LONDON MATHEMATICAL SOCIETY
150 YEARS

NEWSLETTER No. 451 October 2015

THE LMS 150TH ANNIVERSARY ASSOCIATE ARTIST SCHEME

Artists George Legendre (left) and Mark Francis (right)

Artists George Legendre and Mark Francis were commissioned by the London Mathematical Society during the first six months of 2015 to produce unique pieces of artwork that explore and celebrate the beauty and complexity of mathematics.

Conceived as part of the LMS 150th Anniversary programme, the scheme produced spectacular results that were first displayed at the LMS Anniversary Dinner at Goldsmiths' Hall on 18 June.

Mark Francis produced a painting (see back page) titled *Praxis 2015* and a sculpture (see back page). In both instances his work took as points of reference the graphic interpretations of abstract dimensions of mathematics. Inspired by his conversations with mathematicians Dr Iain Moffatt (Royal Holloway, University of London) and Dr Dorothy Buck (Imperial College London), Francis employed a modernist grid structure counterbalanced by dramatic, nebulous brush strokes that, he says, together point to, "various themes to do with science […] imaginary networks which span the universe, and ideas of order and chaos that are intrinsically linked."

George Legendre, meanwhile, produced a series of intricate, 3D printed sculptures titled *30 Pieces* (see back page). Examples included a skyscraper, a chair, a table and a football stadium. Drawing on his experience as an architect, Legendre's models were supported by detailed plans and drawings that, he says, are "written in the language of analytic geometry,

(Continued on page 3)

SOCIETY MEETINGS AND EVENTS

- 21 October: Popular Lectures, Glasgow *page 21*
- 11 November: Popular Lectures, Leeds *page 21*
- 13 November: LMS Graduate Student Meeting, London *page 16*
- 13 November: LMS AGM, London *page 17*
- 28–29 November: Einstein's Legacy, London *page 31*
- 14 December: SW & South Wales Regional Meeting, Southampton *page 24*

Contents

No. 451 October 2015

computer-aided design, and numerically-aided fabrication." The ultimate aim, he emphasises, is to "pitch the familiarity of the everyday against the uncanniness of the mathematical."

The six month journey from initial consultation, studio visits and conversations between the artists and mathematicians to the eventual exhibition at Goldsmiths' Hall provided considerable opportunity for both the Society and the artists themselves to learn more about the many fruitful connections between mathematics and art.

Pamphlet for George Legendre's *30 Pieces*

Asked about his experience of the scheme, Mark Francis said, "The scheme has been very useful in adding more possibilities in the ways that I approach my practice. The dialogue with various mathematicians has certainly contributed to this. Developing an artist's language is a lifelong journey and conversations now can be echoed many years down the line."

Also asked about his impressions, George Legendre said, "I had a genuinely great time doing this. I enjoyed meeting professional mathematicians for the first time, and I had the privilege of collaborating with two of them on part of our proposal. I also enjoyed working with Curator Barry Phipps, and I found the LMS to be an enthusiastic and considerate patron across the board."

LMS Librarian Professor June Barrow-Green commented, "I was lucky enough to be part of the LMS visit to the artists in their studios, and to hear Mark and George each express their excitement about mathematics while talking over their individual ideas for the Scheme. It was then wonderful to see the results of their work on display in the Goldsmiths' Hall at the Anniversary Dinner. The beautiful pieces they have produced bear witness to the deep and intricate relationship between art and mathematics.

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CELEBRATING 150 YEARS OF THE LONDON MATHEMATICAL SOCIETY

LONDON MATHEMATICAL SOCIETY 150 YEARS

The following meetings and events are part of the year-long programme celebrating the 150th LMS Anniversary in 2015. Full details of the Anniversary Programme of Activities are available on the LMS website at www.lms.ac.uk/2015.

DEPARTMENTAL CELEBRATIONS

Aberdeen, TBC
Nottingham, 4 November
Oxford, TBC
Portsmouth, TBC
Queen Mary, 12 October
Southampton, 14 December
St Andrews, 2 October

LOCAL HEROES EXHIBITIONS

Banff Museum in Scotland dates TBC
Carrickfergus 26 September – 31 October
Dundee 22 August – 25 October
Kensington Central Library 3 – 18 October
Tenby 7 September – 23 October

LMS-NZMS AITKEN LECTURE TOUR

Steven Galbraith (University of Auckland) *(see page 31)*
13 October Royal Holloway, London
20 October, Open University
22 October, Oxford
23 October, Bristol
28 October, Sheffield
29-30 October, Loughborough

OCTOBER

Popular Lectures Glasgow
21 October *(see page 21)*
Bloomsbury Festival
22-25 October, London

NOVEMBER

Popular Lectures Leeds
11 November *(see page 21)*
Graduate Student Meeting
BMA House, London
13 November *(see page 16)*
LMS Anniversary Prize Giving, AGM and Society Meeting
BMA House, London
13 November *(see page 17)*
Annual Dinner
Montague Hotel, London
13 November
Mathematics Festival at The Science Museum
25, 27-29 November,
London *(see opposite page)*
Joint Meeting with the Institute of Physics & Royal Astronomical Society *(see page 30)*
28-29 November, QMUL, London

DECEMBER

Joint Meeting with the Edinburgh Mathematical Society
10-11 December, ICMS, Edinburgh
Enhanced South West and South Wales Regional Meeting
14-17 December, University of Southampton *(see page 24)*
LMS Prospects in Mathematics
15-16 December, Loughborough

LONDON MATHEMATICAL SOCIETY
150 YEARS

LMS 150th Anniversary

Mathematics Festival at the Science Museum, London

Science Museum, Exhibition Road, London SW7 2DD (nearest tube: South Kensington)

Wednesday 25 November (6:45–10:00pm; Science Museum Lates); Friday 27 – Sunday 29 November 2015 (daytime)

The LMS is collaborating with the Science Museum and interactive theatre company *non zero one* to create an exciting and immersive Mathematics Festival. Audiences of all ages will be invited to adopt the role of an undercover journalist to discover how mathematics relates to everyday life. By interviewing research groups from a range of universities they will be asked to investigate how mathematics helps us to understand the world around us. The festival aims to be an inspiring and memorable experience that challenges the common perception of mathematics as difficult and esoteric, and to show visitors how contemporary mathematics transforms people's lives and affects everyone.

Science Museum Lates: Wednesday 25 November, 6:45–10:00pm

Roger Penrose talk, 7:00pm: *Einstein's Amazing Theory of Gravity: Black Holes and Novel Ideas in Cosmology*

As an introduction to the festival and part of the 'Lates' event to be held on the evening of 25 November, Roger Penrose will be giving a talk on the subject of general relativity, in light of the 100th anniversary of Einstein's seminal paper "The Field Equations of Gravitation". This will be a free ticketed event with limited capacity; details of how to obtain tickets will be published by the Society very soon.

The Lates event will also include a display of artwork from the LMS 150th Anniversary Associate Artist scheme and a screening of a series of short filmed interviews with prominent UK-based mathematicians.

For further details about the event, please contact Katherine Wright (katherine.wright@lms.ac.uk)

1865 - 2015

LMS 150TH ANNIVERSARY

DEPARTMENTAL CELEBRATIONS

These events are part of a series of receptions being hosted across the UK by mathematics departments, celebrating the 150th Anniversary of the LMS. For further details, and to see if such an event has been organised for your department, visit www.lms.ac.uk/2015-events-listing.

LOUGHBOROUGH UNIVERSITY

The wine reception to celebrate 150 years of the LMS was held in the Department of Mathematical Sciences of Loughborough University on 8 May 2015, on the first day of the international conference *Integrability and All That* (8-10 May, Loughborough). A toast highlighting the key role played by LMS in the international mathematical community was proposed. We thank the LMS for giving us this opportunity, and wish the Society further successes and achievements in its service to mathematics.

UNIVERSITY OF CHESTER

The toast to the LMS at the University of Chester was part of a postgraduate Applied and Computational Mathematics Workshop on 3 July where students displayed posters and gave talks about their research, within the field of Computational and Applied Mathematics. The numerical analyst Professor Christopher Baker gave the introductory seminar *Concerning characteristic functions and the study of oscillatory and non-oscillatory differential equations with deviating arguments.* Prizes were awarded to the two best student presentations, before the event concluded with the wine reception and the toast to the continued good health of the London Mathematical Society and mathematics.

LEICESTER UNIVERSITY

A workshop on *Cluster Algebras and Finite Dimensional Algebras* was held at Leicester University from 3 to 5 June. There were 40 participants, 15 of which were PhD students. On the Wednesday evening there was a joint wine reception with the LMS network TTT (Transpennine Topology Triangle) to celebrate the 150th anniversary of the LMS. This was well received by all conference attendees. During the reception the LMS was thanked for its continuous support of mathematics in the UK and the conference and the TTT in particular and everyone toasted the occasion.

BIRKBECK UNIVERSITY OF LONDON

A drinks reception to mark the 150th anniversary of the founding of the London Mathematical Society was held in the Department of Economics, Mathematics and Statistics in Birkbeck, University of London on Friday 1 May 2015. The toast 'to the continued health of mathematics and the London Mathematical Society' was raised by mathematicians and economist alike along with a host of support staff and PhD students and was much enjoyed by all present.

LMS 150TH ANNIVERSARY

HANDBOOK AND LIST OF MEMBERS: REMINDER

A special commemorative 150th Anniversary edition of the Society's *Handbook and List of Members* will be published in 2016. The Society's *Handbook and List of Members* contains information about the Society's activities including the Anniversary celebrations, publications, grants and events as well as a list of its members and their details; name, address, email, degrees fields of interest, year of election to the Society.

All members are asked to check and amend (if needed) their information on their online membership record, which can be accessed via the Society's website: www.lms.ac.uk/user. The Society would like to include as many members as possible in the *150th Anniversary Handbook and List of Members* and asks that all members confirm their details and their permissions by **31 October 2015**.

Please note that when checking their information, members will have the opportunity to opt out of any contact information that they do not wish to be included in either the printed *150th Anniversary Handbook and List of Members* and/or the online *List of Members* or to opt out completely from the Handbook.

Any queries regarding the *150th Anniversary Handbook and List of Members* should be directed to membership@lms.ac.uk.

Elizabeth Fisher
Membership & Activities Officer

2015 ELECTIONS TO COUNCIL AND NOMINATING COMMITTEE

The Electoral Reform Society (ERS) will once again be managing the LMS elections to Council and Nominating Committee. LMS members will be contacted directly by the Electoral Reform Society (ERS), who will send out the election material for the 2015 elections. All LMS members registered for electronic communication will receive an online ballot only, though may subsequently request a paper ballot if so desired. In advance of this, an email will be sent by the Society to all members who are registered for electronic communication informing them that they can expect to shortly receive some election correspondence from the ERS.

