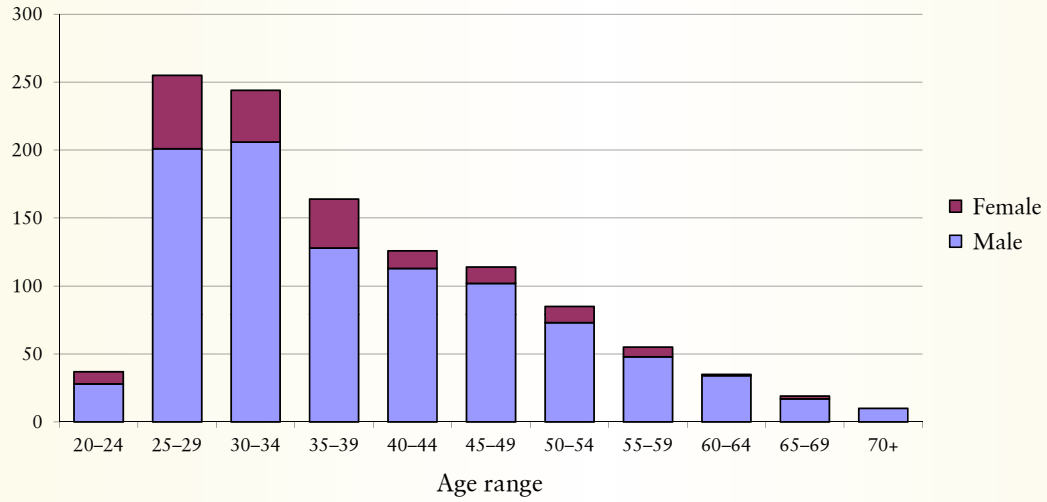
The following chart summarises the total participation figures since the Institute began:



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

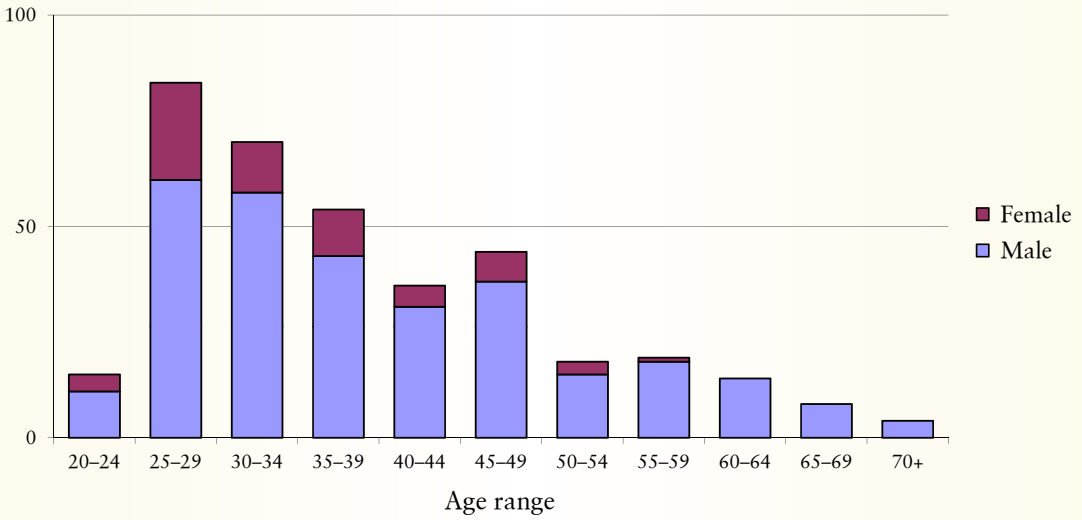


The numbers of all Visiting Fellows, Programme Participants *and* Workshop Participants combined in 2010/11 are shown below, by age and gender:

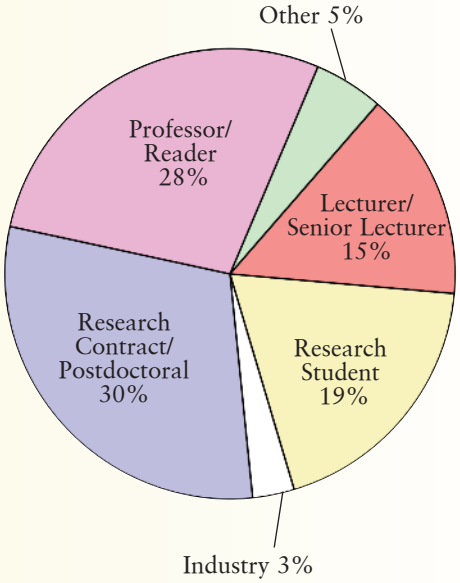


The statistics presented on this page relate only to visitors whose home institutions are in the UK: overseas visitors data are not included.

