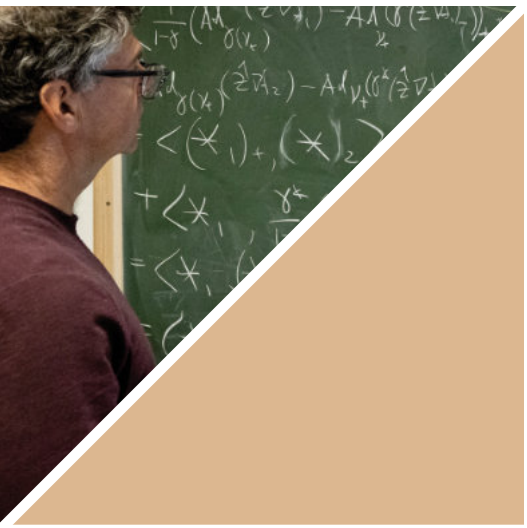
Isaac Newton Institute
for Mathematical Sciences

Annual Report **2021-2022**






UNIVERSITY OF
CAMBRIDGE

Isaac Newton Institute for Mathematical Sciences

The Isaac Newton Institute is an international hub for supporting mathematical sciences research of the highest quality and impact. It aims to attract the world's leading researchers, in all areas of mathematics and its applications, who interact through a variety of long and short thematic programmes as well as associated workshops. Based in Cambridge, and benefiting from a bespoke building and other world leading facilities of this great University, INI is nevertheless an independent forum serving the whole of UK mathematical sciences. INI's environment, and supporting mechanisms, enable its programmes to have a translational effect on their respective research areas.

All INI scientific programmes are carefully designed to allow for novel ideas to be created, nurtured and exchanged. Programme topics cover all areas of mathematics, with increasing focus on emerging intra and interdisciplinary fields, where engagement is with other scientists, social scientists, economists, policy makers etc. The Institute also helps to develop the next generation of mathematical scientists by encouraging participation of young researchers, by widening access, and by addressing the gender gap in mathematics.
The INI has broadened its role in the community in recent years, and informs policy makers and funders about the relevance, value and timeliness of emerging mathematics. Through the Newton Gateway to Mathematics it carries out stand-alone knowledge exchange events, and activities within programmes, aimed at end users of mathematical ideas in commerce, industry, government, and other sciences. Further, it assists universities in achieving their own goals; showcases UK research in the mathematical sciences; and engages with non-mathematicians through public lectures, exhibitions, and other activities for schools and the general public.

Newton Gateway to Mathematics

The Newton Gateway to Mathematics acts as a vehicle for knowledge exchange between the mathematical sciences and potential users of mathematics, including industry, government, business and other academic disciplines, both in the UK and internationally. It does this by facilitating interactions and activities such as programmes of work, research and training events, as well as bespoke projects. The Newton Gateway aims to widen access to mathematics generally, to shorten pathways to impacts for academic research, and to support education and training in areas where mathematical skills are needed.

Director's Foreword

This year has been exceptionally busy for the Institute. In September 2021 we celebrated the life and work of Sir Michael Atiyah, INI's founding director, with a well-attended symposium on *The Unity of Mathematics*. It was the first in-person meeting for the Institute and many of our visitors since the start of the COVID-19 pandemic in March 2020, and marked our return from lockdown. A fitting new beginning! But, come December, Omicron was looming and we had once again to limit our activities. Finally, in April 2022 INI was operating at full capacity and without restrictions.

Indeed, we are now running at 150% capacity. This has meant hiring space at the Møller Institute at Churchill College to allow us to invite back programmes that had been interrupted or cancelled in the previous two years. As a result, instead of the usual two, there have been three, sometimes four, programmes running in parallel, and during the busy summer, the INI staff looked after record numbers of more than 200 participants in Cambridge as well as all those online. While we feel lucky to have found such excellent facilities at the Møller, participants have been disappointed not to find facilities comparable to those at our own building. The lack of individual offices, spaces to work on blackboards with colleagues and suitable lecture rooms are particularly missed. There is just no substitute for the INI building.

But after 30 years, an anniversary we marked in June with an afternoon of lectures, honorary fellowships and a barbecue, our beloved building is bursting at the seams with all the activities that are taking place. And there is more we would like to do. So, an enjoyable part of my time this year was spent with colleagues and architects on exciting and far-reaching plans for a new lecture theatre and office block. Now the task is to raise the necessary funds to turn dreams into reality.

All the additional challenges in navigating the pandemic did not stop us starting new initiatives, especially where we felt a moral duty to do so. Since the first week of the war in Ukraine, the Institute has been developing its "Solidarity for mathematicians" programme to support refugees hosted at maths departments throughout the UK. Many other new initiatives, including our Satellite Programmes, the Network Support Scheme, INI-Simons Postdoctoral Fellowships, and new Gateway projects are described inside this report. In its role as a national institution, INI is helping the UK mathematical sciences community wherever it can. In particular, we have recruited key positions essential for the setting up of the National Academy of the Mathematical Sciences (NAMS) and the Network for Knowledge Exchange (KE-Hub), following a UK-wide consultation earlier in the year.

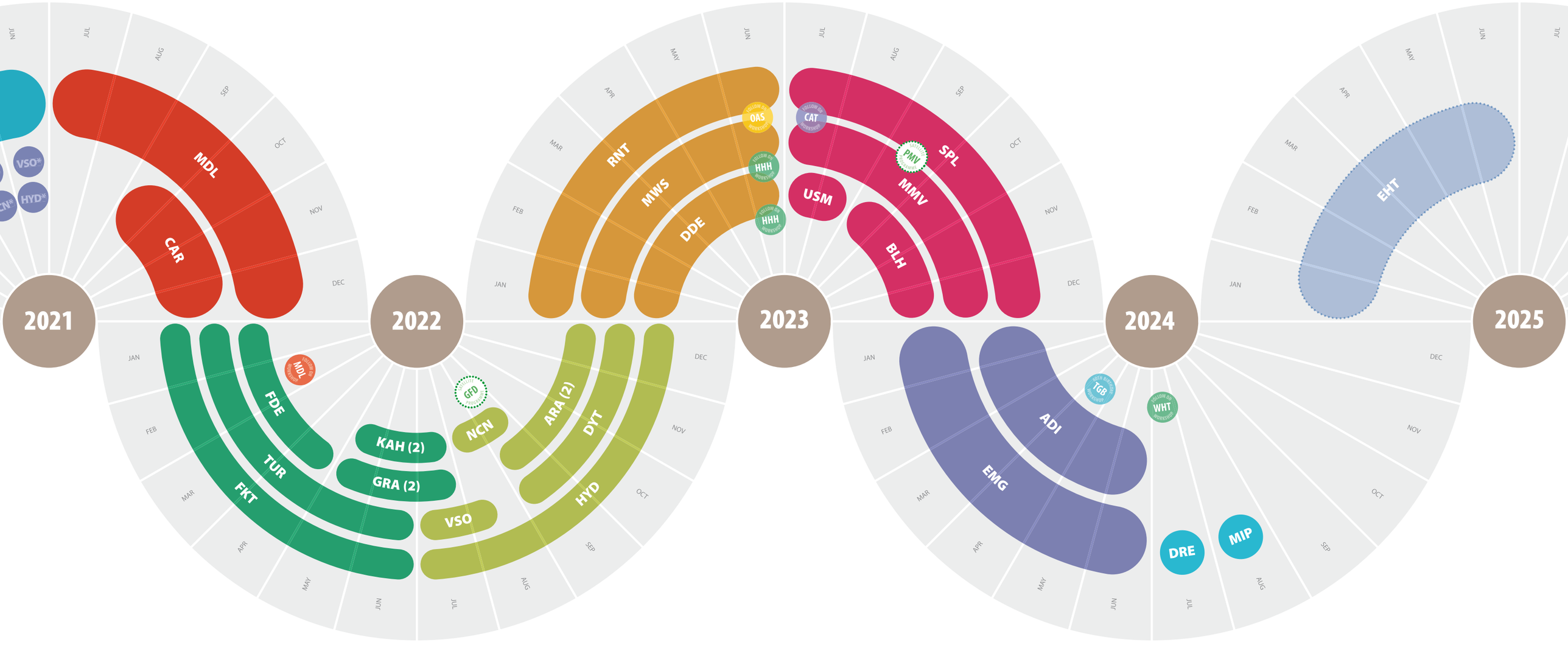
This has been my first year as director and there has been much to learn. I am in great debt to David Abrahams for the thorough and thoughtful handover. I also want to thank all those who have supported me throughout the year, in particular the senior management team of the institute: Christie Marr who as Deputy Director of nearly ten years holds a huge amount of institutional knowledge; our treasured Business and Operations Manager Samantha Skehel and her deputy Susan Gowans who between them smoothly managed the ever-changing COVID measures and with our dedicated staff worked tirelessly to make all our visitors comfortable and taken care of; and Jane Leeks, the manager of the Newton Gateway which delivered a record number of events (many for the Royal Society initiative "RAMP") and was a key member of the award-winning "V-KEMS" initiative.

Sadly, it is time to say goodbye to Jane, who has accepted a new role elsewhere. She founded the Newton Gateway nearly ten years ago and built it up to the well-recognised centre for knowledge exchange in the mathematical sciences that it is today. It is a truly national resource, and we have much to thank her for. We wish her well in a new chapter of her life in Somerset.

It has been a full year with many new initiatives and developments, but above all stimulating and exciting mathematics. Please join us for one of the many events coming up, virtually or in person, as we move forward.

Ulrike Tillmann, Director

Programme schematic



MDL Mathematics of deep learning

CAR Cluster algebras and representation theory

MDL LMS invited lectures on the Mathematics of Deep Learning (Parent Programme: Mathematics of Deep Learning)

FDE Fractional differential equations

KAH K-theory, algebraic cycles and motivic homotopy theory

GRA Groups, representations and applications: new perspectives

TUR Mathematical aspects of turbulence: where do we stand?

