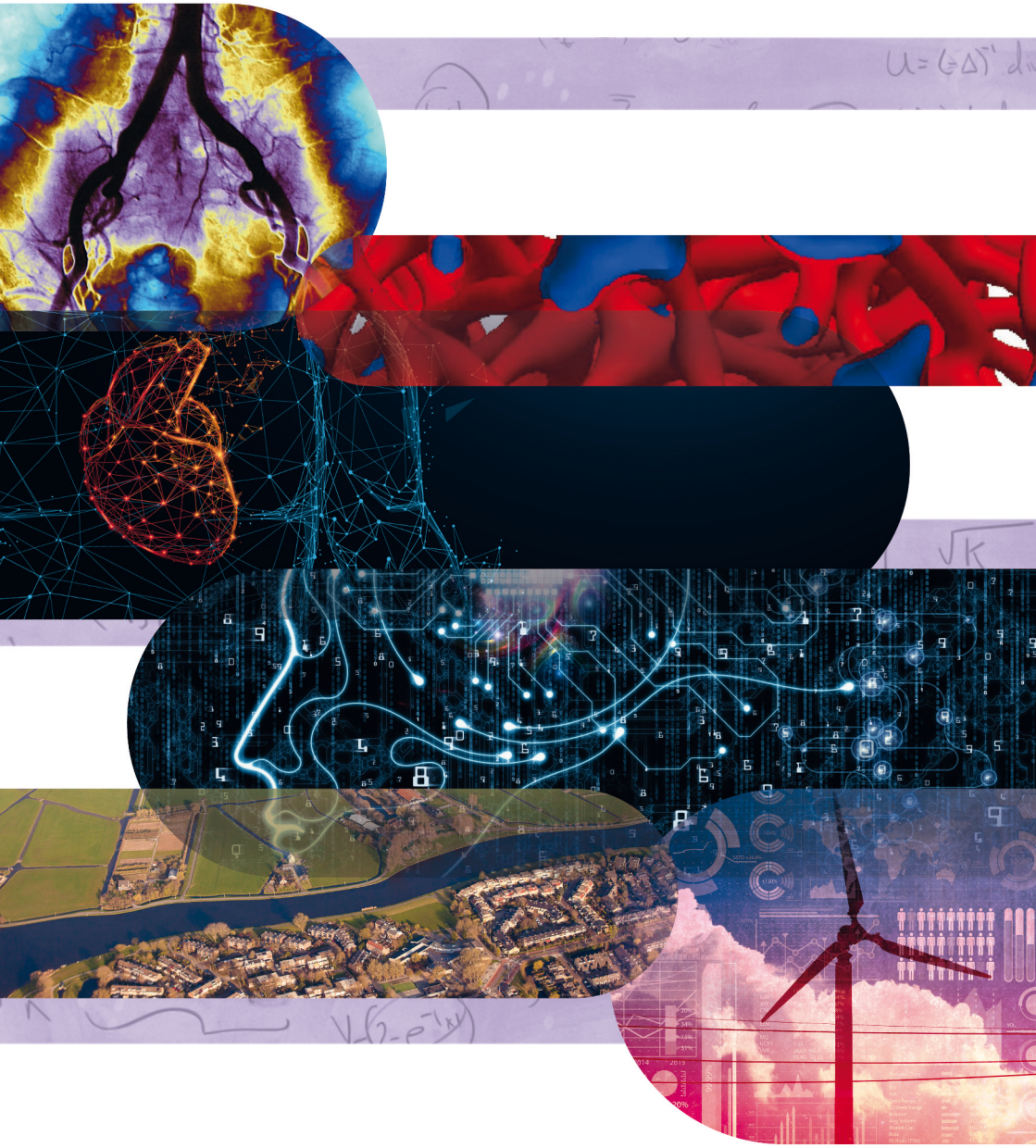
Newton Gateway to Mathematics

Annual Report 2018-2019



UNIVERSITY OF CAMBRIDGE

Isaac Newton Institute for Mathematical Sciences

Mission Statement

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 to Mathematics 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.

What Makes the Newton Gateway to Mathematics different?

The Newton Gateway to Mathematics is a knowledge intermediary for the mathematical sciences. Based at the Isaac Newton Institute for Mathematical Sciences and supported by the University of Cambridge, the Newton Gateway to Mathematics reaches out to and engages with the users of maths – in industry, business, public sector and other scientific disciplines. With extensive access to multiple communities across the UK and globally, the Gateway can respond in an agile and flexible manner. It works as a delivery partner to facilitate the exchange, translation and dissemination of knowledge. Using effective communications and proven methodologies, the Gateway develops and runs activities such as workshops and meetings, bringing people and organisations together in order to share knowledge and stimulate further research and collaboration.

