Isaac Newton Institute
for Mathematical Sciences

Annual Report **2019-2020**

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

Welcome to the 2019-2020 Annual Report of the Isaac Newton Institute (INI). This has been a unique year, both for the Institute and for the world as a whole. The COVID-19 pandemic has brought with it great challenges, tragedy and disruption, but has also demanded innovative thinking and adaptation to ever changing circumstances. The staff of both INI and the Newton Gateway have met these difficulties admirably; helping us continue our mission of enabling the world's foremost mathematical minds to meet and work together.

The INI academic year started well, with three highly successful programmes running in the second half of 2019. In the New Year, two excellent long-term pure mathematical programmes commenced; however, on 23 March 2020 the UK's first lockdown began, bringing with it a curtailing of these programmes and all workshops and other physical events at INI. However, by April, a virtual programme examining the Infectious Dynamics of Pandemics (IDP) was formulated, and within weeks traversed a fast-tracked, academically rigorous approval process to begin in earnest within a record timeframe. Thanks must go to the principal organisers of IDP, Deirdre Hollingsworth, Valerie Isham and Denis Mollison, whose enthusiasm and capability helped ensure great success. The programme has enabled mathematicians from across the world to work collaboratively on one of the most urgent and difficult issues of our time, and contributions to the decision-making bodies of the UK Government have been numerous and vital. INI's team helped support this important initiative at a crucial moment; and congratulations must go to our colleagues Julia Gog, Graham Medley and Catherine Noakes on their OBEs for their services to the UK's pandemic response.

Another initiative that should be celebrated is the creation at the end of March 2020 of the rapid-response Virtual Forum for Knowledge Exchange in Mathematical Sciences (V-KEMS). Its aim has been to provide support from mathematical scientists for research and business continuity to those in other academic disciplines, industry, government, the public sector, and charities. V-KEMS is a joint venture between INI and the Gateway, our sister Institute ICMS, the Knowledge Transfer Network, and several senior members of our community including Alan Champneys, Rebecca Hoyle, Chris Budd and Jo Jordan. Since its inception V-KEMS has helped galvanise mathematical scientists to engage in pandemic-related issues, run 20 virtual events, produced 20 outputs, engaged over 800 participants, leveraged three person-years' worth of academic activity time, and secured new studentships.

The continued situation has meant that our usual busy schedule of physical programmes had to be postponed from March and now likely through to the Spring of 2021. This has left an increasing backlog of programmes and other events to be rescheduled. However, in the background to all of the difficulties has been the very welcome announcement in January of a £300m increase in government funding to the UK's mathematical sciences, to be distributed through UKRI/EPSRC. Over recent months we have set out detailed plans as to how the INI would utilise an increase in our grant, and I am pleased to report that our proposal was successful. We look to soon receive a substantial uplift to our yearly from UKRI, for a five year period in the first instance, which will allow both INI and the Gateway to expand significantly their support to the national and international community. We look forward to reaching out far more to all corners of the UK, allowing greater flexibility in our programming, and redoubling our efforts at inclusivity, diversity and widening access to all our activities.

The learning from the last eight months has been huge, and it will continue. We are developing better and more inclusive ways of working together in a virtual environment, and are confident that we will be able to run many more meaningful events which support our research communities whatever the situation in the short or medium term. When the Institute is able to resume the programming of physical events, it will undoubtedly run these in a hybrid fashion, with virtual (associate) participants able to engage fully, wherever their location.

The success of the Institute relies heavily on the continued commitment and hard work of colleagues, associates and staff. I am indebted to the many referees and committee members, who ensure that the quality of our programming remains excellent. I single out Valerie Isham for especial thanks this year as she finishes her second term as Chair of our Scientific Steering Committee. Valerie has worked tirelessly for the Institute since 2014, and her good judgement, dedication and attention to detail has aided the Institute on many occasions. I further thank all the organisers of our many events, who give their time selflessly for the good of their communities. I extend my particular gratitude to Barry Phipps, INI's Curator of Art and Science, for his activities this year, which include the appointment of Ewan Campbell as our new artist in residence; procurement of a donation of a wonderful sculpture (entitled Star and Cloud) by the acclaimed artist Bruce Gernand; and, with Andrzej Herczynski, organisation of a stimulating workshop on Opportunities at the Intersection of Science and Art. With the aid of external funding, we will hopefully be able to build an international community around this theme, and run an international timetable of bold exhibitions and meetings.

I write this article whilst the progression and resolution of the COVID-19 pandemic are still unclear. However, it is somewhat reassuring for INI to be based at Cambridge University, which has managed to see off several pandemics, the reformation and a civil war in its 800 year history! The very recent news of a the first wave of effective vaccines against SARS-COV-2 gives renewed hope that we can indeed return to normality sooner rather than later, and clearly highlights that science, using the language of mathematics, is such a critical part of modern day society. I wish all readers well for the immediate future.

David Abrahams,
Director, Isaac Newton Institute

Programme Schematic

Please note that the **GRA** and **KAH** programmes are not reported on in this document, as they were suspended by the COVID-19 pandemic. They will be reported upon when the remaining months of the programmes are completed.

2019

2020

2021

2022

KAH · GRA · GCS · CAT · EBD · WHT · IDP · ARA* · MDL · KAH* · CAR · GRA* · FKT · TUR
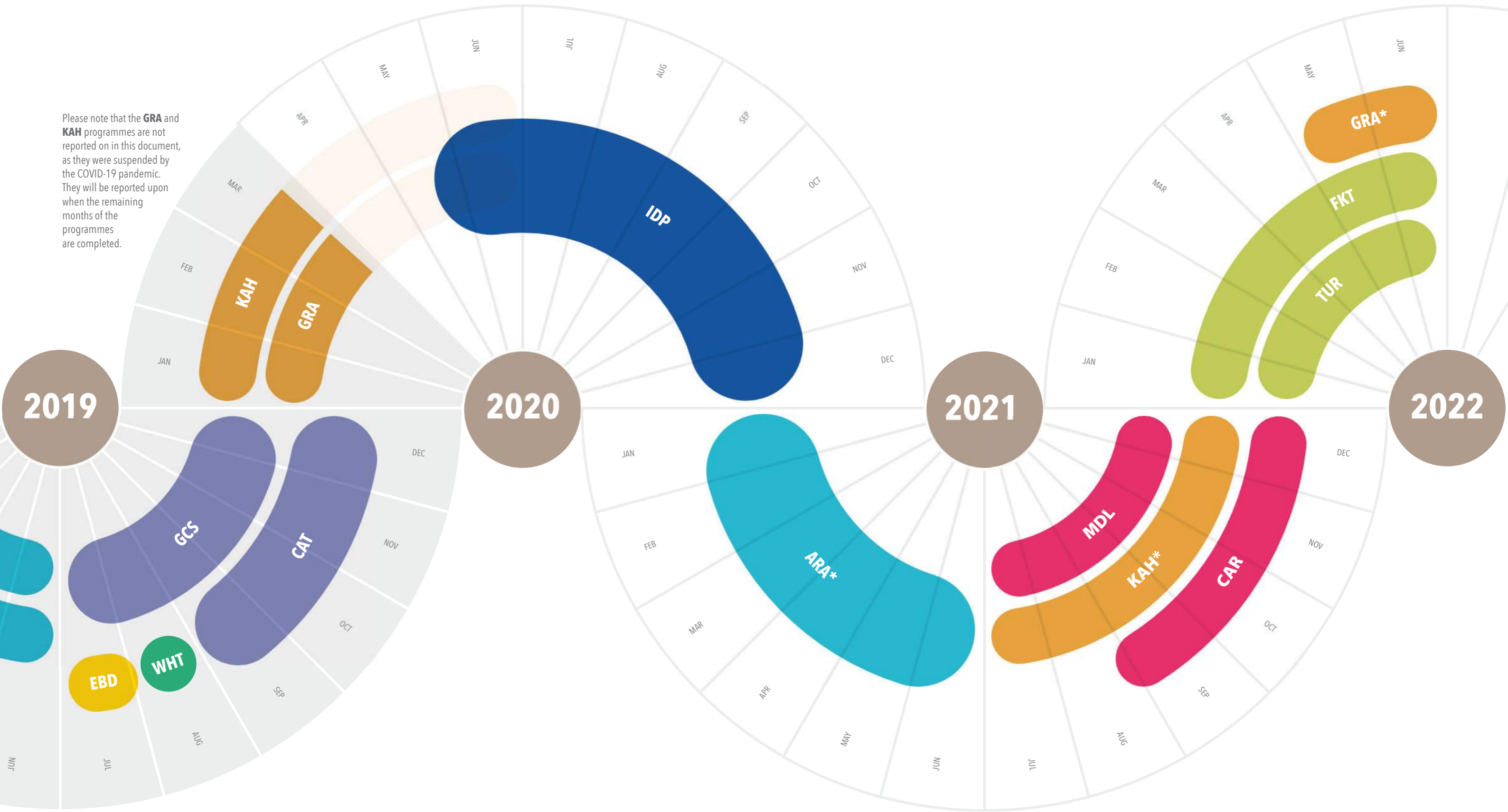
GCS Geometry, compatibility and structure preservation in computational differential equations