FKT Frontiers in kinetic theory: connecting microscopic to macroscopic scales - KineCon 2022

NCN New Connections in Number Theory and Physics

ARA Applicable resurgent asymptotics: towards a universal theory

VSO Verified software

DYT Frontiers in dynamo theory: from the Earth to the stars

HYD Dispersive hydrodynamics: mathematics, simulation and experiments, with applications in nonlinear waves

RNT Rich and Nonlinear Tomography - a multidisciplinary approach

MWS Mathematical theory and applications of Multiple Wave Scattering

DDE The Mathematical and statistical foundation of future Data-Driven Engineering

OAS Operator Algebras: Subfactors and their Applications (Parent Programme: OAS Operator Algebras: Subfactors and their Applications)

HHH A panorama of homotopy theory / Homotopy: fruit of the fertile furrow (Parent Programme: Homotopy harnessing higher structures)

SPL Statistical physics in living matter: nonequilibrium states under adaptive control

CAT Recent Progress in Techniques, Applications and Computation (Parent Programme: Complex Analysis: Techniques, Applications and Computations for the 21st century)

PMV GeomPack geometry and packing in material structure and biology

MMV Mathematics of Movement

USM Uncertainty quantification of Soft Materials

BLH Black holes: bridges between number theory and holographic quantum information

GFD Geophysical fluid dynamics; from mathematical theory to operational prediction

TGB Tim Gower's 60th Birthday workshop

ADI Anti-diffusive dynamics: from sub-cellular to astrophysical scales

EMG Equivarient methods in algebraic and differential geometry

WHT The Applications, Generalisation and Implementation of the Wiener-Hopf Method Organisers (Parent Programme: Bringing Pure and Applied Analysis Together via the Wiener–Hopf Technique, its Generalisations and Applications)

DRE Discretization and recover in high-dimensional spaces

MIP Modelling and inference for pandemic preparedness

EHT Equivariant homotop theory in context

* denotes Bridging Events

... one main purpose of our programme (was) to provide young researchers with an entry into this highly topical and often game-changing research field.

Mathematics of deep learning

July – December 2021

Due to the massive amounts of training data complemented by a tremendously increased computing power, deep neural networks have recently seen an impressive comeback. However, most of the related research is still empirically driven, and a sound theoretical foundation is largely missing. This is not only a significant problem from a scientific viewpoint, but particularly critical for sensitive applications such as in the health care sector. Thus, there exists a tremendous need to build a sound mathematical foundation for deep learning. This programme gathered the top experts from various areas of mathematics and of the theory of machine learning, thereby generating unprecedented research dynamics in the field.

Despite the disruption caused by the COVID-19 pandemic, the *"Mathematics of Deep Learning"* programme enjoyed great success. While it was a shame that not all participants were able to attend on-site and benefit from in-person interactions, the possibility to attend remotely helped to widen participation, allowing more researchers to join the events, profit from them and contribute.

The core programme consisted of six workshops, a weekly reading group and two weekly seminar talks, three short courses on core topics, and the Kirk and Rothschild distinguished lectures. The topics of the workshops were *"Theory of deep learning"*, *"Deep learning and inverse problems"*, *"Deep learning and partial differential equations"*, *"The power of women in deep learning"*, and *"Interpretability, safety and security in AI"*. In particular, the workshop on *"The power of women in deep learning"* was a highlight, with presentations of successful female researchers in this area and various interactions between the mostly female audience and those role models. The workshops were all well attended, with always more than 50 participants on Zoom and more than 30 participants in the room.

The last workshop (the London Mathematical Society Invited Lectures) took place in February 2022 as a first follow-up event, and drew in close to 200 participants (about 80 of which were in physical attendance). It consisted of a lecture series on *"The mathematics of deep learning"* by Gitta Kutyniok (LMU), covering an even larger range of topics than the previous workshops, and including topics such as robustness and limitations of deep learning.

The short courses were given by some of the leading researchers in the field, including Michael Bronstein (Oxford), Weinan E (Princeton) and Lexing Ying (Stanford). In addition to these, there was an engagement event with the Fraunhofer ITWM which presented current topics of research interests of the Fraunhofer Institute and encouraged collaboration. The reading group was led by programme participants and attracted both online and on-site pin equal proportions, stimulating active discussions. It was noted that the younger participants engaged themselves particularly vividly in the discussions. This was in fact also one of the main purposes of our programme: to provide young researchers with an entry into this highly topical and often game-changing research field.

Weekly drinks meetings were held at 5pm on Fridays for the on-site participants, which provided a rich opportunity for informal discussion and network building.

Both the Kirk and the Rothschild Distinguished Visiting Fellowship were excellent and attracted interest from the wider Cambridge mathematical community. The Kirk lecture was given by Rebecca Willett from University of Chicago on *"Machine-learning enabled imaging: from microscopy to medical imaging to astronomy"*. The Rothschild lecture was given by Helmut Bölcskei from ETHZ on *"The mathematical universe behind deep neural networks"*.

ORGANISERS:
Gitta Kutyniok
(Ludwig-Maximilians-Universität München)
Peter Bartlett
(University of California, Berkeley)
Anders Hansen
(University of Cambridge)
Arnulf Jentzen
(Universität Münster)
Carola-Bibiane Schönlieb
(University of Cambridge)

ROTHSCHILD DV FELLOWSHIP
Helmut Bölcskei

KIRK DV FELLOWSHIP
Rebecca Willett

SIMONS FELLOWSHIP
Professor M Burger
Professor R Calderbank
Dr S Grunewalder
Professor G Karniadakis
Professor G Kutyniok
Professor O Öktem

70	28	2

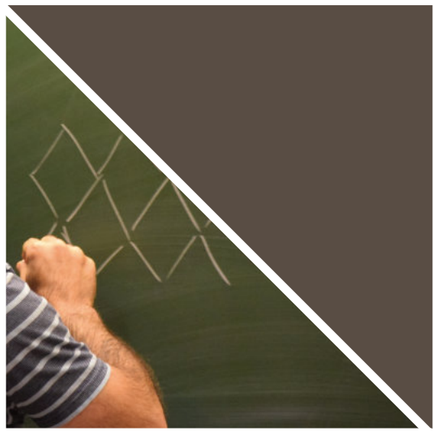
GENDER BALANCE:
(**M** : **F**, %)

23	77

GEOGRAPHIC DISTRIBUTION
(**UK** : **NON-UK**, %)

38	46	16

ECR STATUS
(**ECR** : **NOT ECR** : **UNKNOWN**, %)



Particular emphasis was placed on inclusiveness, resulting in a diverse collection of participants.

Cluster algebra and representation theory
September – December 2021

The theory of cluster algebras is one of the most active research areas in mathematics over the last 18 years. Introduced by Fomin and Zelevinsky in 2002 in the context of Lie theory and total positivity, cluster algebras quickly developed deep connections to different disciplines such as representation theory, combinatorics, algebraic, hyperbolic and symplectic geometry, dynamical systems, topology and string theory. This programme focused on interactions between cluster algebras and representation theory, as well as interdisciplinary applications of cluster algebras

The *"Cluster algebras and representation theory"* programme ran from 6 September to 17 December 2021. This highly successful programme brought together researchers from a variety of areas of mathematics connected to cluster algebras with a focus on representation theory and algebra, as well as geometry and physics.

The programme participants represented a cross-section of the community, with a good mix of established and early career researchers. Particular emphasis was placed on inclusiveness, resulting in a diverse collection of participants.

The research school and workshops were central to the programme. The programme started with a research school comprising five lectures by leading researchers in the field, in order to introduce the diverse new developments in the area and to make the programme accessible to all. This was followed by a workshop on *"New developments in representation theory arising from cluster algebras"* and a second workshop in November focused on *"Interdisciplinary applications of cluster algebras"*. During both workshops the wide-reaching implications and connections between cluster algebras and representation theory and other areas of mathematics were presented and discussed, and the workshops were a catalysing factor in many of the research collaborations and projects initiated during the programme.

The Rothschild and Kirk lectures were a central focus of the programme. The Rothschild lecture on *"Cluster algebras and representation theory"* was given by Bernhard Keller and focused on the categorification of cluster algebras with coefficients in terms of relative Calabi Yau completions. It was followed by a series of three lectures going into greater depth. Gordana Todorov delivered the Kirk lecture on *"Cluster algebras and many related notions on one picture"*, bringing together different guises of a phenomenon known by different names in physics, in the field of cluster algebras, in representation theory, and in algebraic topology. This was followed by a series of three talks explaining and relating the details of the different constructions.

Important factors in disseminating the most recent advances in the area as well as creating a stimulating atmosphere during the programme were the two weekly seminars where programme participants and external speakers reported on the latest developments in the field. This was complemented by a weekly open problem session which initiated many interesting discussions and which was at the origin of some of the major research collaborations started during the programme. Overall, there was a good collaborative atmosphere, with many fruitful discussions. A well-attended session on *"Life decisions in mathematics"*, with a diverse panel, was held during the programme, organised by Deputy Director Christie Marr together with members of the programme and the concurrent *"Mathematics of deep learning"* programme.