Those not registered to receive email correspondence will receive all communications in paper format, both from the Society and from the ERS. Members should check their post/email regularly in October for communications regarding the elections.

With respect to the election itself, there are 12 candidates proposed for seven vacancies for Member-at-Large. Of those vacancies, five are for two years and two are for one year. One candidate has been nominated for the role of Member-at-Large (Librarian). Four candidates have been proposed for two vacancies in the membership of Nominating Committee. The slates and candidate biographies for the election can be found on the LMS website at http://www.lms.ac.uk/about/council/lms-elections.

For both electronic and postal voting the deadline for receipt of votes is **Thursday 5 November**.

Members may like to note that a LMS Election forum, moderated by the Scrutineers, can be found at: http://discussions.lms.ac.uk/elections2015/.

Future elections

Members are invited to make suggestions for future nominees for election to Council. These should be addressed to The Chair of

the Nominating Committee (nominations@lms.ac.uk). Members may also make direct nominations: details will be published in the February 2016 *LMS Newsletter* or are available from Duncan Turton at the LMS (duncan.turton@lms.ac.uk).

ANNUAL GENERAL MEETING

The Annual General Meeting of the Society will be held at 3.00pm on Friday 13 November 2015 in The Great Hall, BMA House, Tavistock Square, London WC1H 9JP.

The business shall be:

1. Elections to Council and Nominating Committee
2. Review of Society Activities 2014-15
3. Report of the Treasurer
4. Resolutions
   a. Adoption of the Trustees' Report 2014-15
   b. Appointment of the Auditors
5. Presentation of Certificates to the 2015 LMS Prize Winners

It is hoped that as many members as possible will be able to attend. The Annual General Meeting will be followed by a Society Meeting at which the presidential address will be given by Terry Lyons, FRS. Also speaking will be Bill Cook.

Fiona Nixon
Executive Secretary

LMS–IMA DAVID CRIGHTON MEDAL – PROFESSOR FRANK KELLY

Professor Frank Kelly, CBE, FRS, is awarded the David Crighton Medal of the London Mathematical Society and the Institute of Mathematics and its Applications for services both to mathematics and to the mathematical community. He is a professor at the University of Cambridge and has been Director of the Statistical Laboratory there. He is currently Master of Christ's College, Cambridge. Kelly has made fundamental contributions to the theory of random processes, networks, control and optimization. One of his main contributions was to show that fairly simple-minded local processes could, when combined in enormous systems, act in such a way as to optimize control and fairness. His results have had major academic impact, as shown by the impressively large number of citations his work receives, and at the same time he has influenced the design of telecommunication networks and internet protocols, where his work has recently been incorporated into the design of TCP (a major internet protocol) as part of Apple's iOS7 release in 2013. Cloud computing protocols also use insight from Kelly's work. His work has been recognized through the award of numerous national and international prizes. He was elected a Fellow of the Royal Society in 1989.

Professor Frank Kelly

Kelly has also promoted mathematical sciences outside academia and supported the mathematical sciences community in many ways. He has served on numerous advisory boards and committees, including

Hewlett Packard's Basic Research Institute in Mathematical Sciences, the Council of the Royal Society, the Advisory Board of the Royal Institution/University of Cambridge Mathematics Enrichment Project, and the Management Committee of the Isaac Newton Institute for Mathematical Sciences. He chaired the Council of Mathematical Sciences (2010-2013), the umbrella group of the Institute for Mathematics and its Applications, the London Mathematical Society, the Operational Research Society, the Royal Statistical Society, and the Edinburgh Mathematical Society and was instrumental in establishing a unified voice for mathematics dialogue with Government. He was Chief Scientific Advisor at the Department of Transport from 2003 to 2006. He was awarded the CBE for services to mathematical sciences in 2013.

These many achievements make it fitting that the IMA and LMS award him the David Crighton Medal for services both to mathematics and to the mathematical community.

LMS 150TH ANNIVERSARY

POSTDOCTORAL MOBILITY GRANTS

The second round of awards under the Society's 150th Anniversary Postdoctoral Mobility Grants has been announced. Nine grants have been awarded by the Society's Research Meetings Committee for the academic year 2015-16 to UK-based early career researchers to visit institutions ranging across the UK, Europe, USA and India. The grants are intended to support promising researchers during the transitional period between having submitted their PhD and the start of their first post-doctoral employment.

Name	Home institution	Visiting institution(s)
Stefanos Aivazidis	Queen Mary, University of London	Universitat de València
Henry Bradford	University of Oxford	Université Paris-Sud
Julian Brough	University of Cambridge	Technische Universität Kaiserslatern
Máté Gerencsér	University of Edinburgh	University of Warwick
Joanna Hutchinson	University of Bristol	Saha Institute of Nuclear Physics
Niko Laaksonen	University College London	University of Copenhagen
Christopher Le Sueur	University of Bristol	University of Münster
Duncan McCoy	University of Glasgow	Boston College
Alberto Ramos	University of Cambridge	Cardiff University

LMS INVITED LECTURE SERIES 2017

CALL FOR PROPOSALS

Proposals for the Invited Lecture Series 2017 are now being sought. Proposers are invited to suggest a topic and Lecturer for the lecture series, which they should be prepared to organise at their own institution or a suitable conference centre within the UK.

The annual Invited Lecturers scheme aims to bring a distinguished overseas mathematician to the United Kingdom to present a small course of about ten lectures held over five days (Monday-Friday). Each course of Invited Lectures is on a major field of current mathematical research, and is instructional in nature, being directed both at graduate students beginning research and at established mathematicians who wish to learn about a field outside their own research specialism.

The format of an annual Invited Lectures series should:

- include meetings at which a single speaker gives a course of about ten expository lectures, examining some subject in depth;
- be held over a five day period (Monday to Friday) during a University vacation;
- be residential and open to all interested.

A grant of up to £4,000 is available to the host department to support attendance at the lectures. In addition to full expenses, the lecturer is offered an honorarium of £1,250 for giving the course. It is intended that the texts of the lectures given in the series shall be published and an honorarium of £1,500 is also available upon receipt of lecture notes in a publishable form.

Enquiries about the Invited Lectures should be directed to the Programme Secretary at the Society (lmsmeetings@lms.ac.uk). The deadline for the submission of proposals is **5 February 2016**.

For more information about the scheme and how to submit a proposal, please visit: www.lms.ac.uk/events/lectures/invited-lecturer-proposals

The Invited Lecturer for 2016 is **Professor Edgar Knobloch** (UC Berkeley), who will visit Loughborough from 21-25 March 2016 to give a series of lectures on Dynamics, Patterns and Spatially Localised Structures.

Recent previous lecturers have been:

2015	M. Shapiro (Michigan State University)	*Cluster algebras and integrable systems*
2014	J. Väänänen (University of Helsinki and University of Amsterdam)	*Games, trees and models, foundations of mathematics and second order logic* and *The mathematical theory of dependence and independence*
2013	F. Bogomolov (NYU)	*Birational geometry and Galois groups*
2012	A. Borodin (MIT)	*Determinantal point processes and representation theory*
2011	E. Candes (Stanford)	*Compressed sensing*
2010	M. Bramson (University of Minnesota)	*Stability of queuing networks*

NEW ISSUE OF REVIVED MSOR CONNECTIONS PUBLISHED

The first new issue of *MSOR Connections* for two years (volume 14 issue 1) was published at the CETL-MSOR Conference at the University of Greenwich in September, and can be viewed online at http://journals.gre.ac.uk.

This practitioner journal aims to publish peer-reviewed articles by and for those involved in learning, teaching, assessment and support of mathematics, statistics and operational research in higher education. Article submissions are encouraged and welcome at any point, with issues planned termly. Submissions could include case studies, opinion pieces, research articles, student-authored or co-authored articles, resource reviews (technology, books, etc.), short updates (project, policy, etc.) or workshop reports. Please visit the website at http://journals.gre.ac.uk for further details.

MSOR Connections volume 1 issue 1 was published in February 2001. This followed *Maths Stats & OR,* a newsletter for the new Learning and Teaching Support Centre (LTSN) subject centre published in 2000, itself taking the baton from the CTI *Maths & Stats* newsletter in the 1990s. *MSOR Connections* was launched as a newsletter for "anyone involved in teaching [Maths, Stats and OR] in higher education", with the stated hope that readers would use this to "share information and expertise with other practitioners" (Surowiec and Bishop, 2001).

Issues were published at first quarterly then, from 2010, termly by the Maths, Stats & OR Network, initially as part of the LTSN and later as a Higher Education Academy (HEA) subject centre, until the Network closed in 2012. Two further issues were published in 2013 by the HEA itself before it stopped publishing its journals due to a cut in funding.

The last eighteen months have seen a good deal of activity by a group working to revive the publication, albeit on a voluntary, shoestring basis. Permission from the HEA and support from the **sigma** network and the Greenwich Maths Centre (University of Greenwich) have allowed *MSOR Connections* to be revived as a termly online journal.

The group working to make this happen now forms the editorial board, from which a group of five have volunteered to be editors: Noel-Ann Bradshaw, Joe Kyle, Alun Owen, Peter Rowlett and Robert Wilson. The wider editorial board is Tony Croft, Neville Davies, Michael Grove, Paul Hewson, Duncan Lawson, Eabhnat Ni Fhloinn and Matina Rassias.

Peter Rowlett (p.rowlett@shu.ac.uk)
Sheffield Hallam University.

References: Surowiec, R. and Bishop, P., 2001. Editorial. *MSOR Connections* 1(1), p1.

EUROPEAN NEWS

Abel Prize

Two new members have been appointed to the Abel Committee: Marta Sanz-Solé (Universitat de Barcelona), and Luigi Ambrosio (Scuola Normale Superiore, Italy). The Abel Committee is chaired by John Rognes (University of Oslo). The other members are: Rahul Pandharipande (ETH Zürich) and Éva Tardos (Cornell University).

The Abel Committee for 2016 met for the first time at the Norwegian Academy of Science and Letters in September to embark on the task of selecting a deserving candidate.

The second committee meeting will take place at the Norwegian General Consulate in Zürich on 20 and 21 January 2016. On 15 March 2016 the President of the Norwegian Academy of Science and Letters will announce the name of the 2016 Abel Laureate.