EBD Mathematical and statistical challenges in landscape decision making

WHT Bringing pure & applied analysis together via the Wiener-Hopf technique, its generalisations and applications

CAT Complex analysis: techniques, applications and computations

KAH K-theory, algebraic cycles and motivic homotopy theory

GRA Groups, representations and applications: new perspectives

IDP Infectious Dynamics of Pandemics: Mathematical and statistical challenges in understanding the dynamics of infectious disease pandemics

ARA Applicable resurgent asymptotics: towards a universal theory

MDL Mathematics of deep learning

CAR Cluster algebras and representation theory

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

TUR Mathematical aspects of turbulence: where do we stand?

*these programmes were split due to the closure of INI during the COVID-19 pandemic

INI's Pandemic Response

Due to the COVID-19 pandemic, the Institute temporarily closed its doors to programme participants on Friday 20th March, halfway through two popular and vibrant programmes on K-theory, algebraic cycles and motivic homotopy theory (KAH), and on Groups, representations and applications: new perspectives (GRA). But even as it was closing its doors, INI was looking to re-invent itself and meet the needs of the mathematical sciences community during this time of crisis, building on networks nurtured over decades: the seeds of the Infectious Dynamics of Pandemics (IDP) programme and the Virtual Forum for Knowledge Exchange in the Mathematical Sciences (V-KEMS) initiative were being sown.

Virtual Forum for Knowledge Exchange in the Mathematical Sciences

INI Director David Abrahams was instrumental in the creation of V-KEMS: as early as 21 March, two days before the UK went into lockdown, he began conversations with Matt Butchers from the Knowledge Transfer Network about how they might best support the UK mathematical sciences community to continue constructive knowledge exchange virtually. Drafting in the Newton Gateway and ICMS (Edinburgh), as well as colleagues from across the UK, they began putting together a suite of software tools including Slack, Zoom, WhiteboardFox, Slido, Mural, HackMD and Overleaf, to facilitate virtual working.

Offering mathematical support to business, industry, government, the public sector and the third sector, as well as facilitating study groups and providing the infrastructure to host relevant webinars and scoping meetings, V-KEMS has run over 20 events, produced 20 outputs, and engaged over 800 participants.

For further details of the V-KEMS initiative see the Newton Gateway Annual Report, visit **www.vkemsuk.org/home** or listen to the INI podcast on V-KEMS with Rebecca Hoyles (Southampton) at **www.newton.ac.uk/news/podcast#Episode 24**.

Infectious Dynamics of Pandemics

In April, INI Director David Abrahams approached the organisers of past INI programmes on epidemiology and suggested that they put together a programme on Infectious Dynamics of Pandemics. Condensing processes that normally take at least 2½ years into a little over three weeks, an Organizing Committee was put together, a proposal was written and developed, referee reports were obtained, and approval granted by the Scientific Steering Committee and Management Committee. The resultant programme, INI's first virtual programme, began on 5 May, just a few weeks after the UK went into lockdown.

Working independently but also supporting the work of the government's Strategic Advisory Group for Emergencies (SAGE), its Scientific Pandemic Influenza Group on Modelling (SPI-M), and the Royal Society's Rapid Assistance in Modelling the Pandemic (RAMP) team, the IDP programme faced many challenges including balancing the need to respond to urgent national questions with the need to take a longer view.

Programme Organiser Julia Gog (Cambridge) and participants Graham Medley (London School of Hygiene and Tropical Medicine) and Cath Noakes (Leeds), all members of SAGE, were awarded OBEs for their service to the COVID-19 response.

For further information on activity and outputs of this programme, read its programme page in this annual report, see **www.newton.ac.uk/event/idp** to watch the seminars or read the preprints produced, or listen to podcasts with the participants here: **www.newton.ac.uk/news/podcast**.

Geometry, compatibility and structure preservation in computational differential equations

Computation of differential equations is a fundamental activity in applied mathematics. In the last 25 years focus has shifted away from all-purpose numerical algorithms for time integration towards purpose-built algorithms tailored to preserve special features of classes of differential equations. However, this line of research has proceeded along very different lines, depending on whether the differential equations were ordinary (ODEs) or partial (PDEs). A central aim of this six month programme was to bring these two disparate communities together.

Geometric and structure preserving methods are a special class of numerical algorithms used to compute solutions to differential equations that preserve the underlying geometry and structure of the system. In addition to being quantitatively accurate, these novel methods have the advantage of also being qualitatively accurate. Due to the increased speed and accuracy of these methods over more traditional algorithms they have become an important tool in weather forecasting, medical imaging, defence, space and robotics.

Work in this area has focused on understanding structure preservation for differential equations either in space or in time, with little or no interaction between the two different research communities. Bringing together experts from these two disparate areas the programme focused on themes of common interest. Namely the preservation of conservation laws and the structure of the manifold on which the solutions live.

The first workshop was devoted to tutorials and surveys originating from each group. A lively well-attended seminar series ran throughout the programme and covered a range of topics including methods for plasma physics, quantum dynamics, virtual element methods and sampling algorithms on manifolds, questions related to deep neural networks and statistical problems which involve smooth constraint structures.

General relativity was the focus of the second workshop. It was very successful in introducing participants from other areas of structure-preserving discretizations to the challenge of developing stable methods preserving appropriate geometric structures in the approximate solution of Einstein's equations.