ORGANISERS:
Karin Baur
(University of Leeds)
Bethany Marsh
(University of Leeds)
Ralf Schiffler
(University of Connecticut)
Sibylle Schroll
(University of Cologne)

ROTHSCHILD DV FELLOWSHIP
Professor B Keller

KIRK DV FELLOWSHIP
Dr G Todorov

SIMONS FELLOWSHIP
Professor K Baur
Dr A Garcia Elsener
Professor D Labardini-Fragoso
Professor B Marsh
Professor PG Plamondon
Professor R Schiffler
Professor S Schroll
Dr K Serhiyenko
Dr H Treffinger

67 : 33 — 2
GENDER BALANCE:
(**M** : **F**, %)

32 : 68
GEOGRAPHIC DISTRIBUTION
(**UK** : **NON-UK**, %)

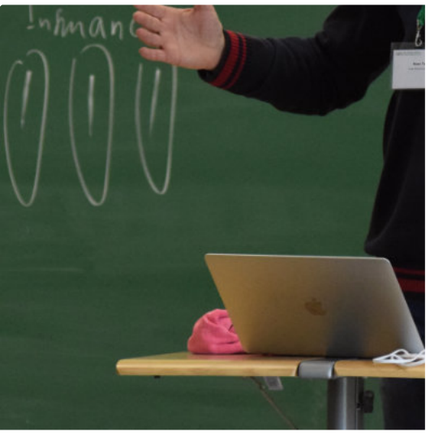
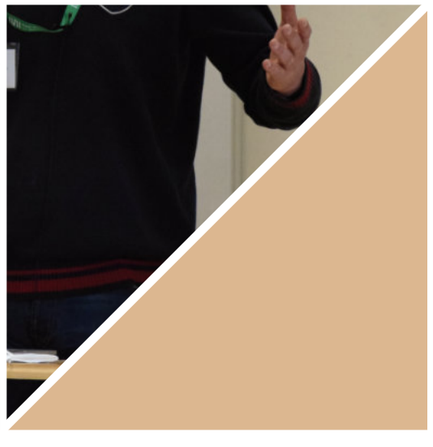
37 : 54 : 10
ECR STATUS
(**ECR** : **NOT ECR** : **UNKNOWN**, %)





The specific (scientific) areas were represented by frontline researchers, all generously making available their expertise, resulting in a high-intensity exchange of ideas and identification of new directions of research.




Fractional differential equations

January – April 2022

Modelling based on differential equations of fractional order and related heavy-tailed probability distributions has recently witnessed a surge of interest due to their ability to model complex phenomena. Applications include modelling contamination of groundwater flow, the electrical dynamics of the heart and the design of new materials. Fractional differential equations capture effects going well beyond the range tractable by conventional concepts and tools, and it is increasingly recognised that this framework is on the way of becoming a new paradigm in scientific modelling. This programme investigated the multiple facets of space-time fractional dynamics and made significant progress in the description and deep understanding of this new phenomenology.

At the centre of the *"Fractional differential equations"* programme was the hosting of a major international event on the highly topical subject of deterministic or stochastic space/time non-local equations, related Markov or non Markovian jump random processes, and a variety of applications in control theory, physics and other sciences. The programme made a first step towards creating a platform for interactions between pure and applied scientists involved with these fields, with participants and contributors from six continents, and a geographical span from New Zealand to Chile. The specific areas were represented by frontline researchers, all generously making available their expertise, resulting in a high-intensity exchange of ideas and identification of new directions of research.

Although the adverse COVID circumstances continued to affect the normal proceeds, the programme was well attended both in person and virtually, including a welcome proportion of female scientists and young researchers. The programme accommodated three five-day specialised workshops, which included special colloquium-type lectures attended by audiences beyond the regular participants. Further events were hosted, including some 35 seminars, a mini-course, and the highly populated Rothschild and Kirk Lectures delivered by prestigious scientists. The programme also engaged in a partnership with the parallel programmes *"Frontiers in Kinetic Theory"* and *"Mathematical aspects of turbulence"* by running a joint seminar (JINX), focused on and especially featuring early career scientists and postdocs.

"Fractional differential equations" has been the first event of this scale, both in the UK and globally, focussing on fractional calculus, integro-differential equations, non-local operators, random processes with jump discontinuities, and their multiple applications. It can be hoped that it marked only the beginning of activities focussing on these emerging interdisciplinary fields. There will undoubtedly be a number of scientific articles and further publications directly resulting from or inspired by the programme, as well as new collaborations and initiatives. The organisers intend to build on the momentum and experience accumulated during the programme in designing follow-up events in the future.

ORGANISERS:
Vassili Kolokoltsov *(University of Warwick)*
Jozsef Lörinczi *(Alfréd Rényi Institute of Mathematics)*
Eulalia Nualart *(Universitat Pompeu Fabra)*
Michael Roeckner *(Universität Bielefeld)*
Laura Sacerdote *(University of Torino)*

ROTHSCHILD DV FELLOWSHIP
Professor S Molchanov

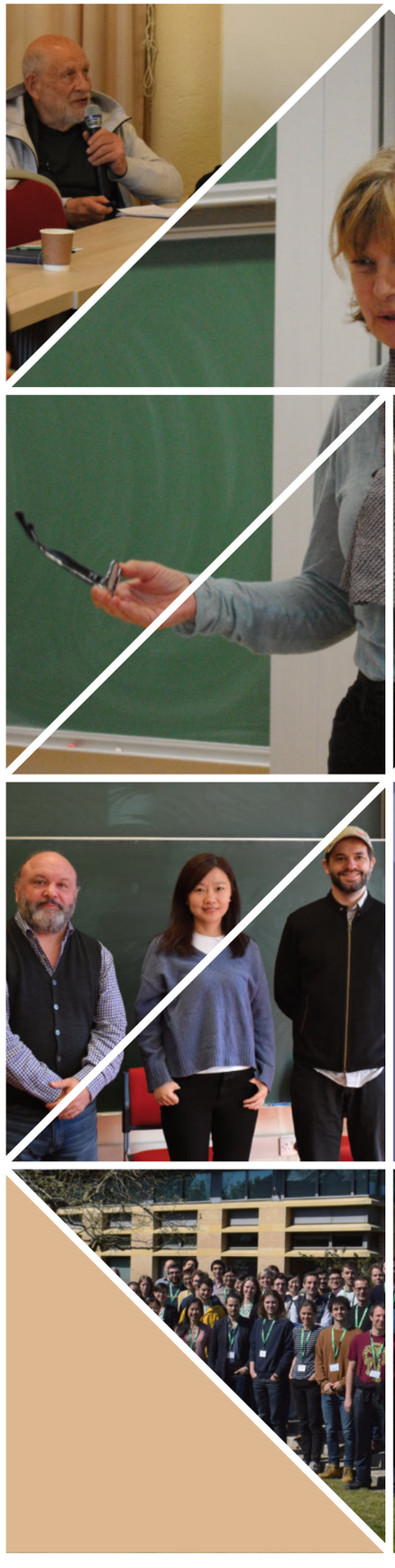
KIRK DV FELLOWSHIP
Professor L Beghin

SIMONS FELLOWSHIP
Dr E Boguslavskaya
Professor Z Brzezniak
Professor P Gonçalves
Professor V Kolokoltsov
Professor I Podlubny
Professor E Shishkina
Professor T Sakajo
Professor S Tanveer

74 : 24 : 2
GENDER BALANCE:
(**M** : **F**, %)

26 : 74
GEOGRAPHIC DISTRIBUTION
(**UK** : **NON-UK**, %)

27 : 67 : 6
ECR STATUS
(**ECR** : **NOT ECR** : **UNKNOWN**, %)



... as one veteran of our research community put it: 'the Isaac Newton Institute is a never-stopping mathematics factory'.

Frontiers in kinetic theory: connecting microscopic to macroscopic scales - KineCon 2022

January – June 2022

Kinetic theory originated from a scientific endeavour launched by Maxwell and Boltzmann at the end of the nineteenth century to explain the macroscopic movement of gases based on the dynamics of many particle systems. The mathematics of kinetic equations continues to flourish, bridging microscopic and macroscopic descriptions of complex systems and using fine analytical tools to uncover these connections and their role.

Kinetic approaches have become ubiquitous in many science and engineering disciplines, due to the indispensable role of kinetic theory in the multiscale modelling hierarchy. Furthermore, kinetic theory has also been a cross-road of interactions with several areas of mathematical physics such as general relativity, plasma physics, and quantum many-body problems. The *"Frontiers in kinetic theory"* programme was a great success, expanding knowledge in theoretical analysis, modelling, and numerical analysis of kinetic theory while fostering the interactions between different and new communities.

After two years of the COVID-19 pandemic and several periods of lockdown designed to save lives, this thematic programme was for many colleagues in our research community a welcome opportunity to reconnect with in-person, lively research discussions and collaborations. In spite of the impact of the Omicron variant in the first month of the semester, it was a resounding success.

During the first month, we unfortunately had to move the first one-week workshop and the tutorials online and some participants had to delay their visit until travels became possible again. However, from February on, the semester slowly but surely grew momentum. We had a core of about 10 "very long-term" participants who participated throughout the whole programme, plus another 20 participants that came for at least a month and often two. This provided the basis and manpower for organising two series of weekly seminars (a "junior" and a "senior" one) with some speakers presenting at both. In total, around 50 talks were organised outside the workshops, often followed by lively discussions over coffee, tea and homemade cakes.

The four workshops all had an impressive attendance: between 50 and 100 participants each time. The one-off lectures also proved very attractive. Our Kirk Distinguished Visiting Fellow, Irene Gamba, gave a long series of lectures in response to the interest of the participants. The general audience Rothschild lecture by Pierre-Emmanuel Jabin gathered more than a hundred colleagues, with many coming from outside the institute.

Indeed, many interactions occurred with the Centre for Mathematical Sciences nearby, such as joint seminars and colleagues from Cambridge's Faculty of Maths joining activities at the Institute. Interestingly, there were also significant interactions with the other research programme, *"Mathematical aspects of turbulence: where do we stand?"*, running at INI at the same time, with some collaborations being of particular note.