David Chillingworth
LMS/EMS Correspondent

MATHEMATICS POLICY ROUND-UP

September 2015

SCHOOLS AND COLLEGES

Post-16 exam results

The number of A-level mathematics entries across the UK is up 4.4% on last year, with 92,711 students sitting the exam. Figures released by the Joint Council for Qualifications also show that:

- A-level further mathematics has continued in popularity, with entries increasing by 6.9% (to 14,993)
- AS mathematics entries increased by 2.2% (to 165,311)
- AS further mathematics entries have increased by 10.2% (to 27,034)

A full list of results is available at http://tinyurl.com/nnbx987.

More students leaving primary with mathematics and literacy skills

Ninety thousand more primary school children are achieving the expected standards in reading, writing and mathematics than in 2010.

- Eighty per cent of students achieved the expected level 4 in reading, writing and mathematics - up from 62% in 2009.
- The highest ever percentage of students reached the expected level in mathematics, at 87% - up 1 percentage point on last year. Since 2010, it has increased by 8 percentage points - equivalent to 46,000 more students reaching the expected levels.

More information is available at http://tinyurl.com/oo796jo.

OTHER

EPSRC Programme Director appointed to new role at Elsevier

Dr Lesley Thompson has been appointed as Elsevier's Director of Academic and Government Strategic Alliances, UK, with effect from 1 November 2015. More information is available at http://tinyurl.com/o282qf4.

Dr John Johnston
Joint Promotion of Mathematics

THE ALAN TURING INSTITUTE – THE UK'S NATIONAL CENTRE FOR DATA SCIENCE – OPENS ITS DOORS

The Alan Turing Institute – the UK's national centre for Data Science – has announced its inaugural director Andrew Blake FRS. At the same time a suite of activities heralds the start of institute activities: a number of partnerships, and a call for expressions of interest in early career fellowships (see https://turing.ac.uk/#research-positions).

The Institute began with a letter from the chief scientific advisor Sir Mark Walport entitled `The Age of Algorithms'. This letter recommended the establishment of a national institute whose activities should be focused on developing data science. Following the recommendation by Sir Mark, in March 2014 the UK government announced its intent to establish such an institute. This announcement was succeeded by a peer-reviewed process, where the joint venture partners of the universities of Cambridge, Edinburgh, Oxford, UCL and Warwick were selected. The sixth partner in this endeavor is EPSRC itself.

The establishment of the Institute is part of an international fabric of developments – at the same time the Simons Center for Data Analysis was established, and the Gordon and Betty Moore Foundation with the Alfred P. Sloan Foundation have supported significant data science activities at the University of Washington, the University of California, Berkeley, and New York University. Such considerable activities highlight the importance of timeliness – the international data science

landscape is evolving rapidly, and the UK needs to invest to stay at the forefront of such developments.

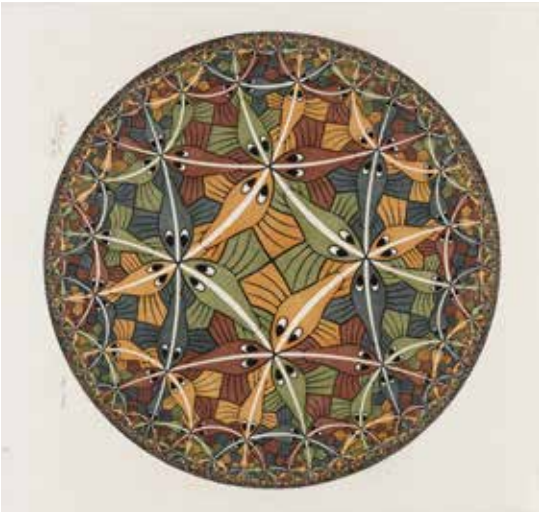
The Mathematical Sciences are strongly invested in the new Alan Turing Institute. Pete Grindrod, past president of the IMA, is a member of the Institute's board of directors. Terry Lyons, current president of the LMS, is a member of the interim programme committee, set up to determine the early research directions of the Institute. Mathematical scientists are also strongly involved in the early scientific scoping workshops. For example, Ulrike Tillman FRS is organizing a workshop on *Topological Data Analysis*, and as part of these activities Ben Leimkuhler is organizing an event linked to the conference on *Mathematical Aspects of Big Data* to be held at the ICMS in December.

The Alan Turing Institute represents a unique opportunity for data science. By involving mathematics strongly right from its inception, theory and applications can be addressed in tandem. All members of the mathematical sciences community are strongly encouraged to participate in Institute activities, including responding to calls for fellows and participating in scoping workshops that will be taking place throughout the autumn.

ESCHER AND MATHEMATICS

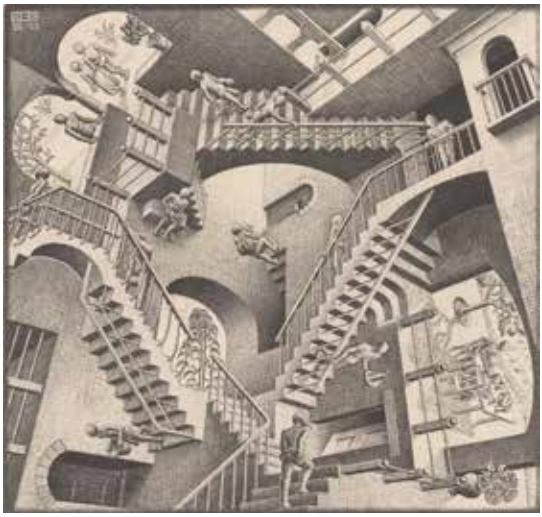
On 14 October 2015 *The Amazing World of M.C. Escher* opens at Dulwich Picture Gallery. The exhibition, the first major Escher show in the UK, which started its run in Edinburgh earlier in the year, will reveal the cross-disciplinary relationships behind the creation of some of Escher's works of astonishing mathematical precision.

In the late 1950s important links were established between Escher and two celebrated mathematicians: H.S.M. Coxeter and Roger Penrose. It is not often that a mathematics conference can have left a significant imprint on the world of art, but this happened with the International Congress of Mathematicians, held in Amsterdam in 1954. Noting the relation between Escher's work and mathematics, the Committee of the Congress staged an exhibition of Escher's work at Amsterdam's Stedelijk Museum. By complete coincidence, both Coxeter and Penrose both attended and saw the exhibition.



Circle Limit III

Coxeter first wrote to Escher in October 1954, noting their shared interest in symmetry and geometry. In reply, Escher acknowledged that the mathematics was 'much too learned for a simple, self-made plane pattern-man like me' but acknowledged that 'since a long time I am interested in patterns with "motives" getting smaller



Relativity

and smaller till they reach the limit of infinite smallness. […] I was never able to make a pattern in which each "blot" is getting smaller gradually from a centre towards the outside circle limit.' This fortuitous correspondence led to the *Circle Limit* series in which a motif gets smaller and smaller as it reaches the outer edge of a circle known as hyperbolic or non-Euclidean geometry. Escher was clearly having trouble with it; he wrote directly to Coxeter, enclosing a diagram and requesting help. Replying at the end of December 1958, Coxeter explained how to extend the geometric pattern right to the edge. In a letter to his eldest son George, Escher acknowledged: 'After a long time of trying, in vain […] I was finally put on the right path by a publication of the English mathematician Professor H.S.M. Coxeter.'

Roger Penrose, then a second-year research student at Cambridge University, also attended the conference in Amsterdam. A chance encounter with a friend who was holding the catalogue of the Escher exhibition piqued his curiosity and he visited the show. He was astonished by the work, particularly the prints of endless stairs such as *House of Stairs* and *Relativity*. Penrose set about designing his own 'problem pictures'. His father Lionel, an expert in genetics and a mathematician, helped him and they produced a short article published in the British Journal of Psychology as 'Impossible Objects: A Special Type of Visual Illusion' introducing a perspectival drawing of a 'tri-bar', a three-dimensional triangle which looks logical at first glance, but is patently 'impossible', and a continuous flight of steps, which seem to go up (or down) forever. The text mentioned the 'Numerous ideas in this field (which) have been exploited by Escher'.

A friend sent Escher an offprint of the article, Escher was impressed and wrote to Lionel and Roger Penrose enclosing a reproduction of *Belvedere* which, Escher wrote, he had invented 'long before having seen the figures of your article and ignoring that others but me are interested in such queer things'. The resemblance between the cube held by the seated man in Belvedere and Roger Penrose's drawing of a tri-bar is uncanny but coincidental. Escher added that the 'continuous flights of steps', were completely new to me and I was so impressed by the idea that it inspired me recently to a new print, of which I should like to send you, as a homage, an original copy'. Lionel replied with thanks, noting their 'great admiration' for Escher's work. Escher then sent Penrose the lithograph *Ascending and Descending* which he had completed in March. It was, he acknowledged, 'inspired by your endless staircase. The monks, ascending and descending continuously, are probably mad, but perhaps very wise as well, because they realise the uselessness of some typical human behaviour.' The exhibition runs until 17 January 2016.

Patrick Elliott, Curator
The Amazing World of M C Escher
Dulwich Picture Gallery

LONDON MATHEMATICAL SOCIETY
150 YEARS

LMS 150th Anniversary

Graduate Student Meeting

BMA House, Tavistock Square, London, WC1H 9JP (Nearest tube: Euston)

13 November 2015

This meeting is intended as an introduction to the Society Meeting later in the day. All graduate students (and indeed any other mathematicians) will be very welcome.

Programme (09.30 – 15.00)

Coffee and Registration

Dan Crisan (Imperial College)

Integration: Past, Present and Future

Graduate Student Talks

Horatio Boedihardjo (Reading)

Rough paths in stochastic analysis and beyond

LMS Annual General Meeting and Society Meeting (see below)

Registration: To register, please email Elizabeth Fisher (lmsmeetings@lms.ac.uk) by **6 November**. Places are free and all refreshments including lunch will be provided.

Student Talks: Students are invited to give short talks (15 minutes) aimed at a general mathematical audience with prizes awarded for the best two talks. If you want to give a talk, email Elizabeth Fisher (lmsmeetings@lms.ac.uk) with a title and short abstract by **23 October**.

Funding for Travel and Accommodation: For students who attend both the Graduate Student Meeting and the LMS AGM, the Society offers funding of up to £50 towards travel costs, and funding of up to £50 towards accommodation costs (for those travelling long distances).

LMS Annual General Meeting and Society Meeting: The LMS Annual General Meeting is a Society Meeting, which is open to all. Bill Cook (University of Waterloo) will give the first Lecture and Terry Lyons (Oxford) will give the Presidential Address. The meeting will be held in the Great Hall at BMA House. After the AGM, there will be a reception at De Morgan House, 57-58 Russell Square.

