Round up

The Oxford Mathematics Annual Newsletter 2020

UNIVERSITY OF OXFORD
Mathematical Institute

Meet the Outreach Team

Minimal Lagrangians

Mathematics of Random Systems

Filming Student Lectures

Oxford Mathematics

Head of Department's letter

Mike Giles

In December we went through our annual undergraduate admissions process. As usual, we had a huge number of very talented applicants, with about 2,700 applicants for 250 places in Mathematics and our various joint degrees, and we very much look forward to seeing this fresh set of students next October.

Admissions statistics are available from the University's main website at ox.ac.uk/about/facts-and-figures/admissions-statistics, with the latest data being for those who started their studies in 2018. Approximately 40% of our students in Maths come from abroad, primarily from China and the EU. Of the UK students, about 75% come from state schools, and 30% are women, reflecting the proportion of girls versus boys taking A-level Further Mathematics. Almost 20% of our UK students are from an ethnic minority heritage, which is just a little lower than the national average but includes some variation between different ethnic groups.

An area in which we hope to make improvements is in admitting UK students from less advantaged backgrounds. For the University as a whole, there is a 5:1 difference in the number of students from the most affluent 20% and least affluent 40% of postcodes. This largely matches the ratio of those achieving the top A-level grades, and so reflects acknowledged inequalities in the UK education system which contribute to large differences in school attainment. We attempt to account for this by considering admissions data in context, considering the background of each applicant, but it is not easy.

This is the setting for the University's new Opportunity Oxford initiative, through which the University, while holding fixed the total number of students, will make up to 200 more offers to students from disadvantaged backgrounds, and back those up with additional online preparation and a two-week residential course in early September. In Maths, we have made 11 of these offers this year, and we aim to double that number next year.

Anyone interested in learning more about this can read the University's Access and Participation Plan which is available at: ox.ac.uk/sites/files/oxford/UniversityOfOxford_APP_2020-21.pdf. For more on our outreach activities, please see page 3.

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Get in touch

We hope that you will enjoy this annual newsletter. We are interested to receive your comments, and also contributions for future newsletters. Please contact the editor, Robin Wilson, c/o lumbard@maths.ox.ac.uk

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Design: William Joseph
Wilson Sutherland image on page 9: courtesy of the Warden and Scholars of New College, Oxford.

Meet the Outreach Team

Vicky Neale
Whitehead Lecturer

Mareli Grady and James Munro lead the Mathematical Institute's outreach activities, as well as coordinating the undergraduate admissions process for the department. Mareli is the Outreach Events Coordinator, organising and running events for schools and the community every year. James is the Admissions and Outreach Coordinator, and he works to encourage and promote applicants from disadvantaged backgrounds. Here we learn more about what they get up to – and why sorting plastic teddies and teacups definitely counts as work.

How did you get into maths outreach?
Mareli: Honestly, a bit by chance! I trained as a medical statistician. My first role wasn't right for me – not enough interaction with people. A year later I came across the advert for my current role. It sounded like a great mix of teaching, event management and public engagement, so I gave it a go. I'm still here, 6 years later!
James: I volunteered on outreach events while I was a student and I haven't stopped yet! I really enjoy talking to people about maths, and now I get to do that with hundreds of people across the country every year.

What are your highlights in the outreach calendar?
James: Without exception, the UNIQ summer schools are the best weeks of my year, every year. These residential programmes give students from under-represented backgrounds the chance to study in Oxford for a week, and it's fantastic to see the students' confidence grow as they meet other keen mathematicians from around the country.
Mareli: For me there are two stand-outs. 'It All Adds Up' brings girls in Years 9–12 to Oxford for mathematical talks and workshops. The buzz from the girls is fantastic, and the confidence they gain during the day is visible and reported back to us by the teachers. The Oxford Maths Festival is another event that brings me joy. Over two days we welcome the residents of Oxford to activities we run both in a shopping centre and in the Mathematical Institute. It's fantastic to see children and adults get excited about maths, and work together to solve problems, play games and create.

Do many of our undergraduate and graduate students get involved in outreach?
Mareli: We run a Maths Ambassador Scheme which trains students and promotes opportunities to get involved. Many of our students get involved throughout the year, and they are absolutely essential to what we do and so generous with their time.

Mareli Grady

James Munro

'I really enjoy talking to people about maths, and now I get to do that with hundreds of people across the country every year.'

James: We run a series of weekend maths talks for local school children, and some of the most popular speakers recently have been our postgraduate students – it's great that we've got so many enthusiastic people right here in the department!

Does sorting plastic teddies and teacups really count as work?
Mareli: I am forever baffling my colleagues with the strange things I order, including plastic teddies, teacups, treasure chests and marble runs. I once ordered 300 plastic frogs to use in a capture-recapture statistics demonstration. I also spend a lot of time picking up new skills I never expected to need, including learning about video production, photography, social media strategies and leaflet design.
James: The teacups are no joke. I've seen teams of mathematicians stuck on that puzzle! Even if you don't have Mareli's teacups, you can try it yourself with the 12 face cards and the 4 aces from a deck of cards. Can you put them in a 4-by-4 grid without two of the same suit or the same face value in any row or column?

What's your favourite piece of maths you like sharing when you're working with groups of students?
James: The chaotic behaviour of the logistic map – simple systems can have incredibly complicated output. I use it both as an example of maths you would learn at university, and also as an analogy for how simple-looking problems can have incredibly deep answers.
Mareli: I'm a statistician by training, so most of my talks focus around this, with particular applications to medicine. I like to get students thinking about the facts and figures involved in screening – it's great to use maths as a way to get students thinking about ethical issues too.