Overall, as Claude Bardos - a veteran of our research community and long-time participant in the programme - put it: *"the Isaac Newton Institute is a never-stopping mathematics factory"*. Generally, the programme became a hub for discussions, collaborations, cross-pollination between research areas, and in particular for junior colleagues to train and build new projects and sometimes get advice on their grant applications. Our initial goals were more than fulfilled. Some highlights have been new interactions generated between general relativity and kinetic theory, between stochastic flows and transport turbulence theory, between the quasilinear theory in plasma physics and the analysis of partial differential equations, and between numerical methods for kinetic equations and global optimisation to name a few.

ORGANISERS:
Jose A Carrillo *(University of Oxford)*
Jacob Bedrossian *(University of Maryland, College Park)*
Jingwei Hu *(University of Washington)*
Clément Mouhot *(University of Cambridge)*

ROTHSCHILD DV FELLOWSHIP
Professor PE Jabin

KIRK DV FELLOWSHIP
Professor IM Gamba

SIMONS FELLOWSHIP
Dr H Dietert
Professor M Gualdani
Dr Q Li
Professor J Lukkarinen
Professor T Rey
Professor J Smulevici
Dr W Sun
Dr L Wang

75	24	1

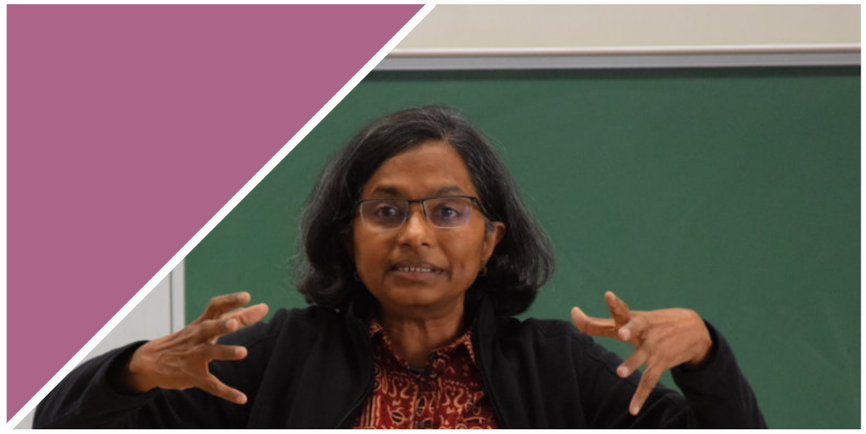
GENDER BALANCE:
(**M** : **F**, %)

37	63

GEOGRAPHIC DISTRIBUTION
(**UK** : **NON-UK**, %)

43	43	14

ECR STATUS
(**ECR** : **NOT ECR** : **UNKNOWN**, %)



By the fourth workshop in late March 2022, the building was overflowing with physical participants... this event in particular highlighted the sheer range and variety of datasets now available.

Mathematical aspects of turbulence: where do we stand?

January – June 2022

Despite the heavy deployment of effort and resources in the study of turbulent fluid flows for well over a century, fundamental questions remain stubbornly unanswered within the field. The associated issues range so widely across the mathematical, physical and engineering sciences that no single research programme could hope to cover all aspects of the subject. The "Mathematical aspects of turbulence" programme therefore concentrated upon the more mathematical concerns, addressing a significant range of valuable topics.

Faced with the challenges of this enormous subject, and despite roughly a third of the participants having their institutional roots in aerospace, mechanical engineering and climate-related departments, the programme was divided into four mathematical "quarters": analysis; mixing & transport; wall-bounded flows; and geophysical & astrophysical turbulence, each with its own triad of organisers and workshop. The global pandemic spanned the whole of the planning period with the Omicron phase developing over the start of the programme in January 2022. All the talks of the opening Workshop (4-7 January) were held online, during which senior speakers were asked to present their grand challenges. A gradual transition from virtual to physical was made over the periods covered by Workshops 2 and 3. Various physical, engineering, and climate applications (including machine learning and AI) were discussed during the latter. By the fourth workshop in late March 2022, the building was overflowing with physical participants. This event in particular highlighted the sheer range and variety of datasets now available. The development of tools for increasing contact with various theoretical models bodes well for the future.

Early in the programme, Mike Cullen (Met Office) set the stage in a series of 4 lectures on atmospheric dynamics. Simons Research Fellows Anagha Madhusudanan and Antoine Remond-Tiedrez (both Cambridge and INI) organised the Junior Isaac Newton Crossover Seminar (JINX), jointly with the *"Frontiers in kinetic theory"* programme. Simon Markfelder (Cambridge) gave a mini-course on Convex Integration, a technique devised in the last decade to analyse very rough solutions of the Euler equations.

Programme highlights were the Kirk Distinguished Lecture on "Mammatus clouds and sedimentation instabilities" (Rama Govindarajan, ICTS Bangalore), and the Rothschild Distinguished Lecture on *"How mathematics helps structuring climate discussions"* (Rupert Klein, Free University of Berlin). A further highlight was the lecture by Joerg Schumacher (TU Ilmenau) on his 3D numerical simulations of extended Rayleigh-Bénard convection layers. An example of continuing cross-cultural interaction among the "quarters" is the collaboration between Rupert Klein (FUB), Leslie Smith and Sam Stechmann (climate scientists, both Wisconsin) and analysts Edriss Titi and Xin Liu (both Cambridge). Moreover, inspired by results from Baylor Fox-Kemper's global ocean model, the three analysts Anna Mazzucato (Penn State), Helena Nussenzveig-Lopes and Milton Lopes (both Rio de Janeiro) have begun a collaboration on the application of 2D Euler vortex methods to the ocean circulation. A further example is the collaboration between Rahul Pandit (IIS Bangalore, Mixing & Transport) and John Gibbon (Imperial, Analysis) on problems in 'active' turbulence caused by the swarming of birds, fish or bacteria.

Please note that we record our sadness at the death of one of our organisers Charles Doering (Ann Arbor) in May 2021. Jean-Luc Thiffeault (Wisconsin) took over Charlie's position and made major contributions to the organisation.

ORGANISERS:
John Gibbon *(Imperial College London)*
Charles R. Doering *(University of Michigan)*
Dan Henningson *(KTH - Royal Institute of Technology)*
Rich Kerswell *(University of Cambridge)*
Anna Laura Mazzucato *(Pennsylvania State University)*
Beverley McKeon *(CALTECH)*
Rahul Pandit *(Indian Institute of Science)*
Leslie Smith *(University of Wisconsin-Madison)*
Jean-Luc Thiffeault *(University of Wisconsin-Madison)*
Edriss Titi *(University of Cambridge)*
Steven Tobias *(University of Leeds)*

ROTHSCHILD DV FELLOWSHIP
Professor R Klein

KIRK DV FELLOWSHIP
Professor R Govindarajan

SIMONS FELLOWSHIP
Professor A Cavalieri
Dr D Chung
Dr A Larios
Professor J Li
Dr X Liu
Professor HJ Nussenzveig Lopes
Professor R Pandit
Dr D Vincenzi

81 | 19
GENDER BALANCE:
(**M** : **F**, %)

24 | 76
GEOGRAPHIC DISTRIBUTION
(**UK** : **NON-UK**, %)

19 | 60 | 21
ECR STATUS
(**ECR** : **NOT ECR** : **UNKNOWN**, %)

... this was an exciting and successful programme, with great progress on its major goals, much of it achieved by the many early career researchers participating

Groups, representations and applications: new perspectives

May – July 2022

Group Theory is essentially the theory of symmetry for mathematical and physical systems, which underpins much of modern pure mathematics, with major connections to diverse areas of mathematics, as well as physics, chemistry, and information science. Born more than two centuries ago in the work of Évariste Galois, it achieved a major milestone when the Classification of Finite Simple Groups (CFSG) was completed. Since then, important and deep connections with areas as varied as topology, algebraic geometry, Lie theory, homological algebra, and mathematical physics, have been discovered and exploited.

Despite the great advances of the past 200 years, Group Theory still abounds with basic problems and conjectures. These include the conjectures of Brauer, McKay, Alperin, Broué and Dade in group representation theory, many of which have been open for decades.

The goal of this programme was to bring together leading experts in group theory and representation theory, on the one hand, and from several different areas of mathematics on the other, with two major focuses: first, to attack some of the representation-theoretic conjectures mentioned above; and second, to take the many connections between CFSG and other areas of mathematics to the next level. As it happened, the programme was divided into two halves by the Covid pandemic – the first January-March 2020, and the second May-July 2022. In fact, several of the most exciting achievements of the programme were announced during the second half, resulting from research undertaken during the first half and in between. Some of the main highlights relate to the conjectures mentioned before. These conjectures are all concerned with the representations of an arbitrary finite group with respect to a given prime number p. Britta Späth completed some final steps towards a proof of McKay's conjecture, and announced the full resolution for $p=3$. Lucas Ruhstorfer, one of the early career researchers on the programme, presented his proof of two of the main conjectures for the case $p=2$ – namely, Brauer's height zero conjecture and the Alperin-McKay conjecture. Major progress on one of the deepest of all the conjectures – Broué's abelian defect group conjecture – was announced by Sasha Kleshchev. There were also breakthroughs reported by Nick Katz and Pham Tiep on another big part of the programme, connecting CFSG with number theory and algebraic geometry via the theory of ℓ-*adic* local systems.

There were five workshops during the programme: an introductory one, three workshops on computational aspects, applications of groups to other areas, and representation-theoretic conjectures, and a final workshop bringing together all the main themes of the preceding months. Overall, this was an exciting and successful programme, with great progress on its major goals, much of it achieved by the many early career researchers participating.