Engaging with Users of Mathematics

The Newton Gateway to Mathematics is the impact initiative of the Isaac Newton Institute for Mathematical Sciences (INI) based at the University of Cambridge. It was established in 2013 (as the Turing Gateway to Mathematics) and acts as a knowledge intermediary for the mathematical sciences in the UK. It aims to extend the reach and highlight the importance of mathematics to all potential users such as other academic disciplines, as well as researchers in business/industry and the public sector. User engagement is therefore a key focus, helping to understand the community and end-users in order to collaborate effectively.

The Newton Gateway to Mathematics delivers a range of activities, such as research scoping workshops and knowledge dissemination events across a number of different themes and sectors including biology and healthcare systems, environment and energy, financial risk, security sectors, Big Data and public policy.

Gateway activities have expanded, with continued emphasis on partnership and collaboration with other organisations, which is a more effective way of engaging with a wider group of stakeholders, helping to reduce duplication.

The Newton Gateway to Mathematics continues in the delivery of the *Edwards Symposium Series* working with the *Edwards Centre for Soft Matter* at Cambridge, the *Durham Centre for Soft Matter* and supported by *Unilever*.

Since 2016, the Gateway has been the user engagement partner for the C*antab Capital Institute for the Mathematics of Information (CCIMI)* and the *EPSRC Centre for Mathematical Imaging in Healthcare (CMIH)*. As part of these collaborations, the Newton Gateway to Mathematics develops programmes of work, disseminates information and develops strategic relationships, to ensure effective translation of science to the user. This is helping partners to understand and gain consensus on the challenges that need to be overcome and facilitate other interdisciplinary collaborations to enrich the existing communities.

From early 2018, the Newton Gateway has been working on the development and delivery of a programme of work, *Evidence Based Decisions for UK Landscapes,* for the *Natural Environment Research Council (NERC)* and the *Department for Environment, Food & Rural Affairs (Defra)*. This demonstrates the ability of the Newton Gateway to Mathematics to work closely and in partnership with funders and Government to effectively deliver mathematical sciences knowledge exchange and create impact.

Foreword

The first thing readers of this Annual Report will note is the change of name from the Turing Gateway to Mathematics to the Newton Gateway to Mathematics. The increased scale of activity of the Gateway was such that it needed to reinforce its identity as both an integral part of the Isaac Newton Institute (INI) and as a national facility for knowledge exchange for mathematical sciences in the UK. There was the additional need to avoid confusion with other organisations and therefore it was decided to rebrand to the Newton Gateway to Mathematics from January 2019.

At the launch event speakers shared their experience of working with the Gateway, explaining its history, the vision and current priorities.

The speakers were:
Ewan Kirk *(Chair - Isaac Newton Institute Management Committee)*
David Abrahams *(Director - Isaac Newton Institute)*
Jane Leeks *(Manager - Newton Gateway to Mathematics)*
Peter Landrock *(Chair - Newton Gateway to Mathematics Advisory Board)*
Richard Pinch *(Vice-President, Profession & Industry - Institute of Mathematics and its Applications)*
Mike Cates *(Lucasian Professor of Mathematics - University of Cambridge)*
Philip Bond *(Lead Author of the Bond Review on Knowledge Exchange in the Mathematical Sciences)*
Priscilla Canizares *(Senior Research Scientist - Schlumberger)*

As in previous years, a number of programmes of work were delivered during this report period, including collaborations with the *EPSRC Centre for Mathematical Imaging in Healthcare (CMIH)*, the *Cantab Capital Institute for the Mathematics of Information (CCIMI)*, *Innovate UK's Knowledge Transfer Network (KTN)*, the *Natural Environment Research Council (NERC)*, the *Alan Turing Institute*, the *National Institute for Health Research (NIHR)* and *GCHQ*.

As part of the *Edwards Symposium Series*, the Newton Gateway to Mathematics delivered a third workshop in September 2018, working with partners from across the *University of Cambridge* and the *EPSRC Centre for Doctoral Training in Soft Matter and Functional Interfaces* at Durham. N*ew Horizons in Soft Matter* highlighted the latest developments in soft matter science and celebrated the life and work of Sir Sam Edwards, who was a pivotal figure in the area. Funding from *Unilever* has ensured that the series can be delivered until 2021, with each year having a different scientific focus.

User engagement activities for the *EPSRC Centre for Mathematical Imaging in Healthcare (CMIH)* continued, with the delivery of an industrial engagement event in October 2018 and an academic event involving all five *EPSRC Centres for Mathematics in Healthcare* in April 2019. The Newton Gateway worked with *CMIH* and the *National Institute for Health Research (NIHR)* to develop and deliver *Artificial Intelligence and Machine Learning in Clinical Imaging Research: Progress and Promise* in November 2018, to consider how to accelerate translation of artificial intelligence into clinical practice.