What are your plans for future outreach activities?
James: We're running a new bridging programme in September 2020 as part of Opportunity Oxford, and I'm working to make that as useful as possible for the students on the course as they make the transition from A levels to university.
Mareli: In order to reach more people we'd like to do more online. This will complement our in-person events: interacting with people personally is very valuable.

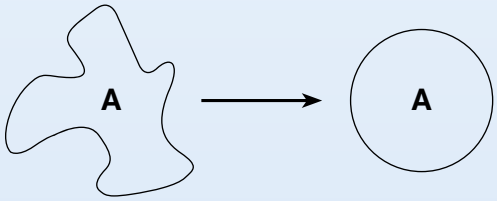
Any favourite outreach moments?
James: I like it when people mention one of our outreach events in their UCAS personal statement! It's great to hear that our events have encouraged someone to apply for Mathematics at university, or to think about a bit of maths in a new light. If you know anyone who might benefit from our outreach, please do let them know what we're doing.
Mareli: During the 2019 Oxford Maths Festival, we were in a shopping centre doing activities with passers-by. One young boy (around 4 years old) with a balloon sculpture on his head was keen to tell me all about infinity: "It's a concept. The numbers, they go on and on, and they don't stop! There is no biggest one." His enthusiasm and sense of awe was palpable, and it is how I want everyone to feel about Maths.

Minimal Lagrangians and where to find them

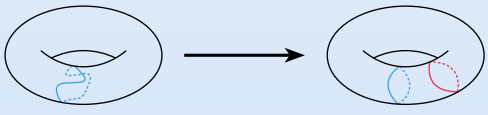
Jason Lotay

Would you like an insight into the types of issues that a modern geometer tackles? Minimal Lagrangians are key objects in geometry, with many connections ranging from classical problems through to modern theoretical physics, but where and how do we find them? Here, Oxford Mathematician Jason Lotay describes some of his research on these questions.

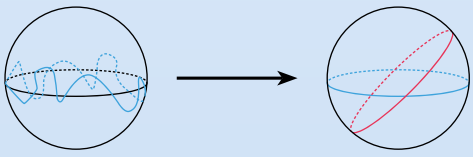
A classical problem in geometry, going back at least to Ancient Greece, is the so-called *isoperimetric problem*: what is the shortest curve in the plane that encloses a given area A? The answer is a circle:



Variants of this problem for curves include finding the shortest curve representing a given class of loops. For example on a torus, we see that both the blue and red curves on the right are shortest curves that represent the original blue loop on the left.



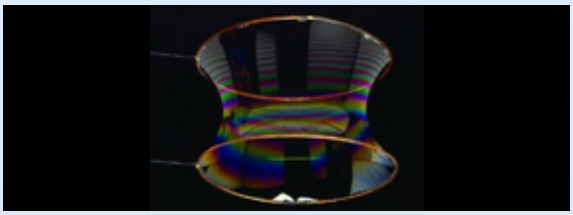
If we look at a sphere, however, then no shortest curve represents any given loop, since we can contract every curve to a point. A natural question for a sphere, which sounds more like the original isoperimetric problem, is to ask for the shortest curve that divides the sphere into two regions of equal area. The answer is (any) equator:

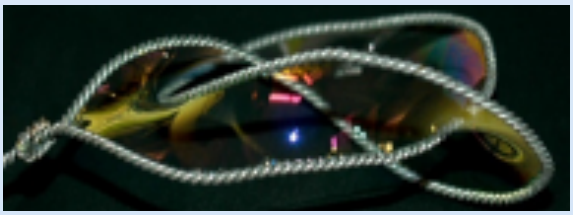


In every case we have considered, the answer for the shortest curve has been a 'minimal Lagrangian'.

In every case we have considered, the answer for the shortest curve has in fact been a 'minimal Lagrangian': on surfaces, minimal Lagrangians are just geodesics – curves that minimise length locally. Moreover, deformations of curves in the plane which contain the same enclosed area, or of the curves on the sphere which always divide the sphere into regions of equal area, are known as 'Hamiltonian isotopies'. In particular, we can rephrase the problem on the sphere as 'to find minimal Lagrangians in the Hamiltonian isotopy class of the original blue curve on the left sphere'.

These ideas also generalise to higher dimensions: we replace the surface by a particular type of even-dimensional space known as a 'Kähler–Einstein manifold' M, we replace curves by Lagrangians that are certain geometric objects in M with half the dimension of M (just as curves are 1-dimensional whilst surfaces are 2-dimensional), and Hamiltonian isotopies are special allowable types of deformations of a given Lagrangian that generalise the area-preserving deformations that we had before. Then minimal Lagrangians are just Lagrangians that minimise volume locally, just as geodesics were curves that minimise length, so we can think of them a bit like soap films:





Kähler–Einstein manifolds and minimal Lagrangians form an important part of modern geometry, particularly because they include so-called 'Calabi–Yau manifolds' and special Lagrangians which play a key role in the study of mirror symmetry and in string theory in theoretical physics.

The definition of Kähler–Einstein manifolds depends on a constant, which can be positive, zero (the Calabi–Yau setting) or negative, and the behaviour of these spaces and the minimal Lagrangians in them is quite different in each case.