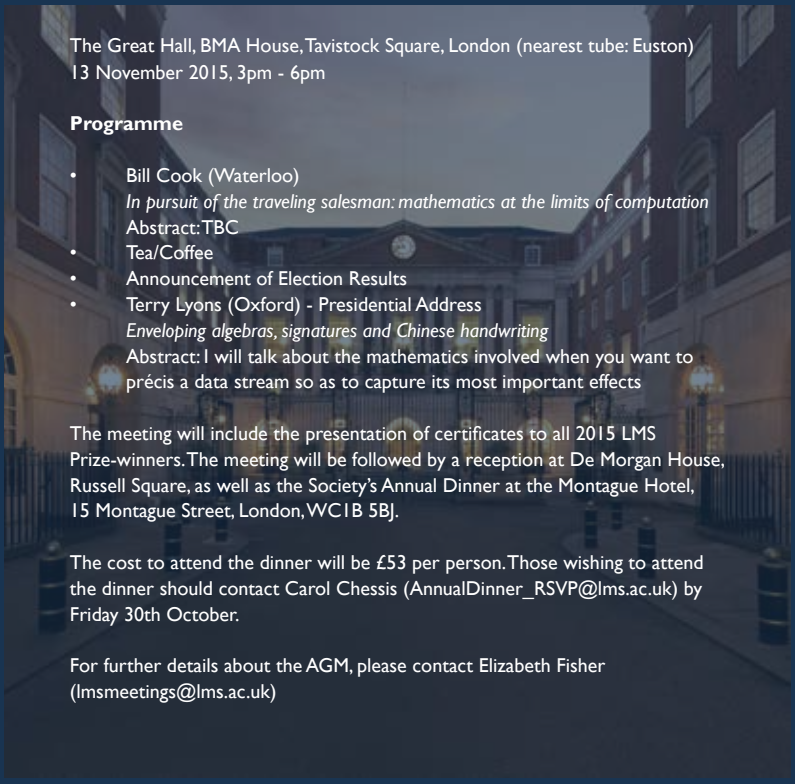
For further details visit www.lms.ac.uk/content/society-meetings

1865 - 2015

LONDON MATHEMATICAL SOCIETY
150 YEARS

LMS 150th Anniversary

Annual General Meeting



The Great Hall, BMA House, Tavistock Square, London (nearest tube: Euston)
13 November 2015, 3pm - 6pm

Programme

- Bill Cook (Waterloo)
  In pursuit of the traveling salesman: mathematics at the limits of computation
  Abstract: TBC
- Tea/Coffee
- Announcement of Election Results
- Terry Lyons (Oxford) - Presidential Address
  Enveloping algebras, signatures and Chinese handwriting
  Abstract: I will talk about the mathematics involved when you want to précis a data stream so as to capture its most important effects

The meeting will include the presentation of certificates to all 2015 LMS Prize-winners. The meeting will be followed by a reception at De Morgan House, Russell Square, as well as the Society's Annual Dinner at the Montague Hotel, 15 Montague Street, London, WC1B 5BJ.

The cost to attend the dinner will be £53 per person. Those wishing to attend the dinner should contact Carol Chessis (AnnualDinner_RSVP@lms.ac.uk) by Friday 30th October.

For further details about the AGM, please contact Elizabeth Fisher (lmsmeetings@lms.ac.uk)

DEVELOPMENTS IN MODERN PROBABILITY LMS-CMI RESEARCH SCHOOL

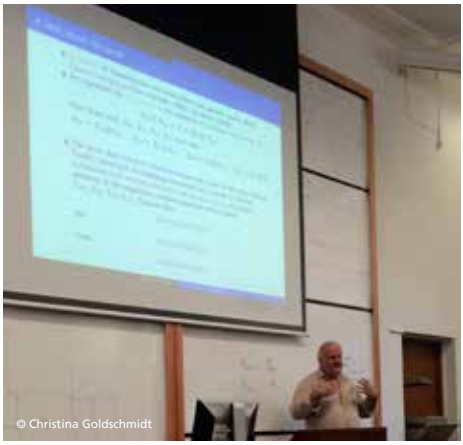
Report

From 5 to 10 July 2015, an LMS-CMI Research School on *Developments in Modern Probability* was held in Oxford, to tie in with the *Stochastic Processes and their Applications* conference (SPA2015) the following week. The school aimed to provide PhD students and early-career researchers with background on some of the important topics in modern probability which featured prominently in the plenary talks at SPA2015. Three inspirational five-hour courses were delivered by Ivan Corwin (Columbia, Institut Henri Poincaré) on *Integrable probability and the KPZ universality classes*, Paul Bourgade (Courant) on *Random matrices and PDEs* and Nathanaël Berestycki (Cambridge) on *Two-dimensional Liouville quantum gravity and the Gaussian free field*. The courses were supported by tutorial sessions given by postdocs Guillaume Barraquand (Paris 7), Kevin Schnelli (IST Austria) and Benoît Laslier (Cambridge). Sixty participants came from around the UK, six European countries, the USA, China and Japan.

Ivan Corwin (course lecturer)

One of the important themes in modern probability is the exploration of random structures either coming directly from physics, or motivated by ideas from physics. This theme was represented in various ways in our three courses. Nathanaël Berestycki's course was motivated by a desire to understand the random geometries that arise in two-dimensional quantum gravity models. A key issue is to obtain a good model for a random surface, and to determine its properties. The course

Coffee break



Steve Evans (guest lecturer)

Lecture audience

Paul Bourgade (course lecturer)

comprised the definition and properties of the Gaussian free field, the rigorous construction of the Liouville quantum gravity measure from it, and applications to the KPZ formula.

Random matrices form a vast subject within probability, with deep and important connections to many other parts of mathematics. Paul Bourgade's course focussed on the proof of the Erdös-Yau theorem on gap universality for the eigenvalues of a random matrix. Roughly, this says that if you make an n x n symmetric matrix whose entries are centred independent random variables (up to the symmetry condition) satisfying certain moment conditions, then the gaps between successive eigenvalues (suitably rescaled) have the same limiting law, regardless of the precise details of the distribution of the matrix entries.

The KPZ equation is an (ill-posed) SPDE which describes the growth of a random interface. The last few years have seen a concerted effort both to make rigorous sense of solutions to this equation and also to understand the class of models whose scaling limits should be described by the KPZ equation. Ivan Corwin addressed the behaviour of particular models belonging to the KPZ universality class which are exactly solvable, and which provide particular insight into the wider class of models.

On Monday night, there was a wine reception in the Mathematical Institute, Andrew Wiles Building and on Tuesday, we had a guest lecture from Steve Evans (Berkeley) on *The fundamental theorem of arithmetic for metric measure spaces*. On Wednesday afternoon, the participants tried their hand at punting on the River Cherwell, followed by a well-deserved barbeque dinner!

More information about the school is available at www.stats.ox.ac.uk/events/lms-cmi_research_school.

Christina Goldschmidt and Dmitry Belyaev
University of Oxford

Attendees

LMS-EPSRC DURHAM SYMPOSIA

CALL FOR PROPOSALS

The London Mathematical Society invites proposals for Durham Symposia in 2017 and beyond.

The LMS and the EPSRC intend to support at least two Durham Symposia between 21 July and 31 August 2017.

The Symposia began in 1974, and have now become an established and recognised series of international research meetings. They provide an excellent opportunity to explore an area of research in depth, to learn of new developments, and to instigate links between different branches. The format is designed to allow substantial time for interaction and research. The meetings are by invitation only and held in July and August, usually lasting 10 days, with up to 70 participants, roughly half of whom will come from the UK. They are held at the University of Durham.

Prospective organisers should send a formal proposal to the Durham Representative, Dirk Schuetz (dirk.schuetz@durham.ac.uk) by **Friday 20 November 2015**.

Proposals should include:

- A full list of proposed participants, divided into specific categories (please see the guidance on submission of proposals at www.lms.ac.uk/events/durham-symposia for more details). Proposers are encouraged to actively seek to include women speakers and speakers from ethnic minorities, or explain why this is not possible or appropriate.
- A detailed scientific case for the symposium, which shows the topic is active and gives reasons why UK mathematics would benefit from a symposium on the proposed dates.
- Details of additional support from other funding bodies.
- Where appropriate, prospective organisers should consider the possibility of an 'industry day'.

The Durham Representative will provide an estimated cost for accommodation for the symposium and estimated travel costs for each participant.

For further details about the Durham Symposia, please visit the Society's website: www.lms.ac.uk/events/durham-symposia.

Before submitting: Organisers are welcome to discuss informally their ideas with the Durham Representative (dirk.schuetz@durham.ac.uk) and/or the Chair of the Research Meetings Committee, Professor Beatrice Pelloni (RMC.Chair@lms.ac.uk).

LONDON MATHEMATICAL SOCIETY
150 YEARS

LMS 150th Anniversary

Popular Lectures 2015

The London Mathematical Society Popular Lectures present exciting topics in mathematics (and its applications) to a wide audience. As a part of the celebrations to mark the LMS 150th anniversary there are four popular lectures being held this year rather than the normal two.

For 2015, the popular lecturers are **Professor Martin Hairer**, FRS (University of Warwick), **Professor Ben Green**, FRS (University of Oxford), **Dr Hannah Fry** (UCL), **Dr Ruth King** (University of Edinburgh) and **Dr Colva Roney-Dougal** (University of St Andrews).

The London lectures took place in June and the Birmingham lectures took place in September. The forthcoming Popular Lectures are:

Glasgow 21 October at 6.30 pm
(Main Auditorium, Technology and Innovation Centre, University of Strathclyde)
Colva Roney-Dougal: *Party hard! The maths of connections*
Ruth King: *How many.....? (Estimating population sizes)*

Leeds 11 November at 6.30 pm
(The Great Hall, University of Leeds)
Hannah Fry: *Patterns in human behaviour*
Ben Green: *A good new millennium for prime numbers*

Entry is free with registration.
Register at lms.ac.uk/events/popular-lectures

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LMS NEWSLETTER http://newsletter.lms.ac.uk

REGULARITY AND ANALYTIC METHODS IN COMBINATORICS LMS-CMI RESEARCH SCHOOL

Report

An LMS-CMI Research School on *Regularity and Analytic Methods in Combinatorics* took place from 1 to 5 July 2015, at the University of Warwick. The school covered three interlinked discrete mathematics topics with many computer science applications: the Regularity Method, Limits of Combinatorial Structures, and Property Testing.

The Regularity Method of Szemerédi gives a way to approximate a large combinatorial object by one of a bounded size. The method has many applications inside and outside mathematics with those in number theory and in theoretical computer science being most often cited. It also forms one of the foundations of the (recently emerged) theory of combinatorial limits, which led to substantial progress on many classical problems in extremal combinatorics.

