LONDON MATHEMATICAL SOCIETY
EST. 1865

NEWSLETTER

Issue: 485 - November 2019

YAEL NAIM DOWKER AND ERGODIC THEORY

GRESHAM'S GEOMETRY PROFESSORS

TEACHING ETHICS IN MATHEMATICS

EDITORIAL OFFICE

London Mathematical Society
De Morgan House
57–58 Russell Square
London, WC1B 4HS
newsletter@lms.ac.uk

Charity registration number: 252660

COVER IMAGE

Yael Naim Dowker in 1961. See the feature on page 27. (Image courtesy of Archives of the Mathematisches Forschungsinstitut Oberwolfach. Photographer Konrad Jacobs.)

ISSN: 2516-3841 (Print)
ISSN: 2516-385X (Online)
DOI: 10.1112/NLMS

NEWSLETTER WEBSITE

The Newsletter is freely available electronically at lms.ac.uk/publications/lms-newsletter.

MEMBERSHIP

Joining the LMS is a straightforward process. For membership details see lms.ac.uk/membership.

SUBMISSIONS

The Newsletter welcomes submissions of feature content, including mathematical articles, career related articles, and microtheses from members and non-members. Submission guidelines and LaTeX templates can be found at lms.ac.uk/publications/submit-to-the-lms-newsletter.

Feature content should be submitted to the editor-in-chief at iain.moffatt@rhul.ac.uk.

News items should be sent to newsletter@lms.ac.uk.

Notices of events should be prepared using the template at lms.ac.uk/publications/lms-newsletter and sent to calendar@lms.ac.uk.

For advertising rates and guidelines see lms.ac.uk/publications/advertise-in-the-lms-newsletter.

CONTENTS

LMS Executive Secretary to Retire

Fiona Nixon, the LMS Executive Secretary, has decided to take early retirement and will be leaving the Society on April 11th next year. Fiona has been with the Society for almost 10 years and has played a major role in enabling the Society to carry out its aims. This includes overseeing the activities at De Morgan House and making sure that everything runs smoothly behind the scenes. She works tirelessly to direct the staff in carrying out all the multitude of activities in which the LMS is now involved, and always takes time to interact with both our members and also colleagues in our sister societies. During her time in post, there has been considerable development and increase in the work of the LMS and Fiona has constantly been an energetic presence taking forward the wishes of Council and members. She will certainly be missed. The Society wishes her well in her future life.

The post will be advertised in early November and details of how to apply will be posted on the News section of the LMS website. The Executive Secretary runs the LMS under the direction of Council and Officers, with responsibility for directing the work of the 18 or so staff and overseeing both its finance and other operations. The successful candidate will have experience of successfully managing staff and finances and the ability and experience to take responsibility for the Society's compliance with charity, employment, tax and H&S law. They will need to have empathy with the ideals of mathematical research and will be expected to carry out an ambassadorial role for the Society, promoting the aims of the Society knowledgeably and enthusiastically.

New Newsletter Editor

I am pleased to announce that Eleanor Lingham has been appointed as our new Newsletter Editor-in-Chief. Eleanor is Senior Lecturer in Mathematics at Sheffield Hallam and has been the Sheffield Hallam LMS Representative since 2015, previously having been the Rep at De Montfort University (2013–15). She has considerable experience of editorial work: she is just completing the major task of working with Walter Hayman to produce a revised and updated Fiftieth Anniversary Edition of *Hayman's List* of problems in complex analysis, and in previous employment she was responsible for an online newsletter for finance professionals. She is full of enthusiasm and ideas for this new job.

We are tremendously grateful to the current Editor-in-Chief Iain Moffatt for the enormous amount of work he has put in to get the new expanded Newsletter successfully up and running. Over the last three years, he has provided invaluable leadership and guidance to the current Editorial Board. Eleanor will formally take over when Iain stands down at the AGM on 29 November 2019, but has already started working with him closely.

I am delighted to welcome Eleanor to her new role.

Caroline Series
LMS President

New Editors for LMS Journals

Bulletin: Professors Andrey Lazarev (University of Lancaster) and Sibylle Schroll (University of Leicester) have been appointed as Managing Editors for the *Bulletin of the London Mathematical Society*. The *Bulletin* continues to welcome short papers (maximum length 20 pages) on subjects of general interest and authoritative survey articles (of any length). The Society would like to take the opportunity to thank the previous Editors for their hard work over the last five years.

Journal: Professor James Maynard (University of Oxford) joins Professor Mark Haskins (University of Bath) as Managing Editor of the *Journal of the London Mathematical Society*. The *Journal* considers submissions of 18 pages and above that represent a significant advance in mathematical knowledge, as well as those that are deemed to stimulate new interest and research activity. Since March 2019 there has been no upper page limit.