The Gateway continued to deliver user engagement for the *Cantab Capital Institute for the Mathematics of Information (CCIMI)*. An engagement event for industry brought those working on specific streams of research together with industrial stakeholders who have been able to apply this research to real world issues. Talks also promoted the research taking place with associated challenges and exploring potential collaborative opportunities.

The 145th *European Study Group with Industry (ESGI 145)* was held in Cambridge in April 2019 and was delivered in partnership with the *Centre for Mathematical Sciences (University of Cambridge)* and the *Smith Institute*. One of the largest events to date, it provided the unique opportunity for academics to work with industry to come up with new ideas and potential solutions for real-world problems posed by a wide range of industries.

The Newton Gateway to Mathematics delivered eight Open for Business/Knowledge Exchange events linked to six Research Programmes being held at INI.

These events are specifically designed to bring together industrial, commercial and governmental organisations with mathematical scientists. They are run as part of an ongoing research programme or as an independent event and help to extend the reach of the research being undertaken by academics who are at INI for an extended period.

Through its engagement activity, the Newton Gateway to Mathematics has continued to extend its reach across different sectors. Delegates who attend Newton Gateway to Mathematics events are offered greater opportunities for interaction between those in industry, the public sector and academia, often for individuals who have not worked together before. As in previous years, activities have been delivered in partnership with other organisations, as detailed above, which has ensured further collaborative opportunities with new connections made across a breadth of sectors and subjects.

Staff and Management

Responsibility for the budget and financial planning is overseen by INI's Management Committee and undertaken on a day by day basis by Newton Gateway staff. The Gateway reports to the INI Director who in turn is responsible to the Management Committee.

The Newton Gateway is supported in delivering activity by an Advisory Board and the Scientific Advisory Panel, who advise on programmes and activities and help with quality assurance in aspects of delivery and operations. The key aim is to help ensure that the highest levels of delivery and operations are achieved throughout Gateway activity and its effectiveness is fully maximised.

Newton Gateway to Mathematics Staff

The Newton Gateway to Mathematics Manager, Jane Leeks, has overall responsibility for managing the Newton Gateway to Mathematics and for developing contacts with non-mathematical academics, with industry and business. This role is pivotal in identifying potential research opportunities of mutual benefit to mathematicians and industry.

The Knowledge Exchange Coordinator, Clare Merritt, supports diversification of the Newton Gateway to Mathematics, coordinates events and marketing activity with industry and businesses, and leads some specific programmes of work, including user engagement on behalf of Newton Gateway to Mathematics Partners.

The Development & Communications Coordinator, Ciara Dangerfield, supports the development of Gateway events and the building of links with non-academic partners and helps with the technical aspects of event coordination and communication.

The Events and Marketing Coordinator, Lissie Hope, provides administrative support to Newton Gateway to Mathematics events and marketing activities, as well as inputting to financial administration.

Governance

The Newton Gateway to Mathematics Advisory Board has Members from industry and public bodies to help advise on strategic matters and on the overall development of the Newton Gateway to Mathematics.

Members have helped to facilitate the delivery of a number of activities and programmes of work and act as 'Ambassadors' for the Gateway in discussion and interaction with other partners.

The Board meets twice a year in Cambridge. The Chair is invited to attend INI Management Committee meetings to provide supplementary reporting on Gateway activity and delivery.

In view of its critical role, the Advisory Board was refreshed and expanded in 2019.

Membership (at July 2019):

Name	Organisation
David Abrahams	Isaac Newton Institute - Director
Matt Butchers	Knowledge Transfer Network
Alan Champneys	Representative of Gateway Scientific Advisory Panel
Nick Easton	BAE Systems Applied Intelligence
Joanna Jordan	Freelance Mathematics Knowledge Exchange
Peter Landrock *(Chair)*	Cryptomathic
Robert Leese	Smith Institute
Dan Shepherd	National Cyber Security Centre
Sian Thomas	Department for International Trade
Stacie Tibos	PepsiCo International

The Newton Gateway to Mathematics Scientific Advisory Panel provides input and guidance on specific scientific or research matters related to Newton Gateway to Mathematics activities. The Committee Members are all academics and operate largely in a virtual way via email and telephone and are responsive to ad-hoc questions and requests for guidance from the Newton Gateway to Mathematics.

The Chair is invited to attend Newton Gateway to Mathematics Advisory Board meetings. All Members of the Scientific Advisory Panel are invited to meet with the Advisory Board every 12 months to ensure they have opportunity to input more strategically to the range and nature of Newton Gateway to Mathematics activities.