The positive Kähler–Einstein manifolds include complex projective spaces which generalise the sphere, and here minimal Lagrangians are typically easy to find because the ambient space has many symmetries (like the sphere). An interesting question therefore is: which minimal Lagrangian in a positive Kähler–Einstein manifold has the least volume in its Hamiltonian isotopy class? For the sphere and curves that divide the sphere into two regions of equal area, the answer is the equator. There is a well-known and unsolved conjecture, due to Y. G. Oh, that says that for complex projective spaces there is a natural minimal Lagrangian (called the 'Clifford torus') which is volume-minimising under Hamiltonian isotopies: this is the higher-dimensional analogue of our isoperimetric problem on the sphere.

A natural way to try to solve Oh's conjecture is to start with a Lagrangian which is related to the Clifford torus by a Hamiltonian isotopy, and then to deform the Lagrangian by minimising volume as quickly as possible: this is called 'Lagrangian mean curvature flow'. I have studied Lagrangian mean curvature flow extensively, most recently with my collaborators, Ben Lambert (Oxford) and Felix Schulze (UCL), with a hope of trying to tackle this and other related problems.

In particular, in the Calabi–Yau setting (which is, in some sense, the analogue of the flat plane or the torus), Lagrangian mean curvature flow is particularly appealing and there is a conjecture due to Thomas and Yau that predicts the behaviour of the flow in special cases. I am actively studying approaches to this conjecture, which would hopefully pave the way towards understanding how we can potentially 'break up' a Lagrangian into special Lagrangian pieces, in the same way that we now know how to break up 3-dimensional spaces into special (or 'prime') pieces using the geometric flow known as the 'Ricci flow'.

Finally, in negative Kähler–Einstein manifolds (which are the higher-dimensional analogues of surfaces with more 'holes' than a torus), minimal Lagrangians are typically very hard to find – in fact, they are conjectured to be unique in their Hamiltonian isotopy class. This is certainly false for positive Kähler–Einstein manifolds – for example, rotating a sphere to get the red geodesic from the blue one is a Hamiltonian isotopy.

That said, there are many examples of negative Kähler–Einstein manifolds, so it is natural to ask whether or not they contain minimal Lagrangians. Together with my collaborator, Tommaso Pacini of Turin, I recently addressed this question by finding infinitely many new cases of negative Kähler–Einstein manifolds containing minimal Lagrangians.

Although we have made a lot of progress in understanding minimal Lagrangians, there are many fascinating and challenging problems left to study. They certainly are fantastic beasts and we should try our best to find them!

Kähler–Einstein manifolds and minimal Lagrangians form an important part of modern geometry.

There are many fascinating and challenging problems left to study. They certainly are fantastic beasts and we should try our best to find them!

Nick Woodhouse awarded CBE

Professor Nick Woodhouse, Emeritus Professor of Mathematics in Oxford and Emeritus Fellow of Wadham College, former Head of the Mathematical Institute and latterly President of the Clay Mathematics Institute, was appointed CBE in the 2020 New Year Honours List for services to mathematics.

Nick has had a distinguished career as both a researcher and a leading administrator in the University. His research has been at the interface between mathematics and physics, initially in relativity and later in more general connections between geometry and physical theory, notably via twistor theory. In parallel he led the Mathematical Institute in Oxford at a time of major expansion and was the leading figure in the Institute's move to the Andrew Wiles Building, completed in 2013. His time as President of the Clay Mathematics Institute saw its profile and influence increase and its roster of talented Clay Research Fellows grow.

Nick also played a leading role in the administration of the wider University including a period as Deputy Head of the Mathematical, Physical and Life Sciences Division; and was a member of the North Commission, set up in 1997 to review the management and structure of the collegiate University, whose recommendations helped to shape Oxford as it operates in 2020.

Oxford Presidents of the London Mathematical Society

As reported on page 8, Jon Keating has been appointed LMS President from 2019–21. Other current and retired members of the Department who have held this position are:

Ioan James (1984–86), Nigel Hitchin (1994–96), John Ball (1996–98 & 2009), Martin Taylor (1998–2000), Frances Kirwan (2003–05), Graeme Segal (2011–13) and Terry Lyons (2013–15).

Mathematics of Random Systems: a new doctoral training centre

Rama Cont
Head of the Oxford Mathematical and Computational Finance Group

Probability theory and stochastic analysis have been among the fastest growing areas in the mathematical sciences in the last few decades, with exciting new theoretical developments as well as an increasingly broad range of applications in physics, biology, finance and data science.

One of the new developments in 2019 at the Mathematical Institute has been the launch of the new Centre for Doctoral Training (CDT) in Mathematics of Random Systems: Analysis, Modelling and Algorithms, a partnership between the Mathematical Institute, the Oxford Department of Statistics and the Department of Mathematics at Imperial College London. Its ambition is to train the next generation of academic and industry experts in probability theory, stochastic analysis, probabilistic modelling and stochastic algorithms. These subjects have applications in physics, finance, biology and data science.

Below: CDT team

Foundations	Applications
Stochastic analysis: foundations and new directions	Interacting particle systems and quantum field theory
Stochastic partial differential equations	Stochastic modelling and data-driven modelling in finance
Random combinatorial structures: trees, graphs, networks	Stochastic models in biology
Computational methods: simulation, stochastic optimisation and control	Mathematical and algorithmic challenges in Data Science
Random dynamical systems and ergodic theory	Collective dynamics: mean-field models and agent-based modelling

Centre for Doctoral Training
Mathematics of Random Systems

Launched in September 2019 with generous support from UK Research and Innovation (UKRI), the Centre offers fully funded DPhil studentships for its comprehensive 4-year training programme, with rigorous training on mathematical foundations in the first year and a focus on supervised research thereafter, leading to a DPhil degree.