Transactions: Professor José Rodrigo (University of Warwick) will take on the Editorship of the *Transactions of the London Mathematical Society*, the Society's fully open access journal which publishes papers of either a general or specialised nature.

Proceedings: As reported in the March *Newsletter*, the *Proceedings of the London Mathematical Society* is

served by its own Editorial Board of leading international experts. As the Society's flagship title it now considers articles (of any length) of the highest quality and significance across a broad range of mathematics.

All four journals are wholly owned and managed by the LMS. All surplus income from the Society's publishing programme is used to support mathematicians and mathematics research in the form of research grants, conference grants, prizes, initiatives for early career researchers, and the promotion of mathematics.

Further details of all of the Society's publications and their Editorial Boards can be found at lms.ac.uk/publications.

Vacancies on LMS Committees

The detailed business of the LMS is run by about 23 committees and working groups, each usually having about 10 people. Altogether this comes to a large number of people, to whom the Society is extremely grateful for this vital work. It is Council's responsibility to make the appointments to all these committees and to turn their membership over regularly, so that (a) the broadest possible spectrum of our membership is represented, and (b) the committees remain fresh and energetic.

Of course when forming a committee account has to be taken of many things, such as maintaining subject and demographic balance, which means that on a given occasion otherwise very strong candidates may not always be able to be appointed. So we are always looking for new people! The list of committees can be found at lms.ac.uk/about/committees. If you are interested, or would like to recommend a colleague, please contact James Taylor at james.taylor@lms.ac.uk in order that Council can maintain a good list of potential members of its various committees. It is not necessary to specify a particular committee. If you would like to know what is involved, you could in the first instance ask your LMS Departmental Representative.

On this occasion we are in particular looking for new members of the Editorial Board of the Newsletter.

Stephen Huggett
LMS General Secretary

Forthcoming LMS Events

Computer Science Colloquium: 13 November, London. (tinyurl.com/cscoll19)

Joint Meeting with the IMA: 21 November, Reading (tinyurl.com/y4sdm74b).

LMS/BCS-FACS Evening Seminar: 21 November, London (tinyurl.com/yyc9oyse).

Graduate Student Meeting: 29 November, London (tinyurl.com/yy58t78v).

Society Meeting and AGM: 29 November, London (tinyurl.com/yy58t78v).

A full listing of upcoming LMS events can be found on page 58.

OTHER NEWS

The International Congress Structure Committee

At the General Assembly of the International Mathematical Union in 2018, it was decided to create a Structure Committee charged with proposing possible changes to the organisational structure of future ICMs. The committee was chaired by Terence Tao. The committee has now finalized its report which has been largely endorsed by the IMU Executive Committee.

The main changes for the ICM 2022 will be to create a new Section 17 (Statistics and Data Analysis) replacing the old Section 17 (Mathematics in Science and Technology), and which also incorporates the Statistics part of the old Section 12 (Probability and Statistics), which now becomes Section 12 (Probability); and to create a new Section 18 (Stochastic and Differential Modeling), which expands on aspects of the old Section 17 (Mathematics in Science and Technology).

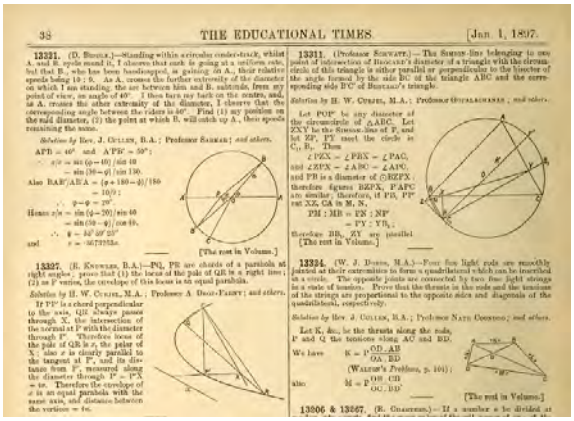
Other Sections with their descriptors and allocated lecture slots will be as in the report. Twenty sectional talks will be left to the discretion of the Program Committee and two or three plenary lecture slots will be left for "special plenary lectures".

The rationale for these changes is to start the process of enhancing the representation of applied mathematics in the ICM, and to keep up with recent ground-breaking developments in applied mathematics. Other recommendations include that the opening ceremony be streamed, and that recordings of other lectures should be made available to the mathematical community in a timely way. The full report can be found at tinyurl.com/y4rj3sqq.