In 2019, the Membership was expanded to reflect the breadth of disciplines that the Gateway can work on and ensure a fuller geographical spread of representation by Members.

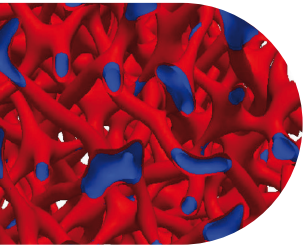
Membership (at July 2019):

Name	Organisation
Philip Aston	University of Surrey
Martine Barons	University of Warwick
Chris Breward	University of Oxford
Peter Challenor	University of Exeter
Alan Champneys *(Chair)*	University of Bristol
Chris Dent	University of Edinburgh
Rosemary Dyson	University of Birmingham
Jacek Gondzio	University of Edinburgh
Des Higham	University of Edinburgh
Jane Hutton	University of Warwick
Arieh Iserles	University of Cambridge
Gabriel Lord	Radboud University (and Heriot-Watt University)
Anotida Madzvamuse	University of Sussex
Adele Marshall	Queen's University Belfast
Jeremy Oakley	University of Sheffield
Surajit Ray	University of Glasgow
Nigel Smart	KU Leuven
Manuchehr Soleimani	University of Bath
Emily Walsh	University of the West of England
Adrian Weller	University of Cambridge
Helen Wilson	University College London

Activities from August 2018 - July 2019

5 - 7 Sep 2018

3rd Edwards Symposium - New Horizons in Soft Matter



This third workshop focused on a number of soft matter areas and associated industrial challenges including microscale fluid dynamics; jamming and flow; soft interfaces and responsive and programmable soft matter. Leading academic speakers conveyed their latest scientific work, helping to foster collaborative and interdisciplinary discussions across the industry/academia boundary.

The Alexei Likhtman Poster Prize acknowledged, celebrated, and promoted achievements of young scientists in early stages of their career. It was established in memory of Alexei Likhtman and in recognition of his contribution to polymer physics. Support was also given by the *Royal Society of Chemistry*. The *Edwards Symposium Series* will run annually to at least 2021, thanks to the generous support of *Unilever*.

17 – 18 Sep 2018

Evidence Based Decisions for UK Landscapes

This two day research scoping workshop formed part of a programme of work, supported by the *Natural Environment Research Council (NERC)* on evidence based decisions for UK landscapes, with a focus on terrestrial land use (rural and urban), coastal and freshwater. It aimed to investigate new mathematical and statistical modelling techniques which can enable better evidence-based decisions to be made around UK landscapes. These need to be flexible enough to incorporate other models, whilst also taking into account many other highly complex factors across different landscapes.

A key challenge was to bring together stakeholders and academics from traditional *NERC* disciplines (environmental sciences, ecology, geography, biology, etc), with mathematicians and statisticians. The programme of work subsequent to this event included a funding call and a one month Research Programme at the Isaac Newton Institute in July 2019.

20 – 23 Sep 2018

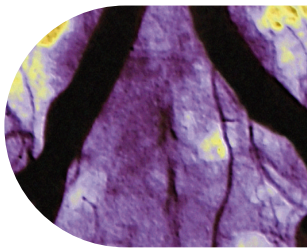
New Scientist Live

Following the success of the previous year's event, the Newton Gateway joined six organisations to exhibit at *New Scientist Live* in September 2018 as part of the *Maths in the Real World* stand. *New Scientist Live* is a festival of ideas and discoveries for everyone curious about science and why it matters.

Over four days, 20,000 visitors attended the event. Volunteering with the *International Centre for Mathematical Science (ICMS)*, *Institute of Mathematics and its Applications (IMA)*, *Institute for Mathematical Innovation at Bath*, INI, the *Operational Research Society* & *UK Mathematics Trust*, the Gateway helped to give away over 6,000 branded foam puzzle cubes and engaged with visitors, specifically young people, to talk about mathematics and how it can help solve real world problems.

17 Oct 2018

Developments in Healthcare Imaging - Connecting with Industry

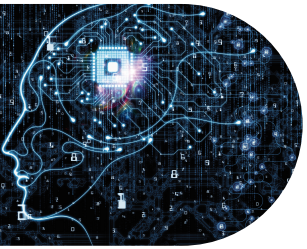


The *EPSRC Centre for Mathematical Imaging in Healthcare (CMIH)* held its 3rd industry engagement day in October 2018, to showcase the research that is being carried out at the Centre and to hear about some of the current project collaborations and other industry challenges.

The Programme included sessions chaired and developed in partnership with *AstraZeneca* and *Feedback Medical Limited*. An elevator pitch session featured talks from academics and more recent imaging start-up companies. Delegates were invited to exhibit a poster and the prize for the most enlightening poster by a student / early career researcher was awarded to Nathan Sjoquist, a PhD student at the Department of Engineering at the *University of Cambridge*.