Recent exciting developments related to the three school topics were covered in courses delivered by Christian Borgs (Microsoft Research), Henry Cohn (Microsoft Research), David Conlon (Oxford) and Asaf Shapira (Tel Aviv). Each of the three courses was equipped with three one-hour tutorial sessions which gave the school participants an opportunity to practice the presented methods. The course lectures were also complemented by three more general talks given by Noga Alon (Tel Aviv), Christian Borgs (Microsoft Research) and Ben Green (Oxford).

Ben Green (Oxford) giving a talk

The school also included opportunities for a less formal interaction among the participants. Its programme contained two social events. On the second day of the school, the participants enjoyed a trip to Coombe Abbey which included a medieval style dinner. The conference reception took place in the evening before the last day of the conference after which many participants stayed and chatted until late. The very nice weather during the school also allowed lunches to be taken outdoors while sitting on the grass.

Tereza Klimosova (Warwick) and Jakub Konieczny (Oxford) discussing during a coffee break

The school attracted a significant interest among young discrete mathematicians: 66 early career researchers and students, including 12 females, from 11 countries (Canada, Chile, Denmark, Germany, Israel, Poland, Slovakia, South Korea, Switzerland, United Kingdom and United States) attended the school. The school participants highly commended the good atmosphere during the school and

Noga Alon (Tel Aviv) and Viktor Zamaraev (Warwick) discussing during a coffee break

Participants having lunch

the choice of the three school topics as the three courses were very well interlinked. Some of the school participants also stayed for the 25th British Combinatorial Conference, which took place on the campus immediately after the school.

The school organizers are grateful to London Mathematical Society, Clay Mathematics Institute and European Research Council for their financial support for the school. They are also grateful to the Mathematics Research Centre of Warwick Mathematics Institute and the DIMAP centre of the University of Warwick for their logistical support. Further information about the school, including its course material, is available on its website http://tinyurl.com/pdusgxh.

Dan Kral
University of Warwick

Drinks before the dinner in Coombe Abbey

Fiona Skerman (Oxford) and Jan Volec (ETH Zurich) talking in Coombe Abbey

LONDON MATHEMATICAL SOCIETY
150 YEARS

LMS 150th Anniversary

LMS South West and South Wales Regional Meeting and Workshop *Aspects of Homotopy Theory*

14 December 2015
56 School of Mathematics, University of Southampton

1:00	Registration
1:30-2:30	**Ralph Cohen (Stanford University)**
	Topological Field Theories and How to Compare Them
2:30-3:00	Tea/coffee break
3:00-4:00	**Jie Wu (National University of Singapore)**
	Combinatorial Approaches to Homotopy Theory
4:00-4:30	Tea/coffee break
4:30-5:30	**Ian Leary (University of Southampton)**
	Uncountably Many Groups of Type FP
6:00	Wine reception

Workshop Speakers (15-17 December):

- Alexander Berglund (Stockholm University)
- Piotr Beben (University of Southampton)
- Natalia Castellana (Universitat Autònoma de Barcelona)
- Alexander Gaifullin (Steklov Mathematical Institute, Moscow)
- John Greenlees (University of Sheffield)
- Brendan Owens (University of Glasgow)
- Nansen Petrosyan (University of Southampton)
- Oscar Randal-Williams (University of Cambridge)
- Svjetlana Terzic (University of Montenegro, Podgorica)
- Sarah Whitehouse (University of Sheffield)

More information is available at www.personal.soton.ac.uk/jg1u11/LMSregional.html

Formal Aspects of Computing Science Specialist Group

LONDON MATHEMATICAL SOCIETY 150 YEARS

BCS-FACS Evening Seminar
Joint event with the London Mathematical Society

Tuesday 3rd November 2015, 6:00pm

Professor Roland Backhouse
(University of Nottingham)

The Mathematics of Program Construction

The Mathematics of Program Construction is the title of a series of conferences that was initiated by Jan van de Snepscheut and Professor Backhouse in 1989 and is how he has described his research since round about that time. Its goal is to improve the reliability and dependability of computer software by developing mathematical theories and methods focused on the process of constructing software. In this talk Professor Backhouse will give a personal view on what the mathematics of program construction is about.

Software construction is underpinned by abstraction and calculation. Abstraction is the process of modelling the real world and calculation is used to construct implementations that achieve desired effects based on those models. Choosing the right abstractions and developing the calculational method are therefore fundamental to developing the mathematics that supports software construction. Professor Backhouse will sketch a number of algebraic systems that, in his view, play a central role in software development. These include regular algebra, relation algebra, fixed-point calculus and category theory. He will also argue that a greater focus on articulating the calculational method can make a significant contribution to improving our constructive problem-solving skills.

The venue is the London Mathematical Society, De Morgan House 57-58 Russell Square, London WC1B 4HS. Refreshments will be available from 5.30pm.

The seminar is free of charge and open to everyone. If you would like to attend, please register at lmscomputerscience@lms.ac.uk.

VISIT OF YURY STEPANYANTS

Professor Yury Stepanyants (University of Southern Queensland, Australia) will be visiting the Department of Mathematical Sciences at Loughborough University from 24 October to 6 December 2015. His main research area is the theory of nonlinear waves and fluid dynamics, with applications to physical oceanography. During his visit Professor Stepanyants will give the following seminars:

- University College London, 27 October at 3.00 pm
  Analysis of modulational stability of quasi-harmonic wave trains in media with double dispersion
  Contact Ted Johnson (e.johnson@ucl.ac.uk)
- University of Keele, 28 October at 2.30 pm
  Scalar description of three-dimensional flows of incompressible fluid
  Contact Victor Shrira (v.i.shrira@keele.ac.uk)
- Loughborough University, 4 November at 2.00 pm
  Transformation of internal waves at the bottom ledge
  Contact Karima Khusnutdinova (K.Khusnutdinova@lboro.ac.uk)

For further details contact Karima Khusnutdinova (K.Khusnutdinova@lboro.ac.uk). The visit is supported by an LMS Scheme 2 grant.

ADA LOVELACE SYMPOSIUM, OXFORD, 2015

An interdisciplinary symposium celebrating the life and legacy of Ada Lovelace, 1815-1852, will take place at the Mathematics Institute, University of Oxford on 9 and 10 December 2015. Ada Lovelace is best known for a remarkable article about Charles Babbage's unbuilt computer, the Analytical Engine, and the symposium will present Lovelace's life and work, in the context of nineteenth century mathematics, science and culture, and present-day thinking on computing and artificial intelligence. New research includes work on Lovelace's mathematical "correspondence course" with Augustus De Morgan.

Speakers include: computer scientists John Barnes, Adrian Johnstone, Ursula Martin, Bernard Sufrin and Moshe Vardi; historians of computing and mathematics, June Barrow-Green, Elizabeth Bruton, Judith Grabiner, Christopher Hollings and Doron Swade; Lovelace scholars Imogen Forbes-Macphail, Julia Markus and Betty Toole; historian and biographer Richard Holmes; and graphic artist Sydney Padua. Participants in a panel on female icons include mathematician Cheryl E. Praeger, computer scientists Valerie Barr and Muffy Calder, founder of Ada Lovelace Day, Suw Charman-Anderson, and cultural historian Murray Pittock.

A reception and dinner in Balliol College on 9th December includes a pre-dinner address by Lovelace's descendant, the Earl of Lytton, and an after dinner speech by philanthropist and entrepreneur Dame Stephanie Shirley.

Registration for the symposium is £40, or £90 including the symposium dinner. Some fully-funded places are available. For further information and registration see https://blogs.bodleian.ox.ac.uk/adalovelace/

Other events include a display at Oxford's Bodleian Library, 13 October – 18 December, with Lovelace's childhood notes, and correspondence with Babbage and De Morgan.

Sponsors: This event has been made possible with support from a London Mathematical Society Conference grant, with other support from ACM, AHRC, Balliol College, British Computer Society, Clay Mathematics Institute, EPSRC, google, Institute of Mathematics and its Applications, and Queen Mary University of London's cs4fn project.

Professor Ursula Martin, CBE
Chair, Ada Lovelace Celebration 2015
University of Oxford; ursula.martin@cs.ox.ac.uk

Ada Lovelace Bicentenary
CELEBRATING WOMEN IN COMPUTER SCIENCE

FRIDAY 16 OCTOBER 2015
Flora Anderson Hall, Somerville College

Join us for a celebration of the life of Ada Lovelace, the mathematician and scientific visionary who was a pioneer of computer programming.

Ada Lovelace was a protégée of **Mary Somerville** and the two exchanged letters over a number of years; a small exhibition will profile Lovelace's literary life.

Professors **Jennifer Widom** and **Ursula Martin** will deliver keynote addresses at the full-day event. Speakers include:

- **Cecilia Mascolo**, Professor of Mobile Systems at the University of Cambridge
- **Jennifer Widom**, Fletcher Jones Professor and Chair of the Computer Science Department, Stanford University
- **Ulrike Sattler**, Professor in Computer Science, University of Manchester
- **Ursula Martin** CBE, Professor of Computer Science, University of Oxford
- **James Essinger**, author of Ada Lovelace, A Female Genius: How Ada Lovelace started the Computer Age (2013)

The celebration will be chaired by **Mason Porter**, Tutor in Applied Mathematics at Somerville. It is open to Oxford alumni and students, Somerville Fellows, secondary school teachers and students, and a limited number of members of the public. Registration from 10am.

To book your place, please email adalovelace@some.ox.ac.uk

www.some.ox.ac.uk

THE SCIENCE OF BEAUTY

A two-day multidisciplinary conference on *The Science of Beauty* will take place at the Royal Society of Edinburgh on Tuesday 10 and Wednesday 11 November 2015. Distinguished speakers drawn from the fields of mathematics, philosophy and neuroscience will discuss the experience of beauty. The speakers include:

- Michael Atiyah
- David Attenborough
- Robbert Dijkgraaf
- David Mumford
- Roger Penrose
- Semir Zeki

The full programme and further information are available from the 'Events' section of the website www.royalsoced.org.uk.

The conference is organized by Sir Michael Atiyah (Edinburgh) and Professor Semir Zeki (UCL, London). The local committee consists of Professor Richard Morris (Edinburgh) and Professor Andrew Ranicki (Edinburgh). The meeting is supported by an LMS Conference grant, as well as other institutions.

7ECM BERLIN 2016

7ECM AT A GLANCE

The quadrennial Congress of the European Mathematical Society will take place from 18 to 22 July 2016 on the Campus of TU Berlin. It is organized by the German Mathematical Society (DMV), the International Association of Applied Mathematics and Mechanics (GAMM), the Research Center Matheon, the Einstein Center ECMath and the Berlin Mathematical School (BMS).