The age range and gender balance of all Visiting Fellows, Programme Participants and Workshop Participants from UK institutions in 2010/11 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 2010/11:



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/1011/appendices.html

Finances

Accounts for August 2010 to July 2011 (Institute Year 11)

	2009/10 Year 18 £'000	2010/11 Year 19 £'000
Income		
Grant Income – Revenue[1]	1,541	1,746
Grant Income – Workshop	111	105
Grant from the University of Cambridge	298	315
NM Rothschild and Sons Trust Funds[2]	117	135
Investment Income[3]	135	143
Donations, Reimbursements and Other Income[4]	37	14
Total Income	**2,239**	**2,458**
Expenditure		
Scientific Salaries[5]	253	232
Scientific Travel and Subsistence[6]	605	676
Scientific Workshop Expenditure	246	370
Other Scientific Costs[7]	25	37
Staff Costs (Payroll)	461	422
Staff Costs (Contract and Agency)	38	53
Net Housing Costs[8]	40	99
Computing Cost	130	45
Library Costs	5	16
Building – Repair and Maintenance	12	11
Consumables	53	43
Equipment – Capital	2	18
Equipment – Repair and Maintenance	2	7
Publicity	4	6
Recruitment Costs	1	0
FEC Estates and Indirect Costs	372	372
Non-FEC Estates and Indirect Costs[9]	16	16
Total Expenditure	**2,265**	**2,423**
Surplus / (Deficit)	**(26)**	**35**

Notes to the Accounts

1. Grant Income – Revenue. The income breaks down as follows:	**2009/10 Year 18 £'000**	**2010/11 Year 19 £'000**
EPSRC Salaries	341	312
EPSRC Travel and Subsistence	497	637
EPSRC Workshop income	157	217
EPSRC other costs	120	2
EPSRC Estates and Indirect Income	247	247
BBSRC	0	25
MRC	0	25
NERC	0	90
STFC	30	29
Garfield Weston Foundation	0	15
Leverhulme Trust	81	80
London Mathematical Society	24	25
Microsoft Research Cambridge	0	20
PF Charitable Trust	37	20
Cambridge Philosophical Society	2	2
Other new income generated	5	0
Total	**1,541**	**1,746**

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

Rothschild Visiting Professorships (drawdown)	19	34
Rothschild Mathematical Sciences (income)	98	101
Total	**117**	**135**

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

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

4. Donations, Reimbursements and Other Income. A total of £410k received via the Cambridge University Development Office (CUDO) was capitalised and is not included in this figure. Sponsorship was received from David and Elizabeth Wallace and the Thriplow Trust. This figure also includes net income received from publications and sale of merchandise.

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

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

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

8. Net Housing Costs.

Income	385	485
Expenditure	425	584
Total	**(40)**	**(99)**

9. Estates and Indirect Costs. These are calculated following the University's costing methodology.

Grants and Donations August 2010 to date

In addition to substantial funding from the Engineering and Physical Sciences Research Council, the Institute is indebted for continuing support from the Cambridge Philosophical Society, Le Centre Nationale de la Recherche Scientifique, the Leverhulme Trust, the London Mathematical Society, PF Charitable Trust, NM Rothschild and Sons, and the University of Cambridge. We are very grateful to the following organisations for their specific support during the year: the Biotechnology and Biological Sciences Research Council, Deutsche Bank, the Garfield Weston Foundation, GLC Charitable Trust (with special thanks to Lawrence and Rosemary Staden), Henderson Global Investors, the Medical Research Council, Microsoft Research Cambridge, the National Environmental Research Council, the National Science Foundation (USA), Schlumberger Limited and the Science and Technology Facilities Council.

Individuals gave generously in support of our activities: Howard & Veronika Covington, Gilbert Dunlop, Mrs Ann and the late Professor Roy Garstang, Patrick Hawke-Smith, Dr Jonathan Hodgson, Duncan McInnes, Steve Mobbs, Andrew Nason, Richard Saldanha, Ian Simm, Simon Yun-Farmbrough, David & Elizabeth Wallace as well as donations from individuals who prefer to remain anonymous.

Cumulative Financial Grants and Donations above £10,000

(listed in order of cumulative value)

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

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Front cover: This figure shows contours of electrostatic potential fluctuations in an annular region of plasma at mid-radius in the MAST tokamak. These fluctuations are from local gyrokinetic simulations (using the code GS2) of the saturated state of electron temperature gradient driven turbulence. The visualisation has been improved by removing a wedge of plasma to view the nature of fluctuations inside the annulus, and by artificially increasing perturbation wavelengths perpendicular to the magnetic field. Image courtesy of CM Roach (Culham Centre for Fusion Energy) a Visiting Fellow on the Institute programme *Gyrokinetics in Laboratory and Astrophysical Plasmas*.

Design, production and typesetting: Sara Wilkinson
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