CDT students have access to a pool of 40 supervisors across Oxford and Imperial, representing research areas which have been driving recent scientific developments in stochastic analysis and its applications (see table). Students are able to learn first hand about many of these new developments from researchers who have pioneered them, including lectures on multilevel Monte Carlo by our colleague Mike Giles who pioneered this simulation technique, and lectures by Fields Medallist Martin Hairer on his award-winning work on regularity structures.

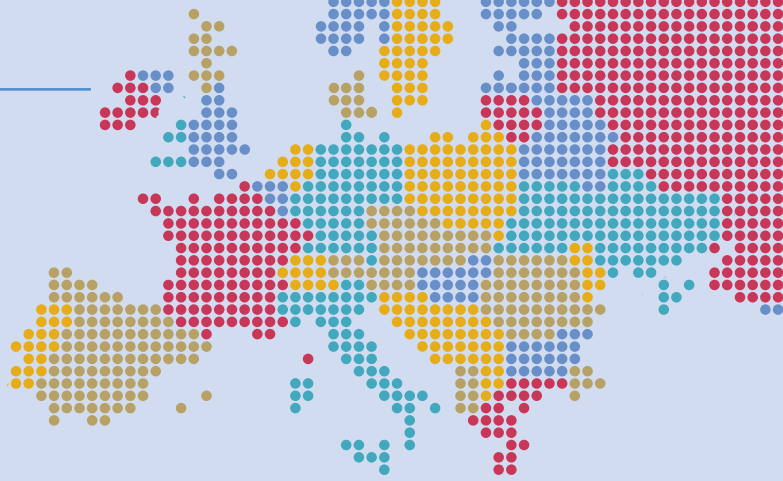
One feature that distinguishes our Centre from some other doctoral training centres in the mathematical sciences is that we deliberately ignore the sterile division between 'pure' and 'applied' mathematics: all students are exposed to both facets of the field through a core curriculum including advanced topics in stochastic analysis as well as simulation methods, stochastic algorithms and machine learning. The Centre has attracted several industry partners – large multinational corporations as well as start-ups – who fund studentships and provide internship and placement opportunities for CDT students.

The first cohort of 16 students, representing ten nationalities, reflects well the scientific breadth and ambition of the Centre, with a diverse range of research topics, such as stochastic differential geometry, mathematical population genetics, applications of rough path theory to data science, the mathematics of deep neural networks, and models of high-frequency market behaviour. That a common mathematical framework underlies such a diverse range of topics is what makes the subject so fascinating.

For more information, visit the Centre's website: randomsystems-cdt.ac.uk If your organisation is interested in becoming an industry partner of the Centre, please contact our Industry Ambassador, Dr Katia Babbar: Katia.Babbar@maths.ox.ac.uk

PROMYS Europe celebrates its 5th birthday

Vicky Neale



2019 saw the fifth PROMYS Europe summer school. The programme brings together enthusiastic and ambitious teenage mathematicians from across Europe, who gather in the Oxford Mathematical Institute for six weeks of intensive mathematics. Participants, who stay at Wadham College, work on activities designed to give them the opportunity to explore mathematical ideas independently. The programme is a partnership of the Oxford Mathematical Institute, Wadham College, the Clay Mathematics Institute, and PROMYS in Boston, which celebrated its 30th birthday in 2019.

PROMYS Europe, like its parent programme PROMYS in the USA, has a distinctive teaching philosophy and structure. Students receive a daily set of problems, and have a daily number theory lecture, but the lectures aim to be at least three days behind the problems sets. Students are invited to experiment, to gather numerical data, to explore ideas, to formulate conjectures and to try to find their own proofs, all before the ideas are formalised in lectures.

This gives students a very different experience of mathematics from anything they have encountered previously, and they are able to see how deeply it is possible to understand an area of maths because they have put the ideas together themselves.

In addition to the number theory course, there is a second course aimed primarily at students attending for the second time. Students also have the opportunity to work on group projects with a research flavour, drawing on ideas from a range of mathematical topics.

The counsellors play a crucial role in the PROMYS Europe community. They are undergraduate students studying maths, who mentor, advise and encourage the younger students. Many took part in PROMYS Europe themselves as students. In addition to working with the younger students, they also work on their own advanced mathematics during the programme, and take it in turns to give talks on their favourite aspects of maths.

Miroslav Marinov first took part in PROMYS Europe as a student and has been a counsellor several times. He is now an MSc student at St Catherine's College, and writes of his time as a counsellor at PROMYS Europe: 'I understand better how one should explain new mathematics to a talented student – by developing the skill to use words and pictures which nicely connect with intuition'.

PROMYS Europe is dedicated to the principle that no one should be unable to attend for financial reasons.

Halfway through the programme, the 2019 students and undergraduate counsellors gathered with faculty, former students and counsellors, and friends of the programme, to celebrate the 5th birthday of PROMYS Europe and the many achievements of the students and counsellors. Many former students and counsellors of PROMYS Europe have gone on to study maths degrees at leading universities, including Oxford, and the oldest are in some cases now embarking on PhD research degrees.

Maria Gyorgy-Spiridon, now studying Mathematics and Computer Science at University College and one of the PROMYS Europe alumni, says: 'If I could choose one experience that influenced my decision to apply to Oxford the most, it would be PROMYS Europe. It had the double effect of reminding me how exciting Maths is and of making me confident that I could pursue it at a higher level'.