Scientific Program: The program of the Congress will cover all areas of theoretical and applied mathematics. There will be ten Plenary Lectures, 33 Invited Lectures, several Prize Lectures, the Hirzebruch Lecture, and the Abel Lecture. Moreover, a lecture series on *Berlin in the History of Mathematics* is scheduled.

Prizes: Calls for the Otto Neugebauer Prize, the Felix Klein Prize and ten EMS prizes are under way.

Friedrich Hirzebruch Lecture: This lecture is in honour of the first President of the EMS, Friedrich Hirzebruch. The speaker is Don Zagier, Director of the Max-Planck-Institute for Mathematics in Bonn.

Abel Lecture: For the first time in the history of the ECM one of the Abel Laureates will give a dedicated Lecture to the 7ECM participants. The speaker will be one of the Abel Prize Laureates.

History Lectures: A dedicated History Session with lectures on Leibniz, Lagrange, Euler and Weierstraß will highlight the mathematical history in Berlin.

Next Generation Outreach Lecture: Peter Scholze (Universität Bonn) will give a lecture in particular for high school students interested in mathematics.

Public Lecture: Everyone with an interest in mathematics is invited to a public lecture by Helmut Pottmann (Technische Universität Wien).

Posters, Mini-Symposia and Contributed Talks: All registered participants are welcome to contribute to the program in terms of posters, mini-symposia or contributed sessions.

Grants: To ensure broad participation in the 7ECM and reduce economic barriers, 100 grants will be offered to mathematicians from less developed countries. The grants will cover a tuition waiver and a financial support of a maximum amount of 400. Women are particularly encouraged to apply.

Satellite Events: Mathematicians are invited to organize satellite events (conferences, etc.) around the Congress. 7ECM participants will enjoy some privileges in registering for the satellite events. Preconditions for granting the satellite status to an event are scientific

quality, geographical proximity and temporal connection with the 7ECM.

Exhibitions: As a publishing house or a specialized company you may want to generate excitement for your products and services and thus maximize your visibility before, during and after the Congress through several sponsorship opportunities. The historical *Lichthof* in the university's main building is the ideal location for exhibitions.

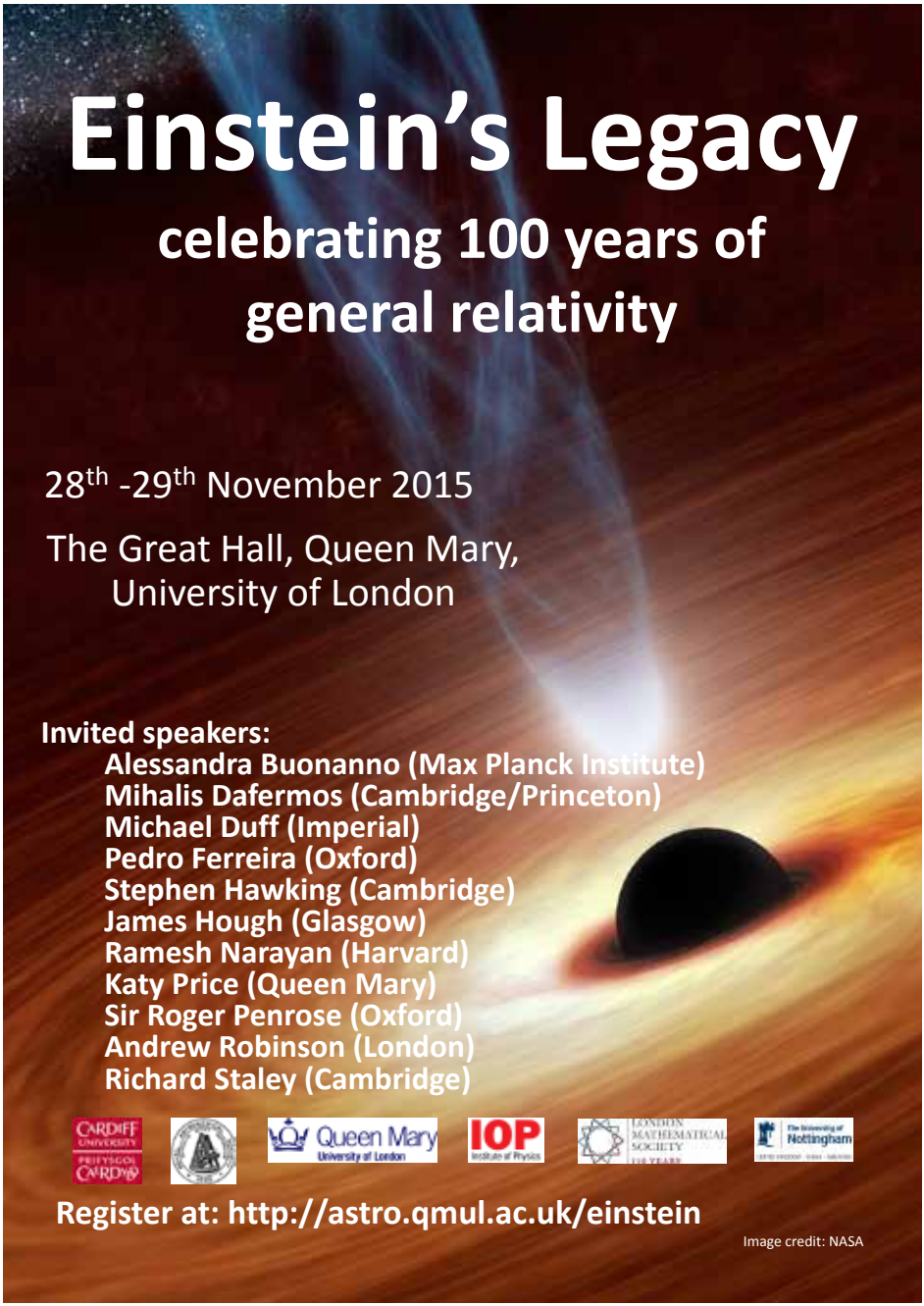
Social Program: The conference dinner will take place at the Palais am Funkturm - a unique location in the architectural style of the 1950s. The costs for the dinner are included in the registration fee. Also, a welcome reception is planned for the first day of the Congress.

Cultural Program: A broad and inspiring cultural side program for the time of the Congress and beyond has been developed. All participants are invited to the Math Film Festival, the exhibition *Transcending Tradition* in the Jewish Museum and much more!

Mathematical Berlin: On the occasion of the 7ECM the guidebook *Mathematical Berlin* by Iris and Martin Grötschel will be published. Readers are guided through the center of Berlin leading to places of mathematical interest and providing background information about mathematics in Berlin, mathematical institutions, and many important mathematicians who have worked here. All participants will receive a hard copy as a welcome gift.

Mathematics in the Society of the Future: Another publication under the (working) title *Mathematics in the Society of the Future* will be published in light of the 7ECM. The essay collection covers various aspects of highly developed mathematics and its applications in our society. The application fields comprise finance, cryptography, industry, weather and climate, telecommunication, politics and much more. The authors are eminent mathematicians.

Registration will be open soon. For up-to-date information subscribe to the 7ECM newsletter at www.7ecm.de/newsletter.html.


Einstein's Legacy
celebrating 100 years of general relativity
28th -29th November 2015
The Great Hall, Queen Mary, University of London
Invited speakers:
Alessandra Buonanno (Max Planck Institute)
Mihalis Dafermos (Cambridge/Princeton)
Michael Duff (Imperial)
Pedro Ferreira (Oxford)
Stephen Hawking (Cambridge)
James Hough (Glasgow)
Ramesh Narayan (Harvard)
Katy Price (Queen Mary)
Sir Roger Penrose (Oxford)
Andrew Robinson (London)
Richard Staley (Cambridge)
Queen Mary University of London
IOP Institute of Physics
Register at: http://astro.qmul.ac.uk/einstein
Image credit: NASA

LONDON MATHEMATICAL SOCIETY
150 YEARS

LMS 150th Anniversary

LMS – NZMS Aitken UK Lecture Tour 2015

The 2015 LMS Aitken Lecturer is Professor Steven Galbraith (University of Auckland)

The Forder-Aitken lectureship scheme is a collaboration between the London Mathematical Society and the New Zealand Mathematical Society in which each Society invites an eminent mathematician from the other country to give lectures at different universities around their country.

Steven Galbraith is the third Aitken Lecturer to visit the UK and he will give talks on *Linear Algebra with Errors, Coding Theory, Cryptography and Fourier Analysis on Finite Groups;* and *Kangaroos, Card Tricks and Discrete Logarithms* at:

Royal Holloway, University of London
13 October
Organiser: Simon Blackburn
s.blackburn@rhul.ac.uk

Open University
20 October
Organiser: Phil Rippon
p.j.rippon@open.ac.uk

Oxford
22 October
Organiser: Victor Flynn
flynn@maths.ox.ac.uk

Bristol
23 October
Organiser: Jim Stankewicz
j.stankewicz@bristol.ac.uk

Sheffield
28 October
Organiser: Kirill Mackenzie
k.mackenzie@sheffield.ac.uk

Loughborough
29/30 October
Organiser: Alexander Veselov
a.p.veselov@lboro.ac.uk

For further information on attending each lecture, please contact the local organisers. For general enquiries about the Aitken Lectures, please contact Elizabeth Fisher (lmsmeetings@lms.ac.uk).

1865 - 2015

IAN CASSELS

Professor J.W.S Cassels, FRS, FRSE, who was elected a member of the London Mathematical Society on 19 June 1947, died on 27 July 2015, aged 93. Professor Cassels was Vice-President of the LMS 1974-76, President of the LMS 1976-8, editor of the LMS Lecture Note Series 1983-97, and was awarded the De Morgan Medal in 1986.

Bryan Birch writes: Ian Cassels was an important mathematician, best known for his fundamental work on the arithmetic of elliptic curves. He published about 200 research papers, almost all on the theory of numbers, and eight graduate texts. He was elected Fellow of Trinity in 1949, and of the Royal Society in 1963. He was appointed Reader in Arithmetic in 1963 and was Sadleirian Professor from 1967 to 1984. He served as head of DPMMS from 1969-84, and as a vice president of the Royal Society from 1974-8. He was awarded the Sylvester Medal of the Royal Society in 1973.