Highlights of the programme included a Kirk Distinguished Visiting Fellow Lecture by Donatella Marini on advances in the application of virtual elements, and a Rothschild Distinguished Visiting Fellow Lecture, by Jesus Maria Sanz-Serna on Hamiltonian Monte Carlo methods for ODEs. A Newton Gateway Open for Business day highlighted the breadth of application areas with talks from academics and end-users in meteorology and climate, medical imaging, and robotics. Monthly seminars with the concurrent INI programme on 'Complex Analysis: Techniques Applications and Computation' led to fruitful discussions on common interests between these programmes.

The programme led to three immediate breakthroughs. The first provided a mathematical justification of ring-polymer molecular dynamics in the study of how molecules transfer energy of light into motion (photochemistry). The second was the preservation of multi-symplectic structures in finite element methods. Finally, a group of participants obtained very promising results on splitting methods for Hamiltonian Monte Carlo simulations.

The final workshop held at ICMS in Edinburgh, pulled together new themes, advances and connections that emerged during the programme. A summary of the future directions for this area is currently being complied in the form of a collection of short communications and open problems.

"The programme's second workshop was very successful in introducing participants from other areas of structure-preserving discretizations to the challenge of developing stable methods preserving appropriate geometric structures in the approximate solution of Einstein's equations."

ORGANISERS:
Douglas Arnold *(Minnesota)*
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Elena Celledoni *(NTNU)*
Arieh Iserles *(Cambridge)*
Elizabeth Mansfield *(Kent)*
Reinout Quispel *(La Trobe)*

ROTHSCHILD FELLOWSHIP
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KIRK DV FELLOWSHIP
Professor D Marini

SIMONS FELLOWSHIP
Professor D Arnold
Professor E Celledoni
Professor E Faou
Dr E Hubert
Professor R McLachlan
Professor H Munthe-Kaas
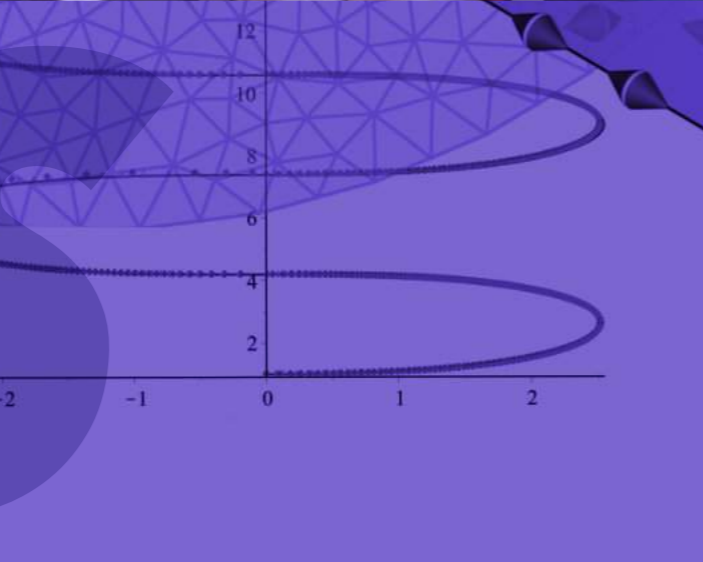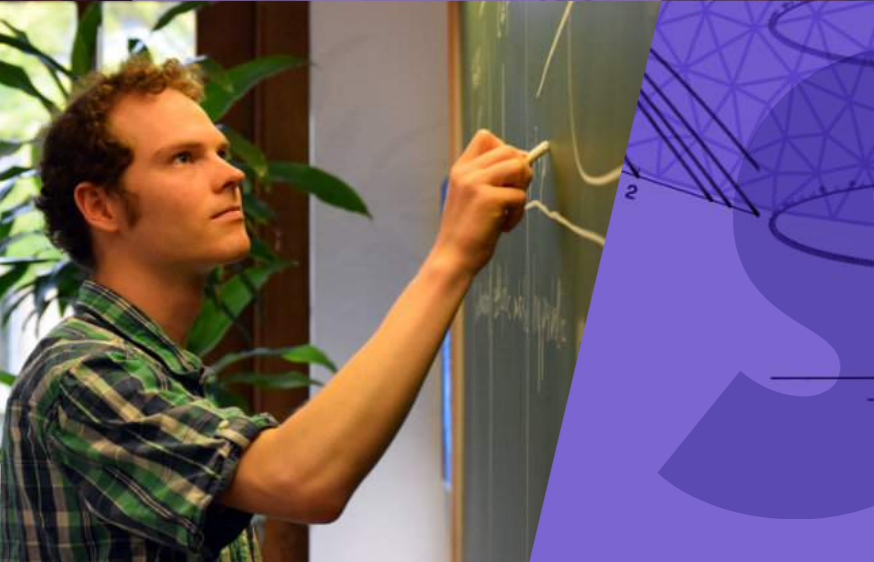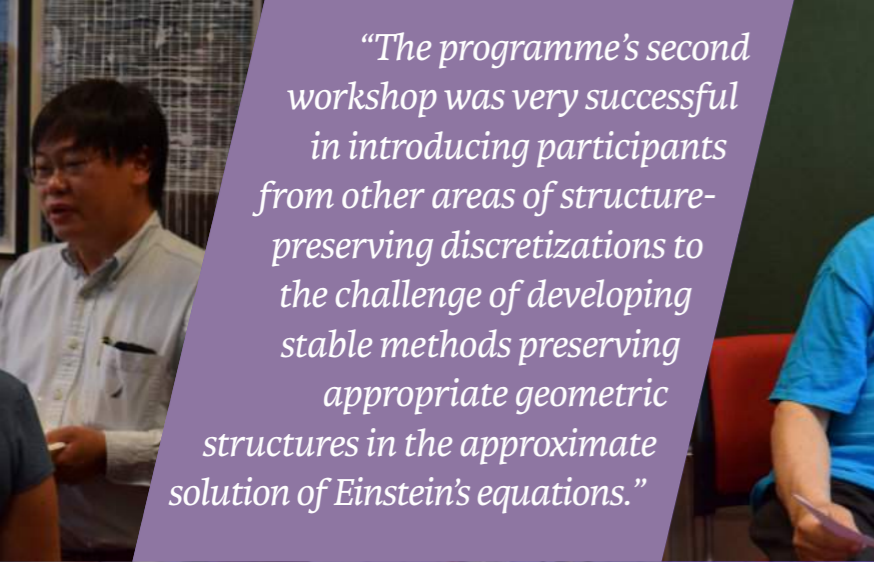Professor R Quispel
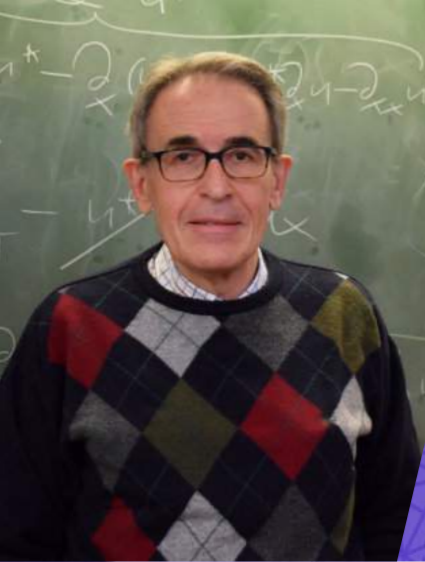Professor A Zanna

GENDER BALANCE:
(M : F, %)
| 77 | 23 |

GEOGRAPHIC DISTRIBUTION
(UK : NON-UK, %)
| 29 | 71 |

AGE DISTRIBUTION
(≤29 : 30-49 : ≥ 50 : unknown, %)
| 13 | 50 | 38 |

Bringing pure and applied analysis together via the Wiener-Hopf technique, its generalisations and applications

The Wiener–Hopf method, interdisciplinary since its inception, has enabled the analytical solution to previously intractable integral and partial different equations. This technique is currently used in a wide range of disciplines including acoustics, finance, hydrodynamics and electromagnetism. The main aim of this programme was to bring together internationally leading experts in the Wiener-Hopf technique and catalyse new interactions between them.