ORGANISERS:
Colva Roney-Dougal *(University of St Andrews)*
Martin Liebeck *(Imperial College London)*
Kay Magaard *(University of Arizona)*
Britta Späth *(Bergische Universität Wuppertal)*
Pham Tiep *(Rutgers)*

ROTHSCHILD DVFELLOWSHIP
Professor R Guralnick

KIRK DV FELLOWSHIP
Professor C Praeger

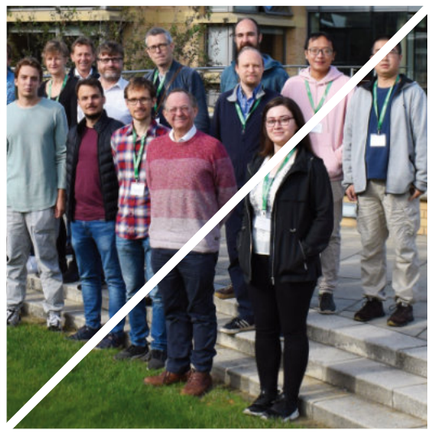
SIMONS FELLOWSHIP
Professor M Broué
Professor P Cameron
Dr I Capdeboscq
Professor A Kleshchev
Professor M Liebeck
Professor G Navarro
Professor C Roney-Dougal

GENDER BALANCE:
(**M** : **F**, %)

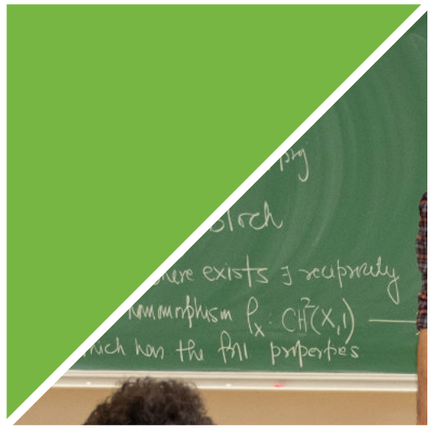
GEOGRAPHIC DISTRIBUTION
(**UK** : **NON-UK**, %)

ECR STATUS
(**ECR** : **NOT ECR** : **UNKNOWN**, %)




The intense atmosphere stimulated existing collaborations and produced many new ones.






K-theory, algebraic cycles and motivic homotopy theory

May – July 2022

Algebraic K-theory, founded by Alexander Grothendieck and extended by Daniel Quillen, has through the decades become connected with many fields in mathematics and parts of mathematical physics. It gave rise to motivic cohomology, a key ingredient of Vladimir Voevodsky's proof of the Milnor conjecture. The goal of this programme was to bring together experts and young researchers from algebraic K-theory, motivic cohomology, arithmetic, Hodge theory, and mathematical physics, and stimulate the connections among those fields.

In the 1960s, Grothendieck sought to explain the shared properties of various cohomology theories for algebraic varieties in terms of a universal motivic theory. However, his approach required affirmative answers to difficult (and still open) conjectures on algebraic cycles, such as those by Hodge and Tate. His work related algebraic K-groups and the classical Chow groups based on algebraic cycles. Similarly, Quillen's later higher K-groups found a cycle theoretic analogue in Bloch's higher Chow theory, which initiated the development of a different motivic cohomology.

In a separate development, Borel and Bloch in the 1970s discovered, for certain varieties over number fields, a relation between regulators of their algebraic K-groups and special values of L-functions. Beilinson provided a common framework for these results and, for example, the Birch-Swinnerton-Dyer conjecture. Later refinements brought in Hodge theory as well as arithmetic tools. Hodge theory and motivic methods also found application in string theory and mirror symmetry. Recently, surprising relations were established between regulators and Feynman integrals, and height pairings were related to quantum field theory.

Spectacular new techniques developed in the past few decades resulted in proofs of important conjectures by Milnor and by Bloch and Kato, and stimulated new approaches to existing questions. To foster these, the programme brought together young researchers and leading experts across the many fields.

Starting in January 2020 with a lively introductory workshop aimed at PhD students, a grounding in the necessary background knowledge was provided through a rigorous lecture series. The momentum continued with a seminar series and study group on Picard-Fuchs differential equations related to the irrationality of the value of the Riemann zeta function at 3. After a two-year interruption due to the pandemic, the programme continued, stimulating discussions and bringing the diverse fields together through seminars, and a study group on Kim's approach to finding rational points on hyperbolic curves.

The three research level workshops, supported by ample external funding and preceded by more background lectures, buzzed with activity. Highlights included the Rothschild lecture by Bloch, the Kirk lecture by Raman, the Clay lecture by Griffiths, new results presented by talented young researchers (including Bachmann, Dogra, Mathew, Morrow and Tang), and a well-received public talk for the INI birthday celebration about the programme by Whitcher (which may yet result in an AMS Feature Column). The intense atmosphere stimulated existing collaborations and produced many new ones, resulting in various papers and preprints, and future conferences in subfields of the programme being planned.

ORGANISERS:
Rob de Jeu *(Vrije Universiteit Amsterdam)*
Aravind Asok *(University of Southern California)*
Charles Doran *(University of Alberta)*
Roy Joshua *(Ohio State University)*
Marc Levine *(Universität Duisburg-Essen)*
James D. Lewis *(University of Alberta)*
Ursula Whitcher *(American Mathematical Society)*

ROTHSCHILD DV FELLOWSHIP
Professor S Bloch

KIRK DV FELLOWSHIP
Professor P Raman

SIMONS FELLOWSHIP
Professor M Kim

M	F	%
73	23	4

GENDER BALANCE: (**M** : **F**, %)

UK	NON-UK	%
22	77	1

GEOGRAPHIC DISTRIBUTION (**UK** : **NON-UK**, %)

ECR	NOT ECR	UNKNOWN	%
37	58		5

ECR STATUS (**ECR** : **NOT ECR** : **UNKNOWN**, %)

The 'Verified software' programme laid the foundation for a rigorous science for specifying what computer hardware and software should or should not do.

Verified software
July – August 2022

The six-week programme "Verified software" brought together a diverse mix of researchers for the purpose of identifying the theoretical and practical challenges in algorithmic verification, synthesis, and certification of software systems; designing new languages, formalisms, tools, and integrated tool suites for the modelling and analysis of complex systems; identifying novel applications and challenge problems for verification technology; and crafting a roadmap for research, education, and technology. "Verified software" also offered an opportunity to take stock of the first fifteen years of Tony Hoare's "Verified Software Challenge" and to formulate a concrete roadmap for international cooperation for the next fifteen years.

In 2011, Mark Andreesen, the creator of the first web browser, said *"Software is eating the world."* Indeed, software is critical for banking, medical devices, cars, planes, factories, the power grid, and a lot more. Bugs in software can be annoying, but they can also cause these systems to fail in catastrophic ways, resulting in damage ranging from identity theft, loss of privacy, to loss of life. Science and engineering have also come to rely on software as a basic tool for calculation, modelling, simulation, archiving, and reporting.

The threats posed by incorrect software provoke the following questions:

- How do we construct software stacks with accurate mathematical models and provably predictable behaviour relative to these models?
- Can we build mathematical models and proofs for verifying safety and security properties of complex software systems that operate cars and planes and manage financial transactions?
- What theoretical advances are needed for modelling and analysing large software systems?
- What language and semantic analysis tools can assist in the large-scale construction of verified software?
- Can we create an ecosystem of high-quality, verified software with well-defined interfaces and composition mechanisms?

The *"Verified software"* programme laid the foundation for a rigorous science for specifying what computer hardware and software should or should not do, for building software that respects this specification, and for creating an ecosystem where we have the tools needed to compose complex software systems. The programme began with a week-long workshop that included presentations from industry-based researchers at Microsoft, Bedrock, Amazon, Synopsys, and Certora, as well as a number of academic researchers. The talks covered software-defined networking, hypervisors, hardware processors, cryptographic libraries, cloud platforms, program logics, and verification tools. The rest of the six-week programme featured a number of mini-events focused on Web Assembly, Rust and C verification, model checking, cyber-physical systems, concurrency, program synthesis, cryptographic systems, and formal method education. The programme led to a number of interactions and cooperative initiatives for creating an ecosystem for achieving measurable and impactful advances in the scientific and engineering foundations of verified software.

ORGANISERS:
Natarajan Shankar *(SRI International)*
Leonardo de Moura *(Microsoft USA)*
Azadeh Farzan *(University of Toronto)*
Philippa Gardner *(Imperial College London)*
Tony Hoare *(Isaac Newton Institute)*
Kim Larsen *(Aalborg Universitet)*
Xavier Leroy *(Collège de France)*
Ken McMillan *(University of Texas at Austin)*
Peter O'Hearn *(University College London)*
Peter Sewell *(University of Cambridge)*
Moshe Vardi *(Rice University)*

ROTHSCHILD DV FELLOWSHIP
None

KIRK DV FELLOWSHIP
None

SIMONS FELLOWSHIP
Professor S Chakraborty
Professor R Piskac
Professor S Prasad

GENDER BALANCE:
(**M** : **F**, %)

GEOGRAPHIC DISTRIBUTION
(**UK** : **NON-UK**, %)

ECR STATUS
(**ECR** : **NOT ECR** : UNKNOWN, %)

New activities at INI

Following the doubling of the Institute's primary grant funding in 2021, the scope of the activities it can offer to the mathematical sciences community has increased dramatically. Here we provide a summary of the initiatives launched so far.

From 2021, INI's funding provision from the Engineering and Physical Sciences Research Council (EPSRC), was doubled by a £10m addition of resources. This increased the Institute's annual operating budget from £3m to £5m over a five-year period. Consequently, INI has launched a number of new schemes and initiatives intended for the benefit of the UK's mathematical sciences community in particular, and the field of mathematics globally as a whole.