Wojtek Wawrów, now studying for an MSc at St Cross College, and like Maria, a former PROMYS Europe student and counsellor, commented: 'PROMYS Europe lets children experience what real mathematics is about. It has convinced me that maths is what I want to do.'

PROMYS Europe is dedicated to the principle that no one should be unable to attend for financial reasons, and full or partial financial assistance is available for those who would otherwise be unable to attend. PROMYS Europe is made possible thanks to funding and other resources provided by the partnership, as well as further generous financial support from alumni of the University of Oxford and Wadham College, and from the Heilbronn Institute for Mathematical Research.

Below: PROMYS Europe students 2019 at Wadham College.

Appointments…

We welcome the following new Faculty members.

Ian Griffiths (Oxford)
Professor of Industrial Mathematics and Tutorial Fellow of Mansfield College
Research interests: hydrodynamics with application to industrial applications, including water purification, filtration and glass manufacture

Andrea Mondino (Warwick)
Associate Professor of Mathematics and Tutorial Fellow of St Hilda's College
Research interests: geometric analysis, optimal transport, PDEs, calculus of variations, gradient flows, nonlinear analysis, geometric measure theory

Yuji Nakatsukasa (NII, Tokyo)
Associate Professor of Numerical Analysis and Tutorial Fellow of Christ Church
Research interests: numerical analysis, eigenvalue problems, numerical linear algebra, rational approximation theory

Stuart White (Glasgow)
Professor of Mathematics and Tutorial Fellow of St John's College.
Research interests: Operator algebras (C*-algebras and von Neumann algebras) and their interactions with related areas of mathematics

…and Achievements

This has been another excellent year for awards and achievements, with a diverse range of prizes and recipients.

London Mathematical Society
Jon Keating FRS has been appointed President of the London Mathematical Society for 2019–21. LMS awards and prizes for 2019 were received by **Sir Andrew Wiles FRS** (De Morgan Medal), **Ben Green FRS** (Senior Whitehead Prize) and **David Conlon** (Whitehead Prize).

European Mathematical Society
Alison Etheridge FRS, OBE and **Nick Trefethen FRS** are invited speakers at the European Mathematical Society's meeting, 8ECM, in Portorož, Slovenia, in July 2020. Robin Wilson is giving one of the invited Public Lectures.

Other awards and prizes
Siddharth Arora, **John Prince** and **Maarten de Vos** were awarded the 2019 Martin Black Prize by the Institute of Physics and Engineering for a paper on 'Big data in Parkinson's disease'.

Martin Bridson FRS has won the Leroy P. Steele Prize, awarded by the American Mathematical Society for mathematical exposition.

Matthew Butler was awarded the Lighthill-Thwaites Prize for 2019.

Jon Chapman has been made a Fellow of SIAM, the Society for Industrial and Applied Mathematics.

Sam Cohen has been appointed by the University of Oxford to lead Public Engagement with Research for Oxford Mathematics.

Artur Ekert FRS was awarded a 2019 Micius Quantum prize (Theory category).

Alison Etheridge FRS, OBE has become Head of Oxford's Department of Statistics.

Heather Harrington was awarded the Adams Prize for 2019.

Sam Howison has become Interim Head of the MPLS Division.

Ehud Hrushovski has been awarded the 2019 Heinz Hopf Prize at ETH Zürich for his contributions to model theory.

Kristian Karadjiev has won the 2019 Gold Award in the Mathematical Sciences category at STEM for Britain.

James Maynard has been awarded the 2020 Cole Prize in Number Theory by the American Mathematical Society.

James Morrill, **Andrey Kormilitzin**, **Alejo Nevado-Holgado**, **Sam Howison** and **Terry Lyons** won the 2019 PhysioNet Computing in Cardiology Challenge.

Anna Seigal has been awarded the 2020 Richard C. DiPrima Prize by the Society for Industrial and Applied Mathematics (SIAM).

Nick Trefethen FRS has been elected to Academia Europaea, and has been awarded the 2020 John von Neumann Prize by SIAM.

Sarah Waters has been appointed a Fellow of the American Physical Society.

Nick Woodhouse has been appointed CBE in the New Year Honours list (see page 5).

Recognition of distinction awards
Xenia de la Ossa and **Eamonn Gaffney** have been promoted to Professor.

2019 MPLS Divisional Awards
Teaching Awards have been made to **Sam Cohen**, **Mareli Grady**, **Ian Griffith** and **Frances Kirwan** and an Equality and Diversity Award has been made to **Dominic Vella**.

Obituaries

Margaret Rayner 1930–2019

Irene Ault

Margaret Rayner, who died on 31 May 2019 at the age of 89, was the applied mathematics tutor at St Hilda's College for over 35 years. She was a highly valued member of the College, as well as the wider academic community in Oxford, and was known nationally and internationally for her work on school examinations.

Both sides of her family were farming with one exception, an aunt who was the headmistress of a village school. With her aunt's encouragement she went to Westfield College, London, to read Mathematics. From Westfield, she moved to Oxford, first as a College Lecturer and then as a Tutorial Fellow at St Hilda's. Her mathematical interests were in differential equations and the calculus of variations, particularly isoperimetric problems, and the 'Payne–Rayner inequality' is named after her. Margaret's efficiency, calm common sense, and willingness and ability to take on any role were recognised from the beginning, and there were many opportunities to stray away from research. As she said, she 'liked to see things happen, things work'. She never lost an early interest in school education and her service on various committees brought contact with teachers and schools. For many years she was chief examiner in mathematics for the International Baccalaureate and, as a member of the Secondary Examinations Council, she took part in approving syllabuses for GCSE and A-level exams. Her work on school examinations was recognised with the award of a CBE in 1990.