When Ian Cassels took his MA in Mathematics at Edinburgh in 1943, he wrote to his parents to tell them that he had been given a fabulous posting, but he would never be able to tell them about it! He worked at Bletchley Park from July 1943 until the end of the war; for a young mathematician it must have been an ideal environment. After the war ended he went to Cambridge to do research with Louis Mordell; he received his PhD in 1949. Ian spent a year as a lecturer in Manchester, and then returned permanently to Trinity, initially as a tutorial fellow. His thesis had been on elliptic curves, but most of his early work was in other areas of number theory, particularly diophantine approximation and the geometry of numbers. At this time he also proved two easy, but very elegant and useful, theorems about rational quadratic forms, now named after him. I was lucky enough to join him in 1954 as his first research student; an early exercise was to read the drafts of his first book, on Diophantine Approximation; for me it was an admirable introduction to research, and it is still in print.

While he was finishing this book, Ian returned to the study of elliptic curves. After really massive computations, Selmer had (in 1954) conjectured that (in modern language) the difference between the Selmer rank and the Mordell-Weil rank was always even. Ian realised why this might be true, and (to use his words) "after several years hard work he managed to construct a skew-symmetric form on the Tate-Shafarevich group". This was a huge breakthrough, immediately appreciated. In eight papers published between 1959 and 1964 he proved one of those big difficult theorems that everyone takes for granted! At the same time (with John Tate) he set up the basic apparatus and language for the arithmetic of elliptic curves that has remained standard ever since.

In addition to his research, Ian always endeavoured to help future mathematicians by making difficult theories more easily understandable. His most valuable contribution of this type came in 1966, when he and Ali Fröhlich organised the wonderful Brighton Conference, as a result of which class field theory was converted from a recondite mystery into an accessible tool.

In 1984 he took early retirement, but he continued to lecture and research. He took on Victor Flynn as his final research student; their joint book on curves of genus 2 was published in 1996.

Though very productive, he did not work rapidly. He thought about a piece of mathematics until it became clear to him, which might take a long time, and then he took the next step. Clarity and honesty were very important to him, in life as well as mathematics. He spoke little unless he had something to say, but he had a sharp sense of humour. Though not at all a simple person, he had simple tastes; he gardened, but he never drove.

While he was in Bletchley, Ian met Constance Senior; they were both billeted in Bedford and travelled daily to work by the same train; soon they went to concerts together. They were married in 1949, and in 1952 moved into a newly built house, in which they lived for the rest of their lives; Constance died in 2000. I remember them as a devoted couple with two children. They are survived by Pat and John, together with five grandchildren and two great grandchildren.

I and many others owe Ian a great deal.

CHARLES READ

Professor Charles John Read, who was elected a member of the London Mathematical Society on 15 November 1985, died on 14 August 2015, aged 57.

Béla Bollobás writes: Charles Read made enormous contributions to mathematics, especially to the theory of Banach spaces, operator theory, and even quantum field theories.

Except for two brief interludes in Baton Rouge, Charles was at Trinity College, Cambridge, from 1975 till 2000, first as an undergraduate, then as a research student, and then, from January 1985, as a Teaching Fellow in Mathematics. From October 2000, he was Professor of Pure Mathematics at the University of Leeds.

Throughout his career, Charles specialised in attacking important and notorious problems, much of the time solving them by highly ingenious counterexamples. His very first result, proved soon after he started to work on his PhD, gave a stunning answer to a question of Lindenstrauss and Tzafriri by constructing a Banach space with precisely two symmetric bases (up to equivalence). Soon after this, Charles started to work on the invariant subspace problem for Banach spaces: *does every bounded linear operator on an infinite-dimensional Banach space have a non-trivial closed invariant subspace?* He was truly obsessed with this problem: he had promising ideas for a counterexample and although his constructions kept breaking down, he persisted in coming up with new approaches.

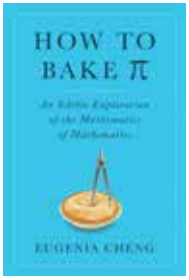
Eventually his efforts bore fruit, and in 1983 he produced a manuscript of enormous complexity giving his construction and proving that it does do the job. This manuscript was so well written that after the careful refereeing process it was published in the *LMS Bulletin* without any changes as a 65-page paper. An even more complicated example was published by Per Enflo three years later, although his paper had been submitted earlier, in 1981. Later, operators without invariant subspaces were renamed *transitive operators*.

Questions involving transitive operators figured prominently in Charles's research. First, he showed that the complicated space in his example could be replaced by the classical sequence space ℓ_1, and then he gave a simple proof that there are transitive bounded linear operators on ℓ_1. In yet another paper, written in the late 1990s, Charles went much further: he produced a *hypercyclic* bounded linear operator on ℓ_1, an operator that has no closed invariant *sets* except the trivial two. Another important question was whether there are transitive quasinilpotent operators on Banach spaces: Charles gave an emphatic answer by showing that there are transitive quasinilpotent operators on ℓ_1. A few years ago, with his student de la Rosa, he solved the great open problem in hypercyclicity by constructing a Banach space and a hypercyclic operator on it whose direct sum with itself is not hypercyclic.

In recent years, Charles worked much with Fereidoun Ghahramani and David Blecher. For example, with Ghahramani he proved that there exists a Banach algebra which is boundedly approximately amenable but not amenable.

On a personal level, Charles lost his father before he turned twelve. After this terrible trauma he became a committed Christian, which he professed in his CV and on the Internet, but never in his lectures or personal contacts. I have never known anyone more honest; he was also totally blind to the colour and creed of his students and colleagues. He loved mathematics with abandon, and had a healthy confidence in himself as a research mathematician. He was a gifted musician: before he went up to Cambridge, he had contemplated becoming a concert pianist, but his love of mathematics prevailed. He never totally abandoned the piano: he played challenging pieces by the great romantic composers, especially Liszt. He was also fond of dangerous hobbies such as *solo* cave-diving. A few years ago he set out to cross the Atlantic all by himself; fortunately his ramshackle catamaran broke in two a few miles from the shore, and he was saved. Sadly, during his visit to Winnipeg to work with Ghahramani, he died of a heart attack while on a run in the park. His passing has left mathematics much poorer and his many friends inconsolable.

CAKES, CUSTARD AND CATEGORY THEORY: EASY RECIPES FOR UNDERSTANDING COMPLEX MATHS by Eugenia Cheng, Profile Books, 2015, pp 304, £12.99, ISBN 9781781252871, E-book ISBN 9781782830825 (US title: ***How to Bake Pi: An Edible Exploration of the Mathematics of Mathematics;*** Basic Books, May 5, 2015, pp 304, $27.50, ISBN 9780465051717, E-book ISBN 9780465051694)



Eugenia Cheng has written a delightfully clear and down-to-earth explanation of the spirit of mathematics, and in particular category theory, based on their similarities to cooking. Sometimes people complain about a math textbook that it's "just a cookbook", offering recipes but no insight. Cheng shows the flip side of this analogy, providing plenty of insight into mathematics by exploring its resemblance to the culinary arts. Her book has recipes, but it's no mere cookbook.

Among all forms of cooking, it seems Cheng's favorite is the baking of desserts – and among all forms of mathematics, category theory. This is no coincidence: like category theory, the art of the pastry chef is one of the most exacting, but also one of the most delightful, thanks to the elegance of its results. Cheng gives an example: "Making puff pastry is a long and precise process, involving repeated steps of chilling, rolling and folding to create the deliciously delicate and buttery layers that makes puff pastry different from other kinds of pastry."

However, she does not scorn the humbler branches of mathematics and cooking, and there's nothing effete or snobby about this book. No special background is needed to follow it, so if you're a mathematician who wants your relatives and friends to understand what you are doing and why you love it, this is the perfect gift to inflict on them.

On the other hand, experts may be disappointed unless they pay close attention There is a fashionable sort of book that lauds the achievements of mathematical geniuses, explaining them in just enough detail to give the reader a sense of awe: typical titles are *A Beautiful Mind* and *The Man Who Knew Infinity*. Cheng avoids this sort of hagiography, which may intimidate as often as it inspires. Instead, her book uses examples to show that mathematics is close to everyday experience, not to be feared.

While the book is written in bite-sized pieces suitable for the hasty pace of modern life, it has a coherent architecture and tells an overall story. It does this so winningly and divertingly that one might not even notice. The book's first part tackles the question "what is mathematics?" The second asks "what is category theory?" Unlike timid people who raise big questions, play with them a while, and move on, Cheng actually proposes answers! I will not attempt to explain them, but the short version is that mathematics exists to make difficult things easy, and category theory exists to make difficult mathematics easy. Thus, what mathematics does for the rest of life, category theory does for mathematics.

Of course, mathematics only succeeds in making a tiny part of life easy, and Cheng admits this freely, saying quite a bit about the limitations of mathematics, and rationality in general. Similarly, category theory only succeeds in making small portions of mathematics easy – but those portions lie close to the glowing core of the subject, the part that illuminates the rest.

And as Cheng explains, illumination is what we most need today. Mere information, once hard to come by, is now cheap as water, pouring through the pipes of the internet in an unrelenting torrent. Your cell phone is probably better at taking square roots or listing finite simple groups than you will ever be. But there is much more to mathematics than that – just as cooking is much more than a mere cookbook.

John Baez
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KNOTS AND BORROMEAN RINGS, REP-TILES, AND EIGHT QUEENS by Martin Gardner, Mathematical Association of America, 2014, pp 140, $16.99, ISBN 978-0-52175-871-0

Martin Gardner's 'Mathematical Games' columns in *Scientific American* have delighted professional and amateur mathematicians alike since they originally appeared between 1956 and 1981. The columns have previously been published across 15 books, but some of these are now hard to find. Starting in 2008 the Mathematical Association of America and Cambridge University Press commenced republishing these 15 books with revised titles and with updates on new developments and discoveries. The book reviewed is the fourth, and most recent, in this series and was formerly published as *The Unexpected Hanging and Other Mathematical Diversions and Further Mathematical Diversions*.

The 20 chapters cover a wide range of topics in recreational mathematics. Some are perhaps over-familiar - the titular 'Eight Queens', for example, refers to the problem of arranging eight queens on a chess board so that none are attacking each other (Gardner goes on to discuss what happens when other chess pieces are used, as well as what happens on $n \times n$ chess boards). However, often these problems are widely known because they were first popularised by Gardner, so in effect one is reading the original popular account.

Some of the topics discussed are used as a springboard into deeper mathematics. The *Borromean Rings* in the title refer to three interlinked rings with the property that if one is removed then the remaining two become unlinked. Gardner uses this to motivate a discussion on topology and knot invariants. The chapter on curves of constant width begins with an account of Reuleaux triangles (and how they can be used to drill square holes) and then moves on to the Kakeya needle problem. This asks: what is the least area of a set in R in which an interval of length 1 can be rotated. Besicovitch proved that there are sets of arbitrarily small area with this property. The related Kakeya conjecture (does a subset of R^n that contains a unit line segment in every dimension necessarily have Hausdorff dimension n) is, for $n \geq 3$, still an open problem of considerable current research interest.