30 - 31 Oct 2018

Novel Computational Paradigms

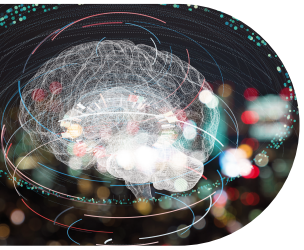


Many of today's interesting problems stem from the ability to generate and process large volumes of data, but the ability to work with all this data has to match the demand. If the speed of processing power is to continue to develop to meet such demands, new forms of computing need to be found. In addition to the development of quantum computers, a number of novel computational paradigms, or next-generation computing architectures are emerging and more are likely to follow.

This workshop was a collaboration with *GCHQ* and aimed to investigate potential next-generation advances in novel computational paradigms. A key aim was to bring together relevant stakeholders from across various UK research communities and industry to provide a forum for identifying challenges and increasing awareness of relevant R&D activities. This endeavoured to gain consensus on what the future research directions should be, stimulating further interest from end-users towards helping to develop and invest in the novel computer paradigms area.

6 Nov 2018

Artificial Intelligence and Machine Learning in Clinical Imaging Research: Progress and Promise



The *National Institute for Health Research (NIHR)* and the *EPSRC Centre for Mathematical Imaging in Healthcare (CMIH)* held this event to consider how to accelerate translation of artificial intelligence into clinical practice. It was held at the *Alan Turing Institute* in London. The event aimed to review scientific and policy developments in the field of artificial intelligence and machine learning when applied to clinical imaging and identified key steps to expedite the delivery of research in the field, in partnership with academia, industry, patients and clinical researchers.

At the event, as part of the delivery of the Industrial Strategy Challenge Fund (ISCF), the Business Secretary announced five new *Centres of Excellence for Digital Pathology and Imaging*, including Radiology, using AI medical advances. The announcement confirmed that the Centres will use AI, to find new ways to speed up diagnosis of diseases to improve outcomes for patients. The Centres are based in Leeds, Oxford, Coventry, Glasgow and London and will help develop more intelligent analysis of medical imaging.

14 Nov 2018

Cantab Capital Institute for the Mathematics of Information – Connecting with Industry

This 3rd industry engagement event from the *Cantab Capital Institute for the Mathematics of Information (CCIMI)* showcased the research that is being carried out at the Institute and current project collaborations. Talks explored the big questions in data science where mathematics is most suited to help provide answers.

Presentations were given by *Cantab Capital Partners, GlaxoSmithKline, the Office for National Statistics* and *Valtech. CCIMI* students hosted a session which they developed and delivered as a group – giving an introduction to the research they are involved in, followed by talks that illustrated specific examples of this work. Students and early career researchers were particularly encouraged to bring a poster, and a prize was awarded to Ferdia Sherry from *CCIMI* for providing the most instructive poster.

14 Mar 2019

Quantum Computing in the Pharmaceutical Industry

Experts from the fields of quantum computing and the pharmaceutical industry were brought together to discuss potential applications of quantum computing by industry. The workshop was a collaboration between *Innovate UK's Knowledge Transfer Network (KTN), Oxford Quantum Circuits, Riverlane* and the Gateway. It brought together businesses, entrepreneurs, academics and funders to help develop ideas, expertise and technologies, that have the potential to be world-beating products.

Some specific topics that were explored were the quantum computing landscape; quantum software; the potential for demonstration of quantum advantage within the next few years; the drug discovery pipeline; simulation on a classical computer and the UK funding landscape. The event closed with a panel session which considered whether technology or application should come first and whether the "critical point" in quantum computing had yet been reached. Discussion highlighted the desire to see industry taking a long term interest and being willing to invest and the importance of focusing on industry-aligned problems in order to attract this investment.

8 - 12 Apr 2019

145th Mathematical European Study Group with Industry

The 145th *European Study Group with Industry (ESGI 145)* was held in Cambridge at the start of April 2019. One of the largest events to date, it attracted 160 participants from academic institutions across the UK. The study group provided a unique opportunity for academics to work with industry to come up with new ideas and potential solutions for real-world problems.

Ten problems were posed that covered a wide range of industries, including agriculture, defence, energy, finance and food manufacturing. These were provided by eight different companies: *Aviva, BP, DSTL, Faraday Predictive, National Grid, PepsiCo, Prudential* and *Syngenta*. Academics worked alongside the companies to identify novel approaches and insights to these problems. Experts from a range of mathematical fields including machine learning, statistics, continuum mechanics and signal processing worked on the problems.