"Participants found the month intensive and highly motivating, crediting the productive outcomes to the friendly, welcoming and productive environment of the INI."

The motivation for this one-month programme was to build connections between different strands of the Wiener–Hopf method. This fascinating technique was conceived around 90 years ago and has since contributed to numerous branches of mathematics. Founded on highly abstract concepts, the method has applications in electromagnetic wave diffraction, fracture dynamics, probability theory, aeroacoustics, machine learning and many other fields. Over time, different research communities that employ the Wiener–Hopf method have developed their own terminology, and have focused their research in different directions, leading to a diverse set of related open problems.

The first week consisted of diverse, stimulating and intensive courses with lectures delivered by experts in pure mathematics, applied mathematics and numerical analysis. This was followed by a week of conference-style talks with cutting-edge presentations from leading researchers. The last two weeks were dedicated to informal interactions, collaborations, discussion of funding opportunities, and study groups that concentrated on particular research topics.

Participants found the month intensive and highly motivating, crediting the productive outcomes to the friendly, welcoming and productive environment of the INI.

At least one grant proposal is currently being developed, two further conferences are being proposed and many new collaborations have been stimulated. A special feature of Proceedings of the Royal Society A consisting of survey and research papers that have arisen as a result of this programme is also planned.

ORGANISERS:
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Dr E Luca
Professor G Mishuris
Dr M Nieves
Professor S Rogosin
Professor L Slepyan
Dr K Ustinov

GENDER BALANCE:
(M : F, %)

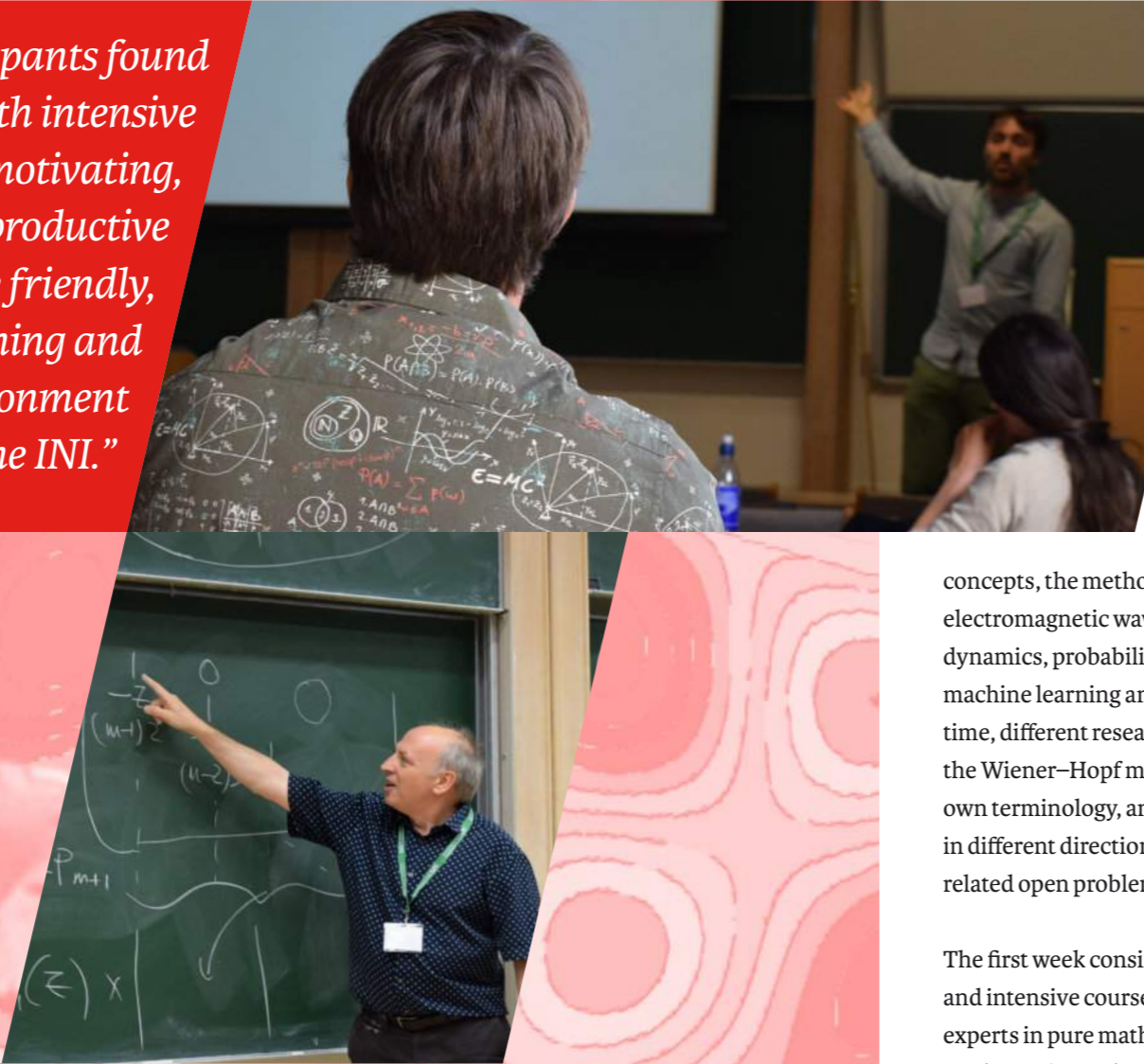| 83 | 15 | 2 |

GEOGRAPHIC DISTRIBUTION
(UK : NON-UK, %)

| 49 | 51 |

AGE DISTRIBUTION
(≤29 : 30-49 : ≥ 50 : unknown, %)

| 21 | 34 | 43 | 2 |

Complex Analysis - Techniques, applications and computations

Complex analysis is unusual in that it pervades many apparently disparate areas of mathematics. Bringing experts together from different disciplines, this programme aimed to explore the unexpected connections between different branches of complex analysis that have been emerging over the past few years.