Core activities

INI's core output of hosting one, four or six-month long research programmes and their associated workshops remains unchanged; likewise established Newton Gateway activities such as the regular Open for Business events that bring together leading academics and industrial, commercial and government partners. However, follow-on workshops and programmes have now been formalised into a structure that will treat with a "lighter touch" any proposals submitted by individuals that were involved in the organisation of the parent programme. The chief criterion is that the follow-on workshop would augment, extend or enhance the impact of this original programme. Events of this kind have already been held across 2021-2022 with great success.

Satellite Programmes

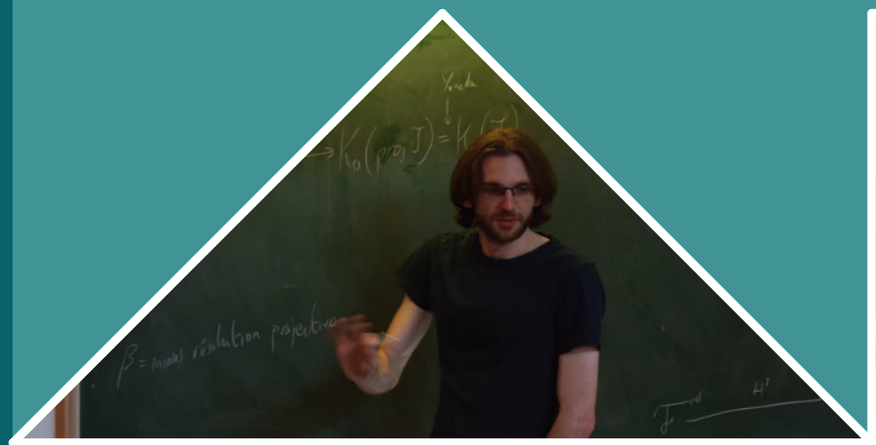
In 2022, INI has been proud to launch its new Satellite Programmes initiative, further strengthening its commitment towards increasing activity in other parts of the UK. Through this scheme, the Institute has invited proposals for satellite research programmes of six-month, four-month or four-week duration in any branch of mathematics or the mathematical sciences. In September 2022 the inaugural satellite programme, *"Geophysical fluid dynamics; from mathematical theory to operational prediction"* will take place at the University of Reading. A further satellite programme *"GeomPack geometry and packing in material structure and biology"* is due to take place at Aberystwyth University in August 2023, with more such proposals due to be approved in the near future.

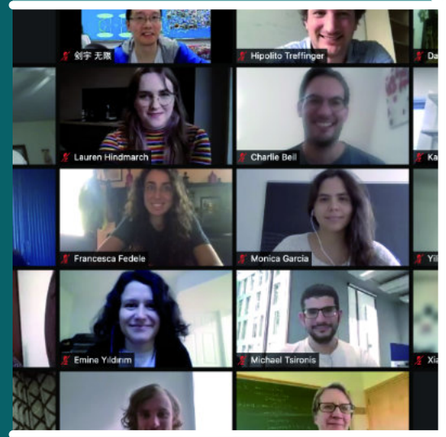
***"Solidarity for Mathematicians"* programme**

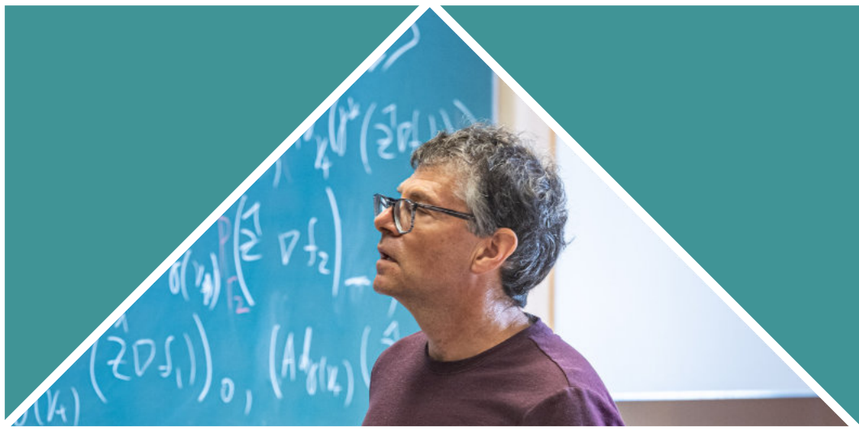
Launched initially as a response to Russia's invasion of Ukraine, this ongoing programme - launched with the generous support of XTX Markets - is designed for the purpose of giving refuge to researchers in the mathematical sciences who have had to leave their country of residence. The aim is not only to offer participants a safe home, but also to enable them to continue their work and start new scientific collaborations. INI has already provided support and welcome to a number of displaced academics, interviews with whom can be found on the Institute's website via the *"Living Proof podcast"* page: www.newton.ac.uk/news/ini-podcast

INI-Simons Postdoctoral Fellowships in Mathematics

INI continues to offer and to celebrate a diverse range of fellowship positions, the most recent of which is the INI-Simons Postdoctoral Fellowships in Mathematics. Launched in 2021, it offers successful applicants a one-year placement split evenly between participation in a suitable INI research programme and further collaborative work at Cambridge University's Faculty of Mathematics or within the mathematics department of another UK-based higher education institution. The aim is to enable exceptional early career researchers to gain experience, foster independence and forge new connections, a goal which has been amply achieved by the seven recipients of fellowships so far. Examples of similar, and longer-established, fellowships include INI collaborations with the Turner Kirk Trust, the Heilbronn Institute and Microsoft Research, details of which can be found here: www.newton.ac.uk/about/fellowships







New activities at INI

INI Network Support for the Mathematical Sciences

The UK mathematical community is supported by a myriad of official and unofficial networks, some of which exist only virtually. Newly launched in 2022, the INI Network Support scheme has been designed to provide modest funding packages of between £5,000 to £25,000 so that these networks can continue and intensify their work, and new ones be formed. It is open to both national and international networks, and eligible costs include international travel of UK residents and travel to the UK, staff time to support such networks, and costs involved in arranging in-person meetings.

National Academy for the Mathematical Sciences

INI has been supporting a cross-community consultation phase for a "National Academy for the Mathematical Sciences" (NAMS). The proposed academy, if the go ahead is given, would represent the mathematical sciences and people who work in them, including educators, practitioners and academics. It would operate across the whole of the mathematical sciences, including mathematics, statistics and operational research. The goal is that the Academy will offer a body which spans the whole of the mathematical sciences. First and foremost, it will be external facing, with advocacy at its heart. Though NAMS would ultimately be a national institution independent of INI, the Institute has been entrusted with the funds to help set up the proto Academy.

Knowledge Exchange Hub

Inspired by Professor Philip Bond's 2018 independent review "Era of Mathematics", the Knowledge Exchange Hub is a nascent organisation that will become a "national centre in impactful mathematics… created to work with industry and government to drive mathematical research through to commercialisation". INI is providing financial and administrative support in the early stages of this project, and working with newly appointed Knowledge Exchange Manager Rachael Harris on the development and delivery of the KE Hub, the appointment of a scientific lead and development of the governance structure. The KE Hub is to be formally launched in spring 2023, with pilot activities starting sooner.

PhD student placements at UKHSA

In October 2021, the UK Health Security Agency (UKHSA) sought to hire six PhD students for their Mathematical Modelling PhD student placement scheme. Both INI and KTN supported the UKHSA throughout the recruitment and onboarding process. As well as work experience, the placement also provided the candidates a pastoral and development programme, together with opportunities for technical skills development. The candidates were provided a choice of projects working at the forefront of the response to COVID-19. Following a successful first round of internships running from January to April 2022, the UKHSA are looking to work with INI for a second round of internships in early 2023.

UKRI's Analysis for Innovators Programme - A4I

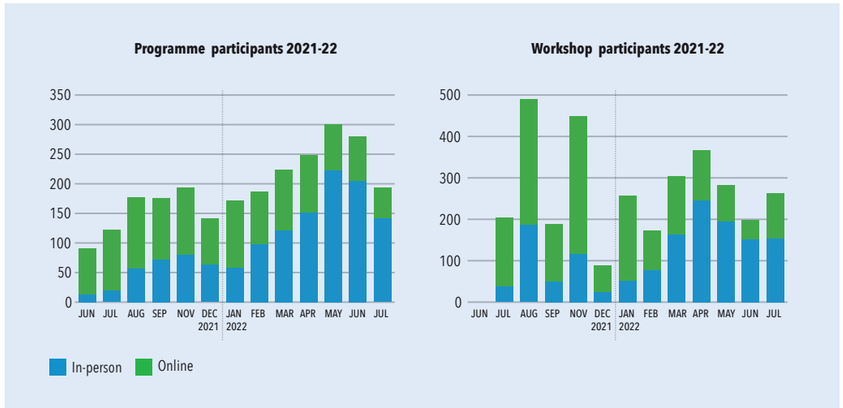
In March 2022 the Newton Gateway to Mathematics was appointed as a new Partner in UKRI's Analysis for Innovators Programme (A4I). The programme gives UK businesses of any size access to cutting-edge R&D expertise and facilities to help solve problems that they have been unable to tackle using standard technologies and techniques. Academics from the Gateway Scientific Advisory Panel (or those associated to it) are providing input to A4I activities, and taking forward a number of projects with individual companies.

Participation and engagement

INI had its busiest year on record in 2021-22, running eight programmes, accounting for 33 months of programming, and 29 workshops. The Institute moved deftly from online to hybrid to predominantly in person activities as circumstances allowed, delivering ground-breaking programmes and welcoming world-leading mathematicians to participate in its activities including: Fields Medallists Sir Tim Gowers (Cambridge), Sir Roger Penrose (Oxford), Maryna Viazovska (EPFL) and Ed Witten (Princeton). Kirk and Rothschild Distinguished Visiting Fellows and other senior participants who added greatly to their programmes included: Claude Bardos (Universite Paris 7 - Denis-Diderot), Pierre-Emmanuel Jabin (Penn State), Rama Govindarajan (ICTS, Bengaluru), Cheryl Praeger (Western Australia), Parimala Raman (Emory), Don Zagier (Max-Planck-Institut fur Mathematik, Bonn) and many others.