Other topics are perhaps more recreational in nature. A rep-tile (short for 'replicating tile' and first introduced by S. Golomb) is a (not necessarily convex) polygon that can be divided into in a number of congruent polygons, each similar to the original. (For example, a square can trivially be divided into four smaller squares.) If there are k congruent polygons then the polygon is said to be *rep-k*. For a given k a rep-k polygon always exists: consider a parallelogram with sides of length 1 and $\sqrt{k}$. However, finding other rep-k polygons is highly non-trivial (the only known rep-7 polygons are given by this parallelogram construction).

The clarity of Gardner's writing stands out throughout the book. One chapter discusses the number e and gives a very clear explanation of why one expects it to appear in relation to compound interest. Another chapter discusses 4-dimensional topology by means of an amusing account of a (fictional!) visit to the Church of the Fourth Dimension in London. (When this first appeared in *Scientific American*, several readers wrote in to ask for the church's address!)

There are many other gems in this book, for example the chapter on divisibility testing. It's very well-known (particularly to anyone who has taught modular arithmetic to undergraduates) how to test if a given integer is divisible by 3 by looking at the sum of its digits; there are similarly straightforward or trivial tests for divisibility by other small integers, with the exception of 7. Divisibility by 7 testing is discussed at length with several methods presented. One test, credited to A. Zbikovski, goes as follows. Take n, truncate it by deleting the right-most digit, then subtract twice this digit from the truncated number, then repeat this process; n is divisible by 7 if and only if the

final number obtained is 0 or 7. (One can see that this works by noting that 21 is divisible by 7.) Other more esoteric tests for divisibility by 7 are given and it's not at all easy to see why they work.

Another chapter focusses on machine learning. Following a brief discussion on chess-playing computers (it's a shame that the addendum wasn't updated to mention that chess-playing computers now routinely beat grandmasters, as Gardner predicts in the main text this will eventually happen), Gardner describes D. Michie's construction of a learning machine, constructed out of 300 matchboxes and several hundred coloured beads, for playing noughts-and-crosses. To illustrate the method in a simpler context, Gardner introduces the game of Hexapawn: a 3×3 grid with three white pawns on the bottom row and three black pawns on the top row. The pawns move and capture as in normal chess, and the first player to capture all their opponent's pieces, block their opponent from making a valid move, or having a pawn reach the third row wins. Detailed instructions of how to build a learning machine from just 24 matchboxes (and a handful of coloured beads) are given, and it is easy to imagine an outreach activity where such machines are built and played against each other.

Another delight is the explanation of how to use an Archimedean spiral, together with a straight edge and pair of compasses, to divide any angle into n equal divisions; this would find a natural home in many undergraduate courses on Euclidean geometry. There is also a discussion of how one might communicate across space with an alien race, including the (surprisingly nontrivial) problem of how to define left-and right-handedness. Finally, two chapters are devoted to puzzles from the mathematical to jokes ('Rearrange the letters of *New Door* to form one word').

Unfortunately, the book is not perfect. Although each chapter has an addendum updating the reader on developments since the book was first written, some of these updates are in places incomplete and with limited references. Other books in the series are referred to but, as the full series has yet to be published and the names of the books have been changed from earlier editions, some detective work on the part of the reader is needed for these references to be useful. The book also has to compete with the many other excellent popular accounts of recreational mathematics that now exist (and which, ironically, probably would not have been written if it were not for Gardner). But these are minor quibbles: the book is an excellent way to find hidden depths and new insights across the spectrum of mathematics whilst playing with puzzles in the hands of the master.

Charles Walkden
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LARS AHLFORS: AT THE SUMMIT OF MATHEMATICS by Olli Lehto, translated by William Hellberg, American Mathematical Society, 2015, 125 pp, £31.50, ISBN 9781470418465

Lars Valerian Ahlfors was born on 18 April 1907 in Helsinki. His father, Axel, was a professor of engineering, but this was not to be Lars's destiny. Reportedly, Axel became so frustrated with Lars's inability to put a screw in the wall that he said Lars "had better become a mathematician". This was a wise suggestion. Aged only 21, Lars resolved a conjecture of Denjoy which, at the time, was one of the major open questions of complex analysis.

He was still in his twenties when he became one of the two recipients of the first Fields medals. His research led to breakthroughs in, for example, quasiconformal maps, Teichmüller theory, and the study of Kleinian groups. He was also a fine pedagogue: his *Complex Analysis* remains one of the great undergraduate texts, combining elegance and lucidity with an absence of the "critical comments on minutiae" that he viewed as "pedantic".

In *Lars Ahlfors: At the Summit of Mathematics* Olli Lehto has given us a first-rate biography, running from a brief review of Ahlfors's

ancestry through to his centennial celebration. Lehto has succeeded in avoiding the twin pitfalls of so much information as to risk being tedious, or so much brevity as to leave the reader with nothing to work with. Instead we are given enough insight to feel that we have got to know Ahlfors as a person, and some notion of the mathematics he created. We also get some understanding into the world events which helped shaped Ahlfors's life and career, and the many eminent mathematicians, particularly from complex analysis, with whom he worked over the course of his long research career.

In his introduction Lehto expresses surprise that the original Finnish language version of this book has been so well received. In fact, this is a delightful work. At times it is perhaps a little discursive, but this just adds to the charm; the author has not intended to write a textbook. Lehto was, in fact, a close friend of Ahlfors, and the text is illuminated by personal recollections and numerous photographs from his own collection. Occasionally the translation from the original Finnish is not entirely smooth, but even this adds to the whole; one can hear the voice of the author all the more clearly.

In reading this book, I came to like Ahlfors as a person, to admire his mathematics even more than previously, and was prompted to go off and read more of his works. I can offer no better recommendation.

One further anecdote from the book (there are many) will, perhaps, illuminate something of Ahlfors' personality as well as something of the tone of the book. One evening, during a conference in Romania, Ahlfors was present at a serious philosophical discussion into the meaning of life. As the senior mathematician, Ahlfors was pressed to give his opinion on what is the most important thing in life. "Stone-faced, he replied gravely. 'There is no doubt about that: it is alcohol'". If you read the book, then you can learn the two things he placed joint second.

David Sixsmith
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CALENDAR OF EVENTS

This calendar lists Society meetings and other mathematical events. Further information may be obtained from the appropriate LMS Newsletter whose number is given in brackets. A fuller list is given on the Society's website (www.lms.ac.uk/content/calendar). Please send updates and corrections to calendar@lms.ac.uk.

OCTOBER 2015

9 Robert Recorde and the History of Science, Tenby Museum (450)
9-10 Integrable Systems in Newcastle (450)
13 LMS-NZMS Aitken Lecture, Steven Galbraith, Royal Holloway, London (451)
16 Ada Lovelace Bicentenary, Celebrating Women in Computer Science, Oxford (451)
20 LMS-NZMS Aitken Lecture, Steven Galbraith, Open University (451)
21 LMS Popular Lectures, Glasgow (451)
22 LMS-NZMS Aitken Lecture, Steven Galbraith, Oxford (451)
22 Challenges for the Next 25 Years, EMS Meeting, Institut Henri Poincaré, Paris (448)
23 LMS-NZMS Aitken Lecture, Steven Galbraith, Bristol (451)
23 Robert Recorde: A Man of Principle in a Turbulent Age, Tenby Museum (450)
26-28 Women in Applied Math & Soft Matter Physics, Mainz, Germany
28 LMS-NZMS Aitken Lecture, Steven Galbraith, Sheffield (451)
29-30 LMS-NZMS Aitken Lecture, Steven Galbraith, Loughborough (451)

NOVEMBER 2015

3 The Mathematics of Program Construction, BCS-FACS Evening Seminar, London (451)
10-11 The Science of Beauty, Royal Society of Edinburgh (451)
11 LMS Popular Lectures, Leeds (451)
13 LMS Graduate Student Meeting, London (451)
13 LMS AGM, London (451)
26 Mathematics in Defence IMA Conference, Harwell, Oxford (448)
28-29 Einstein's Legacy, Celebrating 100 years of General Relativity, Joint Meeting with IOP & RAS, QMUL, London (451)

DECEMBER 2015

7-11 Combinatorial Mathematics and Combinatorial Computing Australasian Conference, Brisbane, Australia (445)
7-11 New Mathematical and Computational Problems, INI Workshop, Cambridge (449)
9-10 Ada Lovelace 200 Symposium: Celebrating the Life and Legacy of Ada Lovelace, Oxford (451)
10-11 LMS Joint Meeting with the Edinburgh Mathematical Society, Edinburgh (443)
14-17 LMS South West & South Wales Regional Meeting and Aspects of Homotopy Theory Workshop, Southampton (451)
14-18 Geometric Analysis, King's College London (450)
14-18 The Role of the Higher Infinite in Mathematics and other Disciplines, INI Workshop, Cambridge (450)
15-16 LMS Prospects in Mathematics, Loughborough (451)
15-17 Cryptography and Coding IMA Conference, Oxford (448)

JANUARY 2016

18-22 Stochastic Dynamical Systems in Biology, INI Opening Workshop, Cambridge (450)

MARCH 2016

21-24 BMC 2016, Bristol
21-25 LMS Invited Lectures, Edgar Knobloch (Berkeley), Loughborough (451)

APRIL 2016

5-8 BAMC 2016, Oxford

JULY 2016

18-22 7ECM, TU Berlin (451)

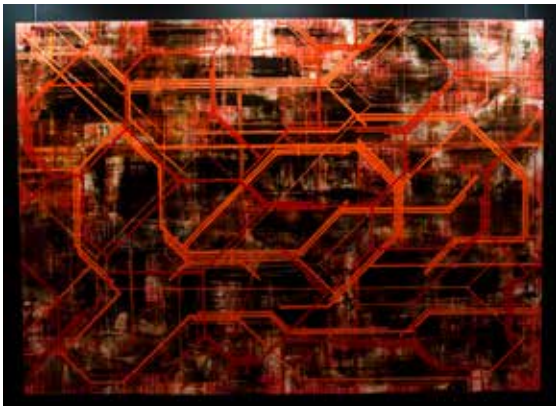
150TH LMS ANNIVERSARY

ASSOCIATE ARTIST SCHEME

(see article on front page)

George Legendre *30 Pieces*

Mark Francis sculpture



Mark Francis *Praxis 2015*