This programme bought together participants from diverse geographical and scientific communities to develop and apply complex analysis to a host of problems from areas including pure and applied mathematics, physics, engineering, and medicine. Activities were focused around three workshops: "The complex analysis toolbox: new techniques and perspectives"; "Complex analysis in mathematical physics and applications"; and "Computational complex analysis." Each was accompanied by masterclasses that ranged from pedagogical background to the latest techniques, including real-time computer demonstrations. The second workshop incorporated a Newton Gateway "Open for Business" day on Industrial Applications of Complex Analysis. Talks from both academic research and industry highlighted how complex analysis methods have the potential to tackle challenging problems in a number of areas including understanding of aeroacoustics, medical imaging methods, tissue engineering approaches and radar signal processing.

Lesley Ward (University of South Australia) gave a beautifully clear account of the relations between Fourier, harmonic analysis and spaces of homogenous type in the Kirk Distinguished Visiting Fellow Lecture. Rothschild Distinguished Visiting Fellow Mark Ablowitz (University of Colorado) gave a fascinating lecture which ranged over the history of integrable systems and its link with complex variables, from beginning to the present, including videos of intersecting waves on the beach and far more.

A regular seminar series provided a forum for the exchange of ideas and projects, and the tables and offices of the Institute were in continuous use.

Exchanges with the concurrent synergistic programme "Geometry, compatibility and structure preservation in computational differential equations" and with the previous programme "Bringing pure and applied analysis together via the Wiener-Hopf technique, its generalisations and applications" were an enriching addition to the programme. Networking sessions organised by programme participants for early career attendees and under-represented groups in mathematics led to productive discussions and were very well received.

A highlight of the programme was the unusually broad spectrum of areas of mathematics represented together with participants from more applied fields. This contributed to a fertile and engaging research environment in which discussions and collaborations frequently crossed traditional disciplinary boundaries. Some of the recurrent themes included recent developments in the Riemann-Hilbert problem, conformal mappings, and special functions, along with their manifold extensions and applications.

The programme sparked a number of collaborations including novel selection problems in Hele-Shaw flow using asymptotics beyond all orders, the general methodology for doubly-connected Stokes flows in non-quadrature domains, relations between Riemann-Hilbert problems and vortex sheets, application of the Szego kernel in conjunction with conformal mapping to the Unified Transform Method, and complex plane singularity dynamics of nonlinear PDEs. At least three participants in the programme have now applied for funding for a joint project entitled "Complex Function Theory: Applications and Computations for Waves and Vortices", and are looking in the future to apply for a larger collaborative effort.

"A highlight of the programme was the unusually broad spectrum of areas of mathematics represented together with participants from more applied fields."

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ORGANISERS:
Darren Crowdy *(Imperial)*
Linda Cummings *(NJIT)*
Stefan Llewellyn Smith
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Bartosz Protas *(McMaster)*
Andre Weideman
(Stellenbosch)

ROTHSCHILD FELLOWSHIP
Professor M Ablowitz

KIRK DV FELLOWSHIP
Professor L Ward

SIMONS FELLOWSHIP
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Professor T DeLillo
Professor L Lanzani
Professor S McCue
Professor I Mitrea
Professor S Mogilevskaya
Professor T Sakajo
Professor S Tanveer

GENDER BALANCE:
(M : F, %)

| 77 | 23 |

GEOGRAPHIC DISTRIBUTION
(UK : NON-UK, %)

| 40 | 60 |

AGE DISTRIBUTION
(≤29 : 30-49 : ≥ 50 : unknown, %)

| 15 | 39 | 51 |

Infectious Dynamics of Pandemics: Mathematical and statistical challenges in understanding the dynamics of infectious disease pandemics

Mathematical modelling has played an unprecedented role in informing public health policy on the control of the COVID-19 pandemic. This programme was put together in record time in response to the urgent need to bring together experts from a diverse range of disciplines and home nations to support the mathematical modelling of COVID-19. A key focus was to provide space for longer-term thinking about the challenges of understanding the dynamics of this and future novel pandemics.

"... the programme has provided space to reflect on longer term issues such as the emergence of new diseases and the interface between science and policy."

Infectious disease modelling groups have necessarily been working in 'response' mode to provide real time modelling of the COVID-19 pandemic as it unfolds. This has left limited time for thinking about the wider challenges of understanding the dynamics of this pandemic, as well as reflecting on lessons learnt for future pandemics. To address these issues this programme had two key aims. Firstly, through programme organisers that were also members of the government's Scientific Advisory Group for Emergencies (SAGE) and Scientific Pandemic Influenza modelling group (SPI-M) in the UK, the programme was able to react to key themes emerging as policy priorities. For example, talks and discussions leading to recommendations for augmenting contact tracing were rapidly put together at the end of May, as the NHS test and trace system launched in the UK. Secondly, building on the strong community that already existed from the previous INI programmes on infectious disease modelling (Epidemic models 1993, Infectious Disease Dynamics 2013 and its 2014 Follow-up Meeting) the programme has provided space to reflect on longer term issues such as the emergence of new diseases and the interface between science and policy.

Activities centred around live streamed plenary talks, smaller informal talks and focused discussion sessions. A wide range of topics have been covered including contact tracing, uncertainty quantification, expert elicitation, the R number, model inference, within-host modelling, urban analytics, modelling in small spaces, data analytics, economics and the interface between science and policy.

There were three workshops, the first of which led to a paper in Proceedings of the Royal Society B which put forward a roadmap to facilitate the development of reliable models to guide exit strategies from the non-pharmaceutical interventions. A Newton Gateway event on COVID-19 in higher education settings, run jointly with the Virtual Forum for Knowledge Exchange (V-KEMS), involved talks from both academics and key stakeholders including the Department of Health and Universities UK. The programme has also provided a forum to link work done via the Royal Societies Rapid Assistance in Modelling the Pandemic (RAMP) initiative to the wider epidemiology modelling community.

Programme activities are continuing until the end of 2020 with a focus on bringing together the diverse topics covered to produce a series of papers that will identify the challenges in modelling pandemics emerging in the context of a number of key areas. It is planned that this series will form a journal special issue.

ORGANISERS:
Julia Gog *(Cambridge)*
Deirdre Hollingsworth *(Oxford)*
Hans Heesterbeek *(Utrecht)*
Valerie Isham *(UCL)*
Denis Mollison *(Heriot-Watt)*
Phil O'Neill *(Nottingham)*
Sylvia Richardson *(Cambridge)*
Nigel Shadbolt *(Oxford)*
Caroline Trotter *(Cambridge)*
Alan Wilson *(ATI)*

The Infectious Dynamics of Pandemics programme, INI's first ever virtual programme, was put together in record time and in response to the emerging global pandemic. The participation statistics are starkly different to those of "standard" INI programmes and so, in order to avoid distorting data, we present the IDP statistics separately. We note in particular:

- There were **record numbers of workshop participants** (868 across the six workshop – an average of 145 participants per workshop from a total of 160 individuals, 88% of whom participated in all of the workshops) although not all of them attended all sessions.

- The UK-centric nature of this programme meant that **over 2/3 of all programme and workshop participants were UK-based**, twice the proportion for standard programmes. The UK-based participants came from 31 different institutions across the UK.

- Although roughly 15% of both programme and workshop participants were either students of post-doctoral researchers, **the proportion of senior academics** (Professors, Associate Professors, Emeritus Professors and Readers) was **significantly higher for IDP than for standard programmes** (63% as opposed to 57% for programme participants and 62% as opposed to 50% for workshop participants).