Programme and Workshop participation numbers

Under the shadow of Covid, the number of people that could be accommodated in the INI building was very limited for the first part of the year, and travel to the UK was either restricted or not allowed. However, INI acted swiftly to install air filters across the building to sanitise the air and hence we were ahead of the curve in terms of re-opening for in person participation. Thus, of the 839 programme participants during the year, 524 (62%) were able to attend in person for at least some of the period, and of the 46844 participant days, 24333 (52%) were in person at INI. Similarly, 1313 of the 2940 workshop visits (45%) were in person, accounting for 6215 in person workshop visit days out of 13685 (45%). There were an additional 51 unregistered visitors, the majority of whom were not Cambridge-based. We see in the charts above the shift from remote to in person participation as the year progressed; the exception to this was the high number of people who attended the workshop to in honour of Sir Michael Atiyah at the beginning of the year in September 2021. This was possible thanks to the clement weather, which enabled us to keep all doors and windows open. This event featured in the 2020-21 Report.



The **geographical distribution** of participants' home institutions has been relatively consistent throughout INI's lifetime, with approximately 1/3 of participants coming from the UK, 1/3 coming from Europe and 1/3 coming from the rest of the world. We saw this repeated again this year with 30% of programme participants coming from the UK, 35% coming from the rest of Europe and the remaining 35% coming from the rest of the world: for in person visits, these values were 39%, 32% and 29% respectively with the majority of the overseas visits occurring in the latter part of the academic year as travel restrictions lifted. The geographical split for all workshop participants followed the typical pattern with 33% coming from the UK, 33% coming from the rest of Europe and 34% coming from the rest of the world. However, a reduced appetite for long-haul travel for shorter visits was evident for in person workshop participation, with 50% of the in person workshop visits coming from UK-based participants, 27% coming from the rest of Europe and 23% coming from the rest of the world.

INI continues to monitor and strive to improve the **gender balance** across all aspects of its activities, and to reflect on its reporting of this protected characteristic whilst preserving anonymity where numbers are small. The proportion of female participants continues to rise year-on-year, with 24% of both programme and workshop participants being female: for in person participation, this increased to 25% for both programme and workshop participants. These figures mask significant variation between programmes, reflecting the discrepancy across fields. We work particularly closely with Organisers in fields with low female representation to incorporative activities within their programming that aim to redress this imbalance in the long term. Examples include *"The Power of Women in Deep Learning"*, a two-day workshop that was embedded in the Mathematics of Deep Learning programme and a *"Life Decisions in Mathematics"* panel session spanning both programmes in the first half of the year. To counter the **under-representation of women in the mathematical sciences**, especially at senior levels, INI puts significant emphasis on role models, and 29% of its Programme Organisers and 27% of its Workshop Organisers were female. Further, 25% of all seminars were given by female speakers. It is important to highlight that 36% of INI's Management Committee and 57% of its Scientific Steering Committee are female.

INI now collects data and reports on **career stage** rather than age, and this data is now 89% complete for programme participants and 84% complete for workshop participants. Using this data, we know that at least 33% of programme participants and 44% of workshop participants identify as Early Career Researchers (ECRs). This is according to the EPSRC's definition that an ECR is: a research student, or (excluding any period of career break e.g. for family care or health reasons) within eight years of the award of their PhD or equivalent, or within six years of their first academic appointment. INI is mindful of nurturing the next generation of mathematical scientists, and 2% of Programme Organisers, and an impressive 45% of Workshop Organisers, and 27% or seminar speakers were Early Career Researchers. Most programmes included either a Summer/Winter School or some form of instructional activity to support the flow of talent into their field. Examples include the *"New developments in representation theory arising from cluster algebras"* research school and the "Kinetic theory: old and new" tutorial workshop.

Supported by the Simons Foundation, INI introduced a new scheme for supporting ECRs especially during the challenging post-covid period. **Five INI-Simons Post-Doctoral Research Fellows** (PDRFs) were appointed for this academic year, each spending six months of their 12-month Fellowship participating in an INI programme and the remaining six months working with a host academic from within Cambridge's Centre for Mathematical Sciences (note that this scheme has now been extended so that in future these ECRs can spend the non-INI period of their Fellowship at any UK HEI). The INI-Simons PDRFs were a wonderful addition to their programmes, organising seminars and social events and facilitating cross-programme interactions.

INI continues to facilitate the participation of **under-represented groups** via the DAC Scheme for supporting those from developing countries as defined by the Organization for Economic Cooperation and Development (OECD) and the Provision of Care Scheme for care providers and those in need of care. This academic year, a total of £96,688 was allocated to programme and workshop participants via these two schemes, including £34,850 to support programme participants with caring responsibilities and £45,478 to support programme participants from DAC-Listed countries. In total, 44 programme participants and 197 workshop participants came from home institutions in a DAC-Listed country. Of these, 52% of the DAC programme participants and 26% of the DAC workshop participants attended in person.

Participation and engagement

INI monitors its **geographic reach** both within the UK and worldwide. Participants from 425 institutions, including 74 in the UK, and 41 countries spanning all continents attended INI activities in person. An additional 143 institutions (7 UK-based), and 12 countries, were represented by the online participants. The **Talks Elsewhere Scheme** continues to thrive and despite the pandemic, 36 of our overseas participants gave 44 talks at 23 different UK HEIs, from Swansea to Abertay Dundee and from Liverpool John Moores to York. Since the Talks Elsewhere scheme began in 2016, 364 talks have been given by 219 individuals at 63 UK institutions. The **Preprints Archive** steadily increases with 28 added to the series this year bringing the total to 1443. Unfortunately, challenges surrounding Covid-19 meant that it was only possible to have one **Satellite Workshop** this year: that was held at the International Centre for Mathematical Sciences (ICMS), Edinburgh.

INI has a strong track record of in person outreach activities. Many of these were not possible this year, however Seminar Room 1 was packed with families for INI's contribution to the Cambridge Festival (formerly known as Cambridge Science Festival) to hear Anotida Madzvamuse (Sussex), give a fascinating talk on "*How do cells walk through complex environments? A mathematics point of view*."

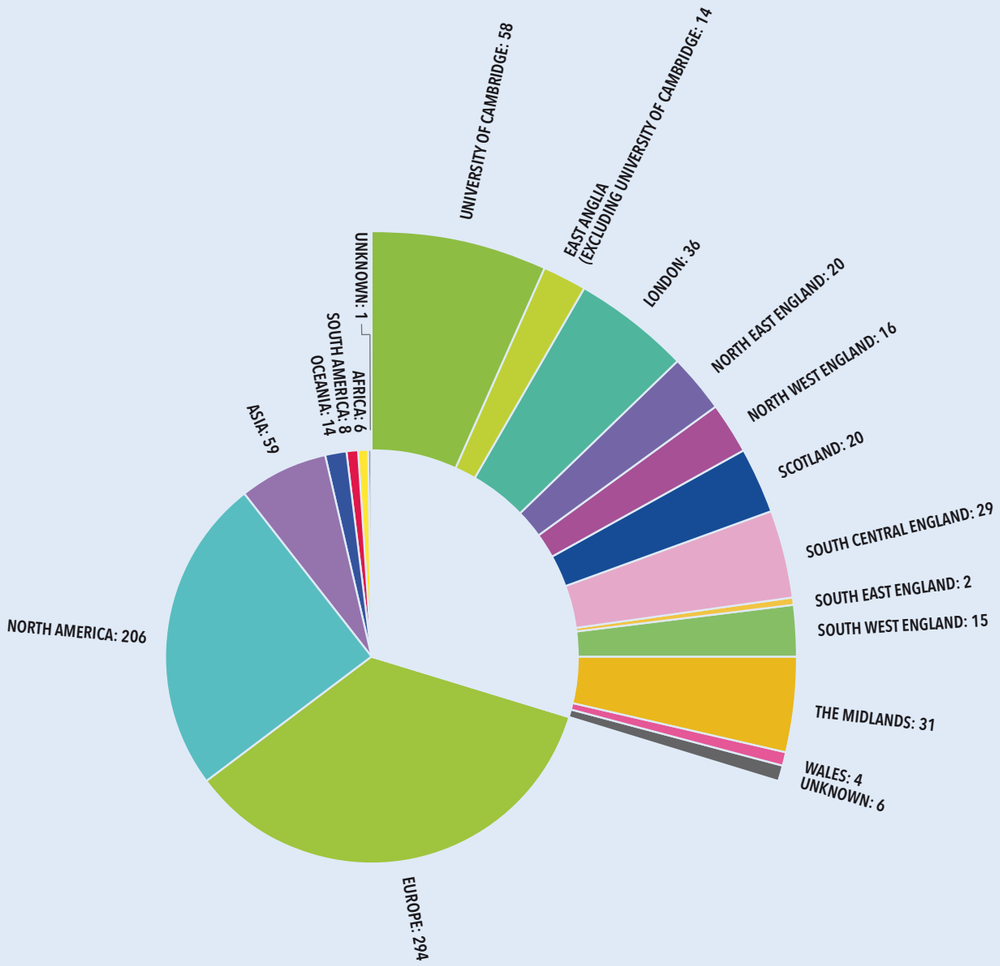
All of INI's **seminars** continue to be streamed live and made available in perpetuity, subject to speaker permissions. This year almost 1000 new seminars were added to the archive which now contains 9500 seminars. The archive dates back as far as 1996, beginning with Fields Medallist Ed Witten's series of three talks on *"Duality and three manifolds"* and followed in 1997 by 2014 Dirac Medal winner Ashok Sen's seminar on *"An introduction to string dualities"*. The seminar archive is complemented by a more recently introduced archive of **video interviews with programme organisers** where they give an overview of their field and the challenges that their programme is hoping to address. There are now 28 such videos, one for each INI programme since the series began. Adding a more personal element, and often touching upon interests or life stories, the **Living Proof Podcast Series** introduced in March 2019 – and produced by INI communications manager Dan Aspel – has become highly popular. The 54 episodes have been "viewed" a total of 14,549 times with episode #33, *"Becoming Bethany Marsh"*, an interview with one of the organisers of the Cluster Algebras programme, receiving an impressive 1,419 "views". This academic year, INI's **Tweets** had 767,000 impressions and our **Facebook** page's reach was 30,528.