10 - 11 Apr 2019

Achieving Impact in Healthcare: From Mathematics to Clinical Support Systems and Devices

The five *EPSRC Centres for Mathematics in Healthcare* have the remit to develop and apply modern mathematical ideas to problems of potential impact to healthcare. This joint workshop of the five Centres focused on the challenges of translating mathematical research into technological advances, as well as outreach and linkage with clinicians and end-user companies.

This workshop, which was attended by 70 delegates, presented the opportunity to hear in detail about the project plans, research and outcomes from each Centre and was an opportunity to share best practice. Speakers from industry, medicine and academia spoke about various aspects of modelling and applications in the clinical setting. Discussion sessions explored Clinical Support Systems, Population Medicine and Mathematical Challenges.

The event helped build specific collaborations across the Centres and enabled members from the Centres to coordinate and consolidate plans for the subsequent years. A number of scoping discussions took place about potential future research projects and programmes.

13 June 2019

Geometric and Topological Approaches to Data Analysis

The third annual academic conference from the *Cantab Capital Institute for the Mathematics of Information (CCIMI)* focused on the academic interactions taking place related to Geometric and Topological Approaches to Data Analysis. This event brought together those academics working to advance data science and provided an update on the research and collaborations taking place at *CCIMI*, associated challenges and other potential collaborative opportunities, as well as highlighting projects being developed elsewhere related to data analysis.

The talks explored diffeomorphic learning, data analysis, geometric inverse problems, sampling with confidence, optimal transport in data sciences and nonlocal inverse problems. It featured a poster competition for the most interesting poster from an early career researcher, which was won by Tamara Großmann from the *University of Cambridge*.

Knowledge Exchange Activities for INI Research Programmes

The Isaac Newton Institute sponsors Knowledge Exchange activity, referred to as 'Open for Business' (OfB) knowledge exchange events, as a part of its continuing objective to bring academic researchers involved with its Research Programmes into contact with industrial, commercial and government organisations and individuals.

These activities, which are delivered by the Newton Gateway to Mathematics, provide opportunities for cross-fertilisation between the activities of users from industry and the public sector, and the research focus of the Institute. OfB events are structured to enable the formation of new public-private partnerships, collaborative research and to assist in identifying the common challenges that have greatest potential for research, knowledge exchange, public policy and commercial impact.

Eight OfB events were hosted during the reporting year and these were developed and delivered with the academic organisers of six INI Research Programmes that took place over this period. These were *Scaling Limits, Rough Paths, Quantum Field Theory; The Mathematics of Energy Systems; The Mathematical Design of New Materials; Approximation, Sampling and Compression in Data Science; The Fickle Heart;* and *Mathematical and Statistical Challenges in Landscape Decision Making.*

Understanding Multi-Modal Data for Social and Human Behaviour

27 Nov 2018

Real benefits to many areas of modern society arise if one can analyse, model and predict different aspects of social and human behaviours. Techniques, such as those offered by Rough Path Theory, increase the range of potential successes to include recognising human actions and understanding changing facial expressions.

This workshop formed part of the *Scaling Limits, Rough Paths, Quantum Field Theory* Programme. It aimed to increase awareness of what is possible - whether better mitigation of risks, management of outcomes, or supporting individuals in their daily lives, across the spectrum of social and human behaviour. Speakers were from the *Alan Turing Institute, South China University of Technology, University of Oxford, BAE Systems* and the *Health and Safety Executive.*

100% Renewables - Future Challenges in Energy Systems

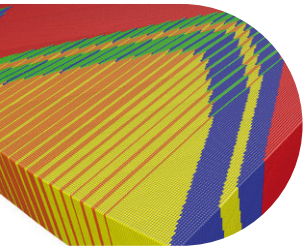
23 Jan 2019

This event explored issues related to the fact that renewable energy generation is set to increase rapidly and will lead to greater variability and uncertainty across all the components related to the production, conversion, delivery and use of energy. The mathematical sciences are well positioned to help address many of the research challenges associated with the move towards more renewables in our energy systems.

The workshop took place within *The Mathematics of Energy Systems Research* Programme and delivery was supported by *National Grid ESO*. The event included academic research talks, as well as end-user presentations from key players across the energy sector supply chain and a number of short academic elevator pitches. It brought together industrial and academic experts from a diverse set of backgrounds and areas, including mathematicians, statisticians, computational modellers, engineers and economists.

27 Feb 2019

Mathematical Design for Solid Complex Materials



This knowledge exchange workshop was part of the Research Programme on *The Mathematical Design of New Materials*. It brought together mathematicians and scientists working in various areas of materials science and applied mathematics in order to initiate a systematic study of the optimal design of new complex materials. The workshop highlighted how mathematical modelling provides a rational way for understanding of complex materials properties and guiding the development strategy for such materials.