- **The proportion of female programme and workshop participants** (30% and 32% respectively) was significantly higher than on average for INI programmes. Further, 2 of the 3 Lead Programme Organisers and 5 of all 10 Programme Organisers were female.

Institute Activities

In this section we describe the activities that took place at INI prior to the closing of the building on Friday 20 March.

Since its inception, INI has been committed to academic excellence, ensuring that its programmes, spanning the breadth of the mathematical sciences and related disciplines, are novel, ambitious and timely, and that they will have a lasting impact on research in the UK.

During this period, across the 5 programmes and 11 workshops that ran (excluding the satellite workshop at ICMS), there were 448 seminars including 11 masterclasses, by 336 different speakers. 347 of these have been made available online via the seminar archive including the Rothschild and Kirk Distinguished Visiting Fellow Lectures by: Spencer Bloch (Chicago) on *Elliptic curves associated to two-loop graphs (Feynman diagrams)* (KAH); Cheryl Praeger (Western Australia) on *The Mathematics of Shuffling* (GRA); Mark Ablowitz (Colorado) on *Extraordinary waves and math: from beaches to photonics* (CAT); Leslie Ward (South Australia) on *Fourier, harmonic analysis, and spaces of homogeneous type* (CAT); Jesús María 'Chus' Sanz-Serna (Universidad Carlos III de Madrid) on *Hamiltonian Monte Carlo and geometric integration* (GCS); and Donatella Marini (Università degli Studi di Pavia) on *A recent technology for Scientific Computing: the Virtual Element Method* (GCS). Where this data is known, 21% of seminar speakers were female, and 22% were ECRs of whom 15% were either students or post-docs. 33% were UK-based and 9% were of DAC-listed nationalities or based in a DAC-listed country. A total of 20 new preprints, with 37 authors, were added to the preprint series.

The Talks Elsewhere scheme, whereby visiting academics give seminars across the UK, with INI paying travel costs and the host institution paying local expenses, continues to thrive, and a total of 56 talks were given by 26 individuals at 30 different institutions across England, Scotland and Wales.

The Network of Correspondents provides an invaluable link between INI, ICMS and mathematics departments across the UK. We greatly enjoy welcoming Correspondents to the Institute each year on Correspondents Day. With 45 attendees coming from universities spanning the UK, a highlight of this year's Day, held at INI on 22 January, was a talk by Fields Medalist Caucher Birkar (Cambridge) on *Algebraic geometry and some applications*. In addition to networking opportunities, there was a session on engagement with INI and ICMS, and an excellent panel session on how to go about proposing and running events at these institutes.

The mix of UK-based and international participants is central to INI's success, with approximately 36% of programme participants coming from institutions based in the UK, 32% coming from the rest of Europe and the remaining 32% coming from the rest of the world; for workshop participants these figures were 39%, 26% and 35% respectively. The participants came from more than 275 institutions across the world including 45 different institutions across the UK.

Institute Activities

Participation by those from developing countries continues to be encouraged through our DAC Support Scheme which provides supports to individuals from DAC-listed countries (see, **www.oecd.org/dac/financing-sustainable-development/development-finance-standards/daclist.htm**) either by nationality or by location of their home institution. To date, support in excess of £37,000 has been provided to 46 DAC participants spanning 19 nationalities and coming from 35 different home institutions and 17 different countries. 54% of the recipients of DAC funding were early career researchers and 20% were female. A little over 60% of the support was for travel with the remainder covering accommodation costs and per diem. An interview with Dr Surinder Kaur, a post-doctoral researcher at the Indian Institute of Technology, on how she benefitted from the scheme can be found here: **www.newton.ac.uk/outreach/DAC**.
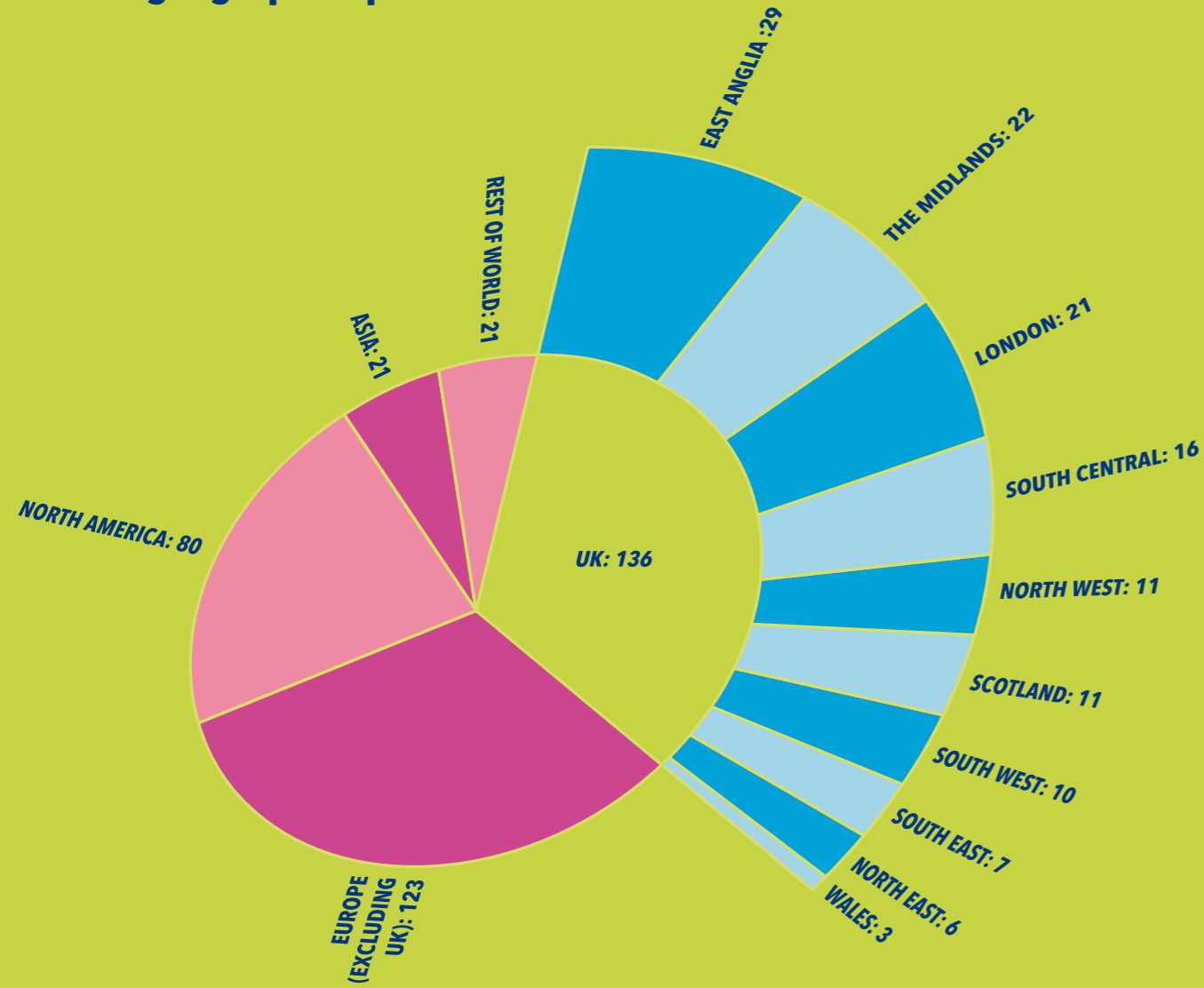
Significant financial, logistical and administrative support also continues to be provided via INI's Provision of Care Scheme in order to remove barriers to participation. Support includes sourcing and covering the costs of nursery places for accompanying children and providing family-friendly accommodation. This year over £15k was allocated to 11 individuals. Following sustained efforts over a number of years, including the development of the Equality and Diversity Action Plan, the proportion of female programme and workshop participants this year was 21%, although it should be noted that this value fluctuated considerably across programmes with much work still needed in certain fields.