Over the years, Margaret took an active part in organising various fundraising projects. In retirement, she produced a definitive and succinct history of St Hilda's College, as well as articles on mathematical figures in the 19th and 20th centuries. Above all, her friendship has meant an enormous amount to a great number of people – students, colleagues, and others. She will be much missed.

Elmer Rees 1941–2019

John Jones

Elmer Rees died peacefully on 4 October 2019, aged 77, after a long period of serious ill health. He was a Welsh-speaking Welshman born in Llandybie, Carmarthenshire, in 1941.

Elmer was an undergraduate in Cambridge and a PhD student at Warwick. After short-term positions in Hull, Princeton and Swansea, he came to Oxford as a Fellow of St Catherine's College in 1971. He left here in 1979 for a professorship at Edinburgh, and in 2005 he moved from Edinburgh to Bristol. In 2009 he was awarded a CBE for his services to mathematics. His mathematical interests were in geometry and topology and his time at Oxford was very influential on his subsequent career. He was great fun and will be remembered fondly.

Wilson Sutherland 1935–2019

Brian Steer

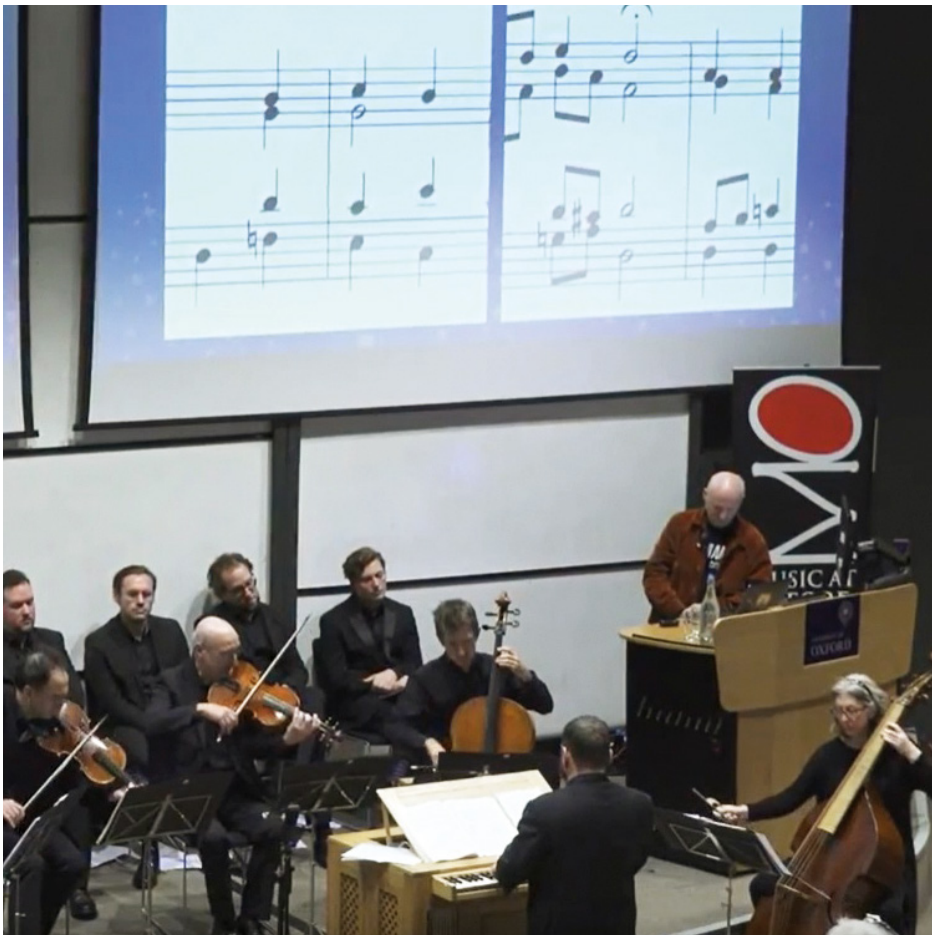
Wilson Sutherland died on 7 October 2019, aged 84. He was born in Forres on the Moray Firth and attended the local school, from which he gained a scholarship to St. Andrews University. On graduation he was awarded a Carnegie scholarship for graduate work in Oxford and in October 1957 joined the Geometry and Topology group, then directed by Henry Whitehead and Ioan James; the latter became his supervisor. His abilities and his clarity of exposition were quickly realised, and it was no surprise when he was appointed a Junior Lecturer in 1960.

In 1963 he took up an Instructorship at MIT, returning to a post in Manchester. In 1967 he was elected a Fellow of New College, Oxford, where he acted as Vice-Warden for a period of time and later, on retirement, was Acting Warden. He served on the Board of the Faculty of Mathematics and was, with Edward Thompson, editor of the *Quarterly Journal of Mathematics*. He wrote several notable papers, most of which were in classical homotopy theory and concerned Stiefel manifolds, Thom complexes and sections of bundles.

As a College Fellow, Wilson's duties were to teach small classes, lecture, and carry out research. With his natural modesty and sense of service he gave greater importance to his teaching than to his research. He was an outstanding tutor and cared about his pupils, who responded with affection, and at his retirement lunch New College hall was full to overflowing with past and present pupils. Something of his clarity and style can be seen in his OUP book *Introduction to Topological and Metric Spaces*. It is a standard text in Oxford and elsewhere.