The event featured talks from leading academic researchers as well as end-users presenting challenges from the medical devices, energy and robotics industries. A focus for the day was on the interesting classes of complex materials - shape memory alloys (SMAs) and those involving phase transformations. These materials have remarkable properties, including the ability to 'memorise' or retain their previous shape when subjected to certain stimulus such as thermomechanical or magnetic forces.

1 May 2019

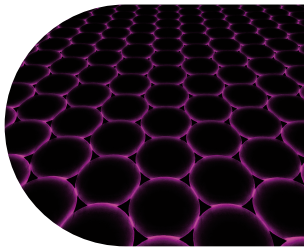
Managing Next Generation Energy Systems

Stakeholders working with energy systems have to make complex decisions formulated from risk-based assessments about the future. The move towards more renewables in our energy systems complicates matters even further, requiring the development of an integrated power grid and continuous and steady transformation of the UK power system.

This workshop was part of the INI Research Programme on *The Mathematics of Energy Systems*. It focused on disseminating the key research outputs from the Programme and highlighted aspects relevant to energy sector stakeholders and the future research agenda. The event featured a number of talks from academic researchers, as well as from end users including transmission and distribution network operators. It provided an opportunity for those from industry and the public sector to access state-of-the-art theory and methods for energy systems modelling, as well as to help foster links between the various communities.

20 May 2019

Soft Matter Materials - Mathematical Design Innovations



This workshop highlighted, with examples, the importance of mathematical modelling for complex soft matter material development. Models and basic understanding are not just of theoretical interest, but are a key requirement for being able to access and further develop the true potential of these materials - to optimise them, to combine them into new materials, and to use them for creating new devices, with predefined abilities and behaviours. This was reflected in the Programme for the day which included talks representing academic research and end-user perspectives from a number of industries and application areas and covered a number of interesting materials design advances and challenges.

This knowledge exchange workshop took place within the Research Programme on *The Mathematical Design of New Materials* and followed an earlier event which featured solid complex materials.

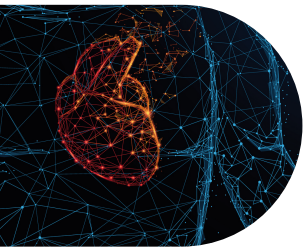
23 May 2019

The Mathematics of Deep Learning and Data Science

Data science is a fast growing academic discipline incorporating many interdisciplinary areas in engineering, physics and mathematics. Deep learning is now established as a significant tool in large parts of modern data science. However, the understanding of deep learning, both from a mathematical and engineering point of view, is somewhat limited.

This event aimed to address questions that highlight the need for understanding the science and the mathematics behind deep learning and data science. It took place as part of the Research Programme on *Approximation, Sampling and Compression in Data Science* and explored both the existing theory and the big unanswered questions regarding the science and mathematics of deep learning. It featured talks from leading academics, as well as researchers from industry and provided a wide perspective on the many facets of modern data science.

4 Jun 2019



Industrial and Clinical Application of Cardiac Simulations: Quantifying Uncertainty in Model Predictions

There are a range of industrial and clinical applications of cardiac simulations that have begun to be tested and used in the last few years including assessing the safety of new drugs and providing patient-specific guidance for clinical procedures. A major obstacle to progress is that the present generation of cardiac simulations do not account fully for all the uncertainties and variabilities that we know to be present.

This event brought together experts and stakeholders to discuss the latest developments in considering uncertainty and variability in cardiac simulation. The introductory talks highlighted the key issues raised during the Research Programme on the *Fickle Heart* and suggested some next steps. A number of end-user talks from industry and the public sector described how organisations manage the uncertainty of modelling and the challenges they face.

3 Jul 2019

Challenges in Landscape Decision-Making

This event featured talks from academic researchers and stakeholders to highlight the needs for and challenges associated with landscape modelling, as well as relevant advances in mathematical and statistical modelling techniques. The initial session set the scene in terms of stakeholder needs for landscape models and the interacting components of landscapes that must be represented in such models. This was followed by presentations from academics and stakeholders describing the state-of-the-art in landscape modelling from the rural, urban and coastal/inland waters domains.

The workshop took place at the start of the Research Programme on *Mathematical and Statistical Challenges in Landscape Decision Making* and it was intended that this would help to reveal key knowledge gaps and research questions to be explored during the Research Programme.