Extensive support continues to be made available to early career researchers (ECRs). During this period, there were 117 ECR programme participants (31% of all programme participants) who stayed for a total of 4060 days (an average stay of 35 days). Additionally, there were 234 ECR workshop participants, 36% of all workshop participants. The vast majority of these ECRs, both programme and workshop participants, were provided with accommodation and/or given some form of financial support to facilitate their participation.

INI continues to actively pursue public engagement opportunities. Although March's Cambridge Science Festival had to be cancelled, our stand at the 2019 New Scientist Live exhibition at the ExCeL Arena proved as popular as ever. Our methods of dissemination are varied: 22 video interviews with programme organisers are now available here **www.newton.ac.uk/news/video-interviews;** there are 27 episodes in the podcast series ranging from a discussion of *How to win at Pandemic* with Julia Gog OBE (Cambridge), to *Promoting maths via social media with ECRs* Ollie Jones (Birmingham) and Kamilla Rekvényi (Imperial), to *Peer Support and the "ability to develop agency"* with Kirk Distinguished Visiting Fellow, Lesley Ward (South Australia) which can be found here **www.newton.ac.uk/news/podcast**; and a new case study *Crossing the boundaries of subject and specialism* has been added to that collection **www.newton.ac.uk/news/case-studies/cell-motility.**
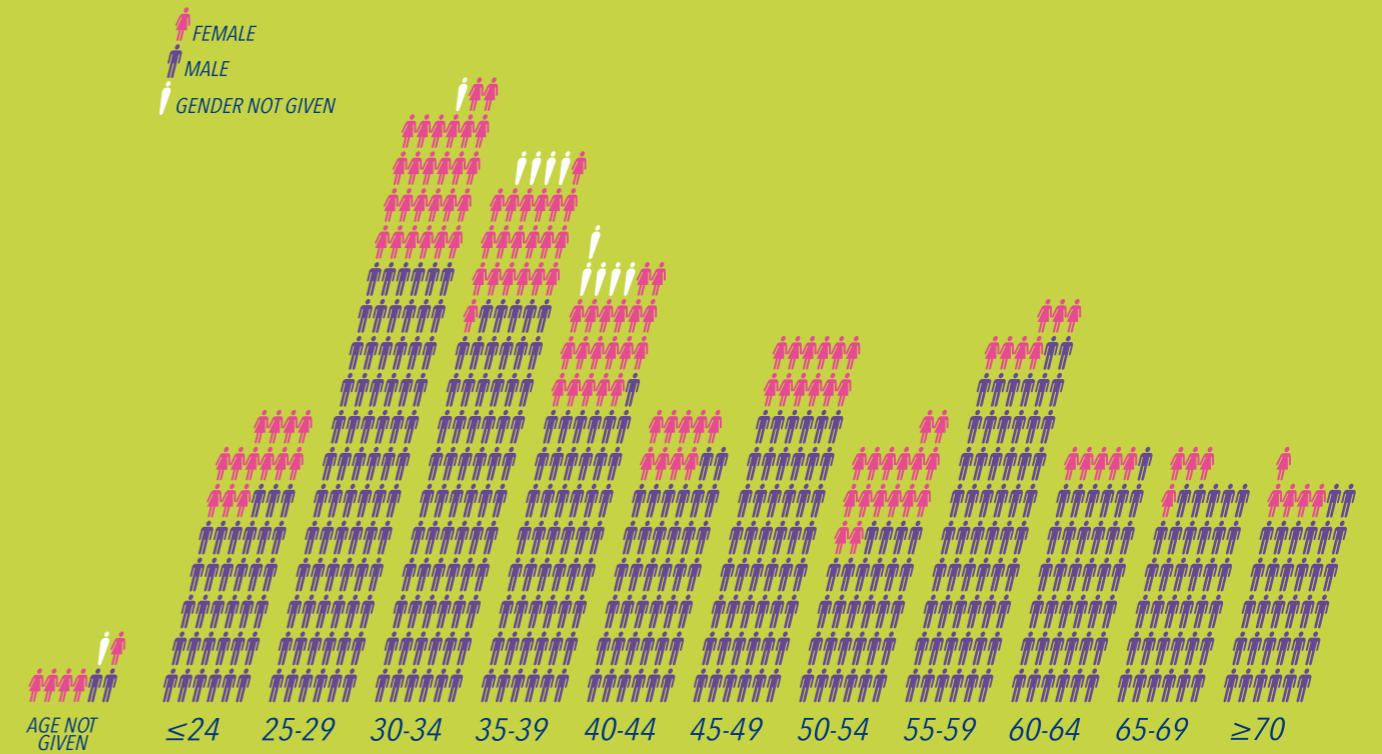
Worldwide geographic spread