Wilson was a modest and a warm caring man with a strong sense of service and a gentle sense of humour, to me a wonderful colleague and friend, and to his family a beloved husband and grandfather.

What's on in Oxford Mathematics?



Oxford Mathematics Music Events

Dyrol Lumbard

Wander around the Andrew Wiles Building and you'll frequently hear the sound of music (no, not that 'Sound of Music') accompanying the mathematics. It varies, of course, but there are certain sounds that recur. Unsurprisingly, J. S. Bach, whose fascination with order and pattern was decidedly mathematical, has featured most prominently in the growing number of musical collaborations taking place in the building.

Most striking has been a series of concerts – or, more precisely, Sunday Services – with the Orchestra of the Age of Enlightenment (OAE). Entitled Bach, the Universe and Everything and taking place in King's Place, London, and in our main Oxford lecture theatre on the same day, they feature short pieces and readings alongside a Bach Cantata and a 15-minute talk on an aspect of mathematics from one of our faculty. The brain, AI and beauty have featured so far, and the plan is for six more over the next eighteen months.

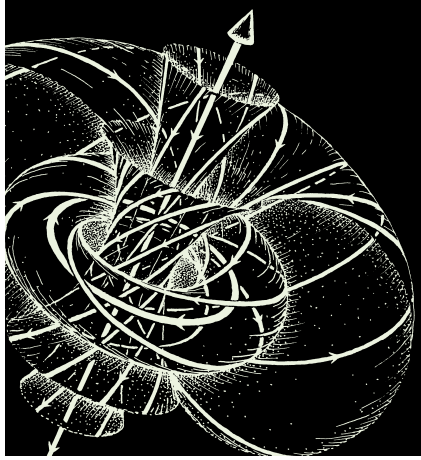
You are all very welcome – you even get the chance to sing!

In addition, the Villiers Quartet, the Faculty of Music's Quartet in Residence, made their debut in our venue in February, having outgrown their home in the Holywell Music Rooms, and later in 2020 will play their first concert as part of a collaboration between Oxford Mathematics, St Hilda's College, and the Music Faculty. Like the OAE they report that a lecture theatre built for talking is also ideal for playing music – an acoustically perfect collaboration.

To cap an excellent year for music and maths, thanks to a generous legacy from Paul Shreder we have established a doctoral scholarship which provides a musically gifted student with the opportunity to study mathematics at Oxford and to contribute to our musical collaborations.

Roger Penrose's scientific drawings

As you might expect from a man whose family included the surrealist artist Roland Penrose, **Sir Roger Penrose** has always thought visually. That thinking is captured brilliantly in a selection of his drawings that he produced for his published works and papers, and which has been on display in the Mathematical Institute. From quasi-symmetric patterns, via twistor theory and the brain, to graphic illustrations of the paradoxical three versions of reality, they capture the stunning range of Roger's scientific work and of the visual thinking that inspires and describes it.



Oxford Mathematics FRSs

The Oxford Mathematics Department counts no fewer than 26 Fellows of the Royal Society among its current and retired members:

John Ball, Bryan Birch, Martin Bridson, Philip Candelas, Marcus du Sautoy, Artur Ekert, Alison Etheridge, Ian Grant, Ben Green, Roger Heath-Brown, Nigel Hitchin, Ioan James, Dominic Joyce, Jon Keating, Frances Kirwan, Terry Lyons, Philip Maini, Jim Murray, John Ockendon, Roger Penrose, Jonathan Pila, Graeme Segal, Martin Taylor, Ulrike Tillmann, Nick Trefethen, Andrew Wiles.

Oxford Maths Festival

Mareli Grady

The second annual Oxford Maths Festival was held in May 2019, and the third in February 2020. Visitors were once again shown the beautiful, creative and collaborative side of mathematics, and families were able to do hands-on maths activities (provided by NRICH), make craft items to take home, and play board games together.

On the first day of each festival, activities took place at Templars Square Shopping Centre in East Oxford, reaching a new audience in our commitment to make Oxford Maths accessible to all. The second day took place at the Andrew Wiles Building, allowing local families a chance to experience our beautiful building. Alumnus Barney Maunder-Taylor of House of Maths provided several maths shows alongside Andrew Jeffrey, using magic, juggling and balloons to explore mathematical topics.

Each year the event was well attended, with around 2,000 visitors. More than 50 undergraduate and graduate volunteers make the festival possible by providing their time and enthusiasm. One visitor commented: 'Just want to say 'thank you' for organising and holding such a wonderful event that promotes the importance and fun of exploring maths. My family had a fantastic time, and we can't wait for next year.'

If your organisation might be interested in supporting the Oxford Maths Festival or other outreach projects, then please contact info.mathsfest@maths.ox.ac.uk. We are also grateful for donations of any size via oxgive.info/maths-fest.

400 years of Savilian professors

Robin Wilson

A well-attended one-day meeting was held at the Bodleian Library in November, in conjunction with the British Society for the History of Mathematics and the Weston Library, to celebrate the founding of Oxford's Savilian Chair of Geometry in 1619. The seven speakers covered the early years, John Wallis, Edmond Halley and the astronomers, the Victorian period (Baden Powell & Henry Smith), James Joseph Sylvester, G. H. Hardy & E. C. Titchmarsh, and Michael Atiyah and beyond. These talks will eventually be available in book form.