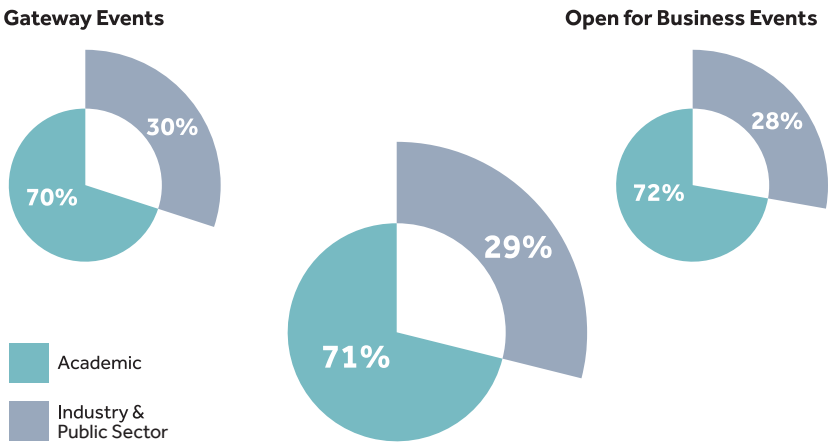
Participation

The Newton Gateway to Mathematics remains successful in facilitating links between industry, academia and the public sector, ensuring participation from a significant number of researchers in disciplines other than the mathematical sciences.

The Newton Gateway to Mathematics has continued to engage across a wide range of sectors, with 1104 delegates attending the sixteen events that the Newton Gateway to Mathematics developed and delivered between August 2018 and July 2019. The diversity of sectors has expanded and includes analytics, biotechnology, communication, data science, defence, energy, engineering, environment, finance, healthcare, information technology, medical imaging, security, space, technology and transport.

As in previous years, Open for Business events took place related to the Research Programmes held at INI and these attracted a higher proportion of academics than industry or public sector attendees. However, the events linked to *The Fickle Heart* and *Mathematical and Statistical Challenges in Landscape Decision Making* in particular, were attended by delegates from a wide range of academic disciplines, so enabling discussion linked to other relevant fields of research.

The pie charts below show attendance at Newton Gateway to Mathematics delivered events, divided by affiliation.



Accounts to 31 July 2019

	Actual 2018 - 2019 £000's	Actual 2017 - 2018 £000's
Income		
University of Cambridge Funding [1]	55	55
'Open for Business' Events Income [2]	17	20
Gateway Events Income [3]	143	41
Corporate Partnership Scheme	0	46
Isaac Newton Institute [4]	119	63
Total Income	**334**	**225**
Expenditure		
Staff Costs	174	145
'Open for Business' Events Expenditure	27	32
Gateway Events Expenditure	80	47
Overheads & Administration	16	9
Total Expenditure	**297**	**233**
TOTAL SURPLUS/(DEFICIT)	**37**	**(8)**

[1] University of Cambridge Higher Education Innovation Funding

[2] OFB Income - sponsorship	12,559
OFB Income - registration fees	4,150
	16,709
[3] Event Income - sponsorship	119,790
Event Income - registration fees	22,702
	142,492

[4] INI contribution to staff costs

Grants and Funding

The Newton Gateway to Mathematics is a vital component of the Isaac Newton Institute that helps meet its aims of serving the national and international sciences community. Therefore support is provided by INI to enable the Newton Gateway to Mathematics to continue to develop and grow its broad range of activities.

The University of Cambridge has contributed to the funding of the Newton Gateway to Mathematics through the *Higher Education Innovation Funding* scheme, which has partially covered administrative costs but not expenses for specific Newton Gateway to Mathematics activities. The latter are funded through partnerships with stakeholders from industry and the public sector, philanthropy and participant registration fees.

Future Development

The Newton Gateway to Mathematics aims to respond in a speedy and focused way to new ideas and approaches, but recognises the need for a targeted and continuous approach to the delivery of longer term knowledge exchange activities in the mathematical sciences. A series of Thematic Knowledge Exchange Programmes are designed to stimulate and support research activities and include workshops, consultations and project meetings. These include Mathematics of Big Data, Mathematics for Biology and Healthcare Systems, Mathematics for the Environment and Energy, Mathematics for Financial Services, and Mathematics for the Space and Security Sectors.

Activity from September - December 2019

With its aspiration of playing a key national role in mathematical sciences knowledge exchange, the Newton Gateway to Mathematics has developed the following activities in collaboration with stakeholders, funders and other academic partners.

4th Edwards Symposium - Emerging Trends in Soft Matter
(4-6 September 2019)

Verified Software
(24 – 25 September 2019)

Artificial Intelligence Developments in Healthcare Imaging
(23 – 24 October 2019)

Industrial Applications of Complex Analysis
(30 October 2019)

The Future of Distributed Ledger Technology
(6 November 2019)

Cantab Capital Institute for the Mathematics of Information - Connecting with Industry
(27 November 2019)

Advances in Numerical Modelling
(3 December 2019)

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