EAST ANGLIA :29

THE MIDLANDS: 22

REST OF WORLD: 21

LONDON: 21

ASIA: 21

SOUTH CENTRAL: 16

NORTH AMERICA: 80

UK: 136

NORTH WEST: 11

SCOTLAND: 11

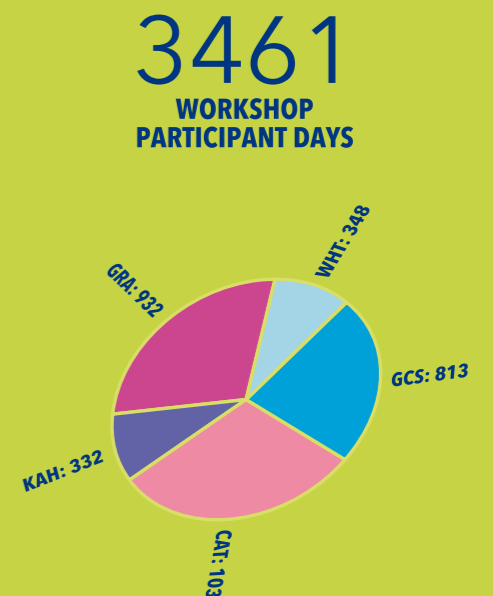SOUTH WEST: 10

SOUTH EAST: 7

NORTH EAST: 6

WALES: 3

EUROPE (EXCLUDING UK): 123

Excluding University of Cambridge

Gender and age

FEMALE
MALE
GENDER NOT GIVEN

AGE NOT GIVEN   ≤24   25-29   30-34   35-39   40-44   45-49   50-54   55-59   60-64   65-69   ≥70

Programme and workshop participant numbers

381
PROGRAMME PARTICIPANTS

GRA: 80
WHT: 47
KAH: 81
GCS: 111
CAT: 62

13739
PROGRAMME PARTICIPANT DAYS

GRA: 2243
WHT: 10061
KAH: 2190
GCS: 4879
CAT: 3421

659
WORKSHOP PARTICIPANTS

GRA: 932
WHT: 66
KAH: 64
GCS: 154
CAT: 192

3461
WORKSHOP PARTICIPANT DAYS

GRA: 932
WHT: 348
KAH: 332
GCS: 813
CAT: 1036
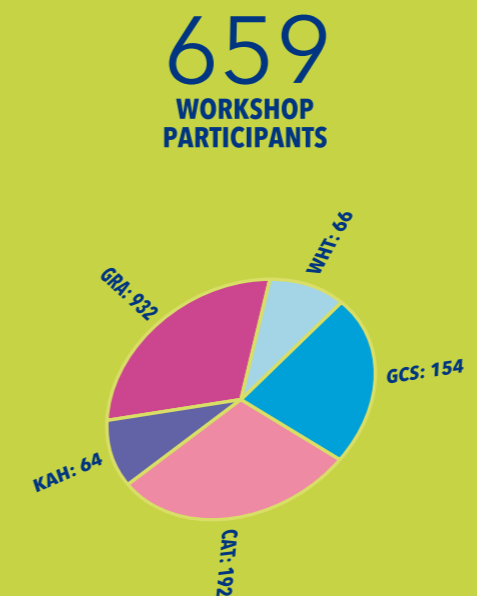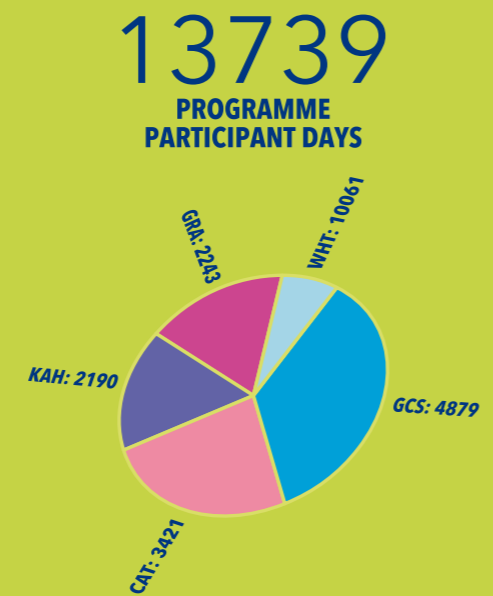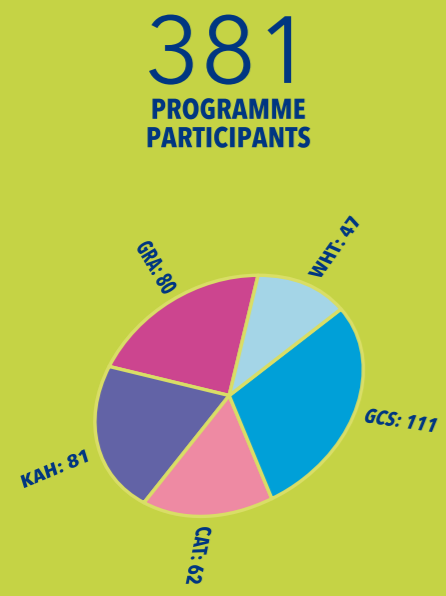
These statistics only represent the period up to 20 March 2020. For the IDP programme statistics see page 13

Finances

Accounts for August 2019 to July 2020
For the Isaac Newton Institute and Newton Gateway to Mathematics

Income	Notes	2019-2020	2018-2019
		£000	£000
Research Grants and Contracts	1	1,911	2,068
Contribution from the University of Cambridge	2	441	485
Donations	3	60	500
Additional workshop income		24	117
Additional income	4	206	312
Endowment and investment income	5	512	483
Total income		**3,154**	**3,965**
Expenditure			
Staff costs		952	959
Travel and subsistence	6	1,115	1,487
Other operating expenses	7	369	446
Overheads paid to the University	8	551	491
Total expenditure		**2,987**	**3.383**
Surplus / (deficit)		**167**	**582**

Notes to the Accounts

Note 1 - Research Contracts and Grants (EPSRC & Simons Foundation)

Salaries	468
Participant costs (travel and subsistence)	976
Estates and indirect income	467
Total	**1,911**

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	45
Heilbronn Institute r Mathematical Research	5
Donations, other	10
Total	**60**

Note 4 - Additional income

Merchandise sales	2
Programme sponsorship	19
HEIF (NGM)	55
INI (other) events income	31
Newton Gateway events income	99
Total	**206**

Note 5 - Endowment & Investment income
Endowment & Investment income from Garfield Weston Foundation, Clive Humby and Edwina Dunn, Henderson Group, PF Charitable Trust, Rothschild and Turner Kirk Charitable Trust is now shown separately.

Note 6 - Travel and Subsistence

Programme & workshop	1,110
Staff travel & subsistence	5
Total	**1,115**

Note 7 - Other operating expenses

Computing	37
Institute running costs	79
Catering	34
Housing costs (Benians Court refurbishment and loan payment)	169
Furniture	2
Professional & brought in services	48
Total	**369**

Note 8 - 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 2020 was as follows:

Name	Institution	End of Service
Dr Ewan Kirk (Chair)	General Board	31-Dec-22
Professor David Abrahams	Director, Isaac Newton Institute	30-Sep-21
Professor Miguel Anjos	University of Edinburgh	31-Dec-22
Dr Katie Blaney	EPSRC	
Professor Tara Brendle	University of Glasgow	31-Dec-21
Professor Colm-Cille Caulfield	Head, DAMTP, University of Cambridge	
Professor John Greenlees	University of Warwick	31-Dec-22
Professor Valerie Isham	Chair of the Scientific Steering Committee	31-Dec-20
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	
Dr Richard Pinch	Retired	31-Dec-21
Professor Marian Scott	University of Glasgow	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 2020 was as follows:

Name	Institution	End of Service
Professor Valerie Isham (Chair)	University College London	31-Dec-20
Professor David Abrahams	Director, Isaac Newton Institute	30-Sep-21
Professor Ken Brown	University of Glasgow	31-Dec-23
Professor Mark Chaplain	University of St Andrews	31-Dec-21
Professor Paul Glendinning	Director, ICMS / University of Manchester	
Professor Robin Henderson	University of Newcastle	31-Dec-23
Professor Jon Keating	University of Oxford	31-Dec-20
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 Richard Taylor	Institute for Advanced Study	31-Dec-20
Professor Susanna Terracini	Università degli Studi di Torino	31-Dec-20
Professor Helen Wilson	University College London	31-Dec-23

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

How to Donate

You may donate to the Isaac Newton Institute online by credit or debit card through the University of Cambridge's secure site. US tax payers may donate to Cambridge in America, a 501(c)(3) tax-exempt organisation and qualify for an income tax deduction. Please state when making your gift that you would like your donation to support the Isaac Newton Institute for Mathematical Sciences. The University has charitable status and so donations made to it or its constituent parts, including the Institute, may attract tax relief. For UK tax payers this is available under Gift Aid.

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).

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SIMONS FOUNDATION

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Biological Sciences
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Research Council