Below: Balliol College's portrait of Frances Kirwan, DBE, FRS, Oxford's current Savilian Professor of Geometry

Thank goodness it's Friday

Each Friday, students and early-career mathematicians gather in the Mathematical Institute for Fridays@2 and Fridays@4. No prizes for guessing the time of each!

Fridays@4 began back in October 2016, with the aim of supporting the personal and career development of the department's DPhil students and postdocs. The weekly programme during term time includes workshops, panel discussions and talks on careers (both within and beyond academia), together with personal and skills development. It is organised by Sam Cohen, Ian Griffiths and Frances Kirwan, with additional input from the Early Career Researcher Committee and DPhil students.

It also incorporates the departmental and the 'North meets South' colloquia, the latter featuring talks by two early-career mathematicians, one a pure mathematician from the north end of the Andrew Wiles Building and one an applied mathematician from the south end. Sam, Ian and Frances received their 2019 MPLS Teaching Awards (see page 8) 'for their work on Fridays@4, an initiative which has enhanced graduate students' study skills and their long-term educational development, and helped integrate students within the department'.

Building on the success of Fridays@4, the new Fridays@2 programme was launched in October 2018, on a similar model but tailored for undergraduates and MSc students. The first year of the programme included sessions on varied topics such as tips for mathematics undergraduates based on research in cognitive science, a discussion of ethics in maths, and 'Managing a busy workload and having a life too'. There were also extra-curricular maths talks, under the heading Mathematics: the past, present and future, which proved to be very popular.

Student societies

You may remember the Invariant Society, our long-running and still very active undergraduate mathematics society. We now have several other societies that complement it and demonstrate that mathematics and mathematicians are engaging with the issues that affect their world and the society in which they live. These include:

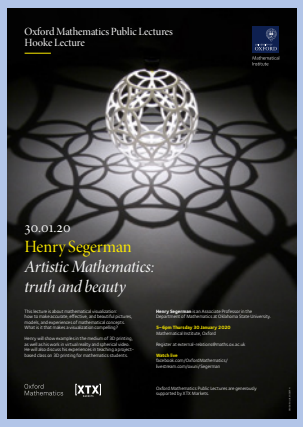
- **Mathematrix**, a DPhil student-led group which provides a platform and network for postgraduates, postdocs and staff to discuss and explore topics related to challenges in academic life and being a minority in the maths community
- **Maths in Society**, also led by DPhil students, but which was started last year by three MSc students
- **The Mirzakhani Society**, the undergraduate-led society for women and non-binary students studying maths at Oxford

Oxford Mathematics Public Lectures

One thing that has nagged us about our Public Lectures, successful though they have been, is that we don't always get the balance right. There may be too much maths, too many sudden slides filled with a secret language of equations and geometry. So we asked our audiences what they thought.

Their answer was that they like to be challenged – if anything, they were less impressed by the more entertaining maths-lite lectures. All rather encouraging really. As a result we now have a strapline – **#forthecurious** – both to promote the lectures and to reflect what they represent. This year we have travelled the mathematical universe via prime numbers, cosmology, sound waves and AI – and we have been in London and Newcastle and are going to Cornwall.

All of our lectures are live-streamed and can be found on the Oxford Mathematics YouTube channel.



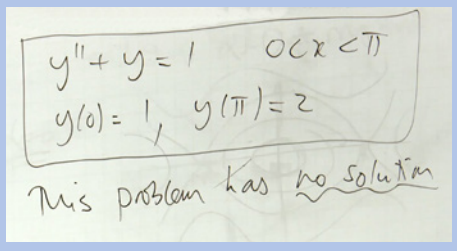
Public engagement – student lectures

In academia there is much noise around Public Engagement. But who is this mysterious public that is so eager to know how its money is being spent? The question is hard enough, let alone the answer, and consequently we have taken a cautious approach – or, rather, a simple one. We will tell the world what we do, not as part of some huge education exercise, but as a more realistic (and valuable?) demystification exercise.

We have done this by (for example) putting as many of our research case-studies online as we can (there are over 150 of these), and most recently by filming some undergraduate lectures and making them publicly available via our YouTube Channel.

This may not sound dramatic, but the results tell a different story. Over three million people have viewed some of a first-year student lecture on *Introductory Calculus*. Over one-and-a-half million have tuned in to *Analysis III: Integration*. The lesson? People of all ages, and especially the young, are interested in Oxford and in mathematics. Our conclusions? We should do more of it. There is much to say about Oxford. It shouldn't be a secret.

To see the full range of filmed lectures, visit the Oxford Mathematics YouTube channel.



Climate change: a sustainable café

Oxford University is at the forefront of research into the impact of diet on health and climate – from obesity, via the contribution of meat consumption to carbon emissions. So what should a university café, in this case the Mathematical Institute's Café π, do about it? Should we align our menu with our research?

The answer is: 'yes, we think we should' – and so we have. Two-thirds of our hot dishes and most of the rest of our menu are now vegetarian or vegan, while sugar and salt levels have been reduced. Of course, it is a balancing act and people must make their own choices, but the response has been very positive. From the till to the customer, the feedback has been that we should do it, and not least from our undergraduates who will face these issues far into the future.

If you're ever in Oxford, Café π would be delighted to feed you, vegetarian or not...

Alumni Weekend

Again this year there is no Oxford Mathematics Garden Party as we continue to widen our range of Public Lectures, both in Oxford and around the UK. However, we would encourage you to join the many alumni who will attend the University Alumni Weekend on 11–13 September 2020. This will again take place in the Mathematical Institute. See alumni.ox.ac.uk/alumni_home