In January 2020 INI began a collaboration with *PLUS Magazine* (https://plus.maths.org/), a freely available website that produces maths-related articles and news stories for young adults, students, teachers, and life-long learners. This collaboration has provided an excellent opportunity for INI participants to communicate their work to new audiences and in the first 18 months PLUS produced and published 65 articles and 10 podcasts based on INI activities. These attracted 136,000 page views on PLUS's website in addition to those viewed via INI's website here: **newton.ac.uk/news/plus-magazine-articles**.

The past year has been a challenging one in many ways for INI and its participants, but the appetite for returning to face-to-face interactions has been immense. The biggest lesson of the year is that whilst we have the technology to facilitate online participation, and whilst it has enabled mathematicians to continue working together when other options were not available, in fact there is no replacement for standing together working side-by-side at one of INI's 130m² of blackboards.

A highlight of the year was INI's **30th Anniversary Celebration** Event with compelling talks by **Michael Shearer** *(North Carolina State University),* **Ursula Whitcher** *(American Mathematical Society, University of Michigan)* and **Edriss Titi** *(University of Cambridge, Texas A&M University and Weizmann Institute of Science)*, all organisers of the concurrent programmes, and a wonderful Plenary Talk by Fields Medallist **Sir Tim Gowers** *(Cambridge)*. **Correspondents Day** the following day was well attended with participants from 23 institutions.

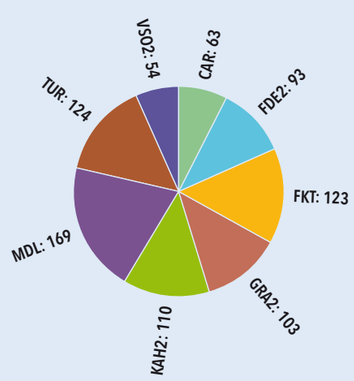
Worldwide geographic spread



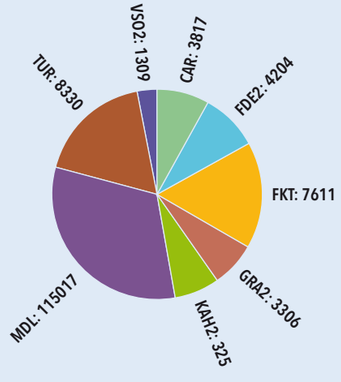
Gender and ECR Status

Programme and workshop participant numbers

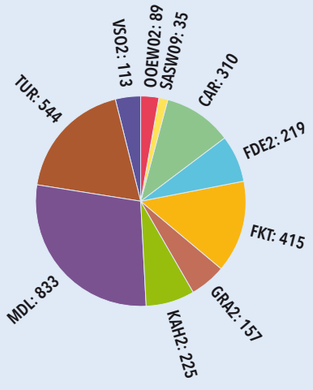
839
PROGRAMME PARTICIPANTS



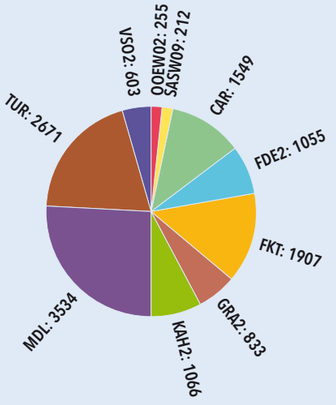
46844
PROGRAMME PARTICIPANT DAYS



2940
WORKSHOP PARTICIPANTS



13685
WORKSHOP PARTICIPANT DAYS



Finances

Accounts for August 2021 to July 2022

For the Isaac Newton Institute and Newton Gateway to Mathematics

Income	*Notes*	2020-2021 £000	**2021-2022 £000**
Research Grants and Contracts	*1*	1,997	**3,250**
Contribution from the University of Cambridge	*2*	443	**499**
Donations	*3*	18	**33**
Additional workshop income		7	**53**
Additional income	*4*	123	**281**
Endowment and investment income		525	**582**
Total income		3,113	**4,698**
Expenditure			
Staff costs		1,085	**1357**
Travel and subsistence	*5*	877	**2011**
Other operating expenses	*6*	242	**472**
Overheads paid to the University	*7*	605	**830**
Total expenditure		2,809	**4,670**
Surplus / (deficit)		304	**28**

Notes to the Accounts

Note 1 - Research Contracts and Grants (EPSRC, Simons Foundation & Heilbronn Institute for Mathematical Research)

Salaries	791
Participant costs (travel and subsistence)	1729
Estates and indirect income	730
Total	**3,250**

Note 2 - Contribution from the University of Cambridge

The University's financial contribution towards the Institute's running costs. In addition, the University provides the main and Gatehouse building, and pays for all services and rates.

Note 3 - Donations

London Mathematical Society	30
Donations, other	3
Total	**33**

Note 4 - Additional income

Merchandise sales	1
HEIF (Newton Gateway)	52
Newton Gateway events income	156
Programme Sponsorship	56
Mathematical Community Support	5
Miscellaneous Income	10
Total	**280**

Note 5 - Travel and Subsistence

Programme & workshop	1920
Staff travel & subsistence	10
Total	**1930**

Note 6 - Other operating expenses

Computing	110
Institute running costs	88
Catering	27
Furniture	10
Professional & brought in services	237
Total	**472**

Note 7 - Overheads paid to the University

Includes Estates and Indirect costs on grants and overheads on Trust Funds.

Governance: Advisory Council

Management Committee

The Management Committee is responsible for overall control of the budget of the Institute and for its financial planning. The Director is responsible to the Management Committee, which provides essential advice and support in relation to fund-raising activities, employment of the staff of the Institute, appointment of the organisers of programmes and general oversight of Institute activities. Its aim is to facilitate to the fullest possible extent the smooth and effective running of the Institute's programmes and all related activities. Membership of the Management Committee at 31 July 2022 was as follows:

Name	Institution	End of Service
Dr Ewan Kirk (Chair)	General Board	31-Dec-22
Professor Miguel Anjos	University of Edinburgh	31-Dec-22
Dr Katie Blaney	EPSRC	
Professor Colm-Cille Caulfield	Head, DAMTP, University of Cambridge	
Dr Nira Chamberlain	SNC-Lavalin	31-Dec-24
Professor Mark Chaplain	St Andrews	31-Dec-24
Professor John Greenlees	University of Warwick	31-Dec-22
Professor Niall MacKay	Chair of Correspondents, York	
Dr Christie Marr (Secretary)	Deputy Director, Isaac Newton Institute	
Professor James Norris	Head, DPMMS, University of Cambridge	
Professor Nigel Peake	Head, School of Physical Sciences	
Professor Marian Scott	University of Glasgow	31-Dec-23
Professor Ulrike Tillmann	Director, Isaac Newton Institute	
Professor Helen Wilson	Chair of the Scientific Steering Committee	31-Dec-23

Scientific Steering Committee

The Scientific Steering Committee (SSC) meets twice each year to consider proposals for programmes (of 4-week, 4-month or 6-month duration) to run two or three years later. Successful proposals are usually developed in a discussion between the proposers and the SSC conducted through the Director, and may well be considered at more than one SSC meeting before selection is recommended. Complete details of the Institute's regular call for proposals, including guidelines for submission, can be found on the Institute's website at **www.newton.ac.uk/science/proposals**. Membership of the Scientific Steering Committee at 31 July 2022 was as follows:

Name	Institution	End of Service
Professor Helen Wilson (Chair)	University College London	31-Dec-23
Professor Nick Barton	Institute of Science and Technology Austria	31-Dec-25
Professor Andrea Bertozzi	University of California Los Angeles	31-Dec-24
Professor Ken Brown	University of Glasgow	31-Dec-23
Professor Susanne Ditlevsen	Københavns Universitet	31-Dec-24
Professor Robin Henderson	University of Newcastle	31-Dec-23
Dr Kristin Lauter	Facebook AI Research (FAIR)	31-Dec-24
Professor Sara Lombardo	Loughborough University	31-Dec-24
Professor Aleksandar Mijatovic	University of Warwick	31-Dec-22
Professor Mary Rees	University of Liverpool	31-Dec-23
Professor Carola-Bibiane Schönlieb	University of Cambridge	31-Dec-22
Professor John Shawe-Taylor	University College London	31-Dec-22
Professor Ulrike Tillmann	Director, Isaac Newton Institute	
Professor Minhyong Kim	Scientific Director, ICMS	

Cumulative Financial Grants and Donations above £10,000

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

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All donors will be acknowledged formally in the Institute's Annual Report (unless anonymity is preferred). The Institute offers recognition in various ways, including naming opportunities. If you would like to discuss these or other aspects of supporting our work, please do not hesitate to contact the Director (+44 (0)1223 335980 /director@newton.ac.uk) or Josh Bowerman at Cambridge University Development and Alumni Relations (+44 (0)1223 330112 / gw366@cam.ac.uk).

UNIVERSITY OF CAMBRIDGE

SIMONS FOUNDATION

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