UCL Educational Times (1847–1923) available online

University College London (UCL) Special Collections holds the most comprehensive run of the College of Preceptors' journal *The Educational Times* (1847–1923) as part of the Institute of Education's collections, and all editions are now freely available online thanks to the support of the London Mathematical Society.

The College was founded in 1846 by a group of private schoolmasters concerned about standards within their profession and the monthly journal began publication the following year. Although the periodical naturally contains articles on all aspects of education, it is particularly interesting for its mathematical content. First and foremost, are the regular mathematical problems posed and answered by many eminent British and European mathematicians of the day. Some of this content was brought together in an annual publication called *Mathematical Questions*, but the journal contains many more examples, with some of those questions posed resulting in new branches of mathematics. Regular articles and contributions were also submitted by figures such as Augustus de Morgan, Arthur Cayley and James Joseph Sylvester. Finally, editions feature regular notices and reports on meetings of the LMS and other associated groups and societies.


38 THE EDUCATIONAL TIMES [Jan. 1, 1897.

13331. (D. Biddle.)—Standing within a circular cinder-track, whilst A. and B. cycle round it, I observe that each is going at a uniform rate, but that B., who has been handicapped, is gaining on A., their relative speeds being 19 : 8. As A. crosses the further extremity of the diameter on which I am standing, the arc between him and B. subtends, from my point of view, an angle of 40°. I then turn my back on the centre, and, as A. crosses the other extremity of the diameter, I observe that the corresponding angle between the riders is 60°. Find (1) my position on the said diameter, (2) the point at which B. will catch up A., their speeds remaining the same.

Solution by Rev. J. Cullen, B.A.; Professor Sawaiyar; *and others.*

13331. (Professor Sawaiyar.)—The Simson-line belonging to any point of intersection of Brocard's diameter of a triangle with the circumcircle of this triangle is either parallel or perpendicular to the bisector of the angle formed by the side BC of the triangle ABC and the corresponding side B'C' of Brocard's triangle.

Solution by H. W. Curjel, M.A.; Professor Gullagharan; *and others.*

13327. (E. Knowles, B.A.)—PQ, PR are chords of a parabola at right angles; prove that (1) the locus of the pole of QR is a right line; (2) as P varies, the envelope of this locus is an equal parabola.

Solution by H. W. Curjel, M.A.; Professor A. Dixie-Farey; *and others.*

13334. (W. J. Dobbs, M.A.)—Four fine light rods are smoothly jointed at their extremities to form a quadrilateral which can be inscribed in a circle. The opposite joints are connected by two fine light strings in a state of tension. Prove that the thrusts in the rods and the tensions of the strings are proportional to the opposite sides and diagonals of the quadrilateral, respectively.

Solution by Rev. J. Cullen, B.A.; Professor Nath Ghosh; *and others.*

13306 & 13307. (E. Coleman.)—If a number n be divided at

An extract from *The Educational Times*

As with many old journal collections, the paper used for *The Educational Times* is cheap and brittle and the volumes were suffering degradation similar to that of newspapers. Surviving copies are already rare meaning requests for access were high and this was inevitably putting long term preservation at risk. Work to digitise the collection began in 2015 and we had successfully digitised issues dating from 1847–65. However, with the support of the LMS this work is now complete ensuring both wider access and supporting the long-term preservation of this important publication.

Access the full set of *The Educational Times* via UCL's Digital Collections at tinyurl.com/yyme2uyv. UCL is also currently working on improving access to all of the Special Collections and a guide on Mathematics.

Registration for 8ECM now open

Registration for the 8th European Congress of Mathematics (8ECM) is now open. The Congress will be held from 5 to 11 July 2020 at the Congress Centre Bernardin, which is located at the head of the Adriatic Sea, between the medieval town of Piran and modern Portorož, both within walking distance of the venue.

An extensive scientific programme for the 8ECM is planned, including many minisymposia, public lectures and other activities. Plenary and Invited speakers are already confirmed, as well as four public speakers — Sir Vaughan F.R. Jones, Bojan Mohar, Andrei Okounkov and Stanislav Smirnov. The President of the European Research Council, Professor Jean-Pierre Bourguignon, will be giving a live interview at the 8ECM.

Many researchers and students, along with publishing houses and representatives from industry will be present at the 8ECM, which will provide plenty of opportunities for networking and collaboration on future projects.

To register for the Congress visit 8ecm.si/register. The website has information about accommodation and where direct reservations can be made through the 'Book your accommodation' link to obtain the event rate. Early Bird registration and accommodation rates are available until 31 January 2020. Subscribe to the 8ECM Newsletter for updates and new content.

Just before and after the 8ECM a large number of engaging satellite conferences will be held in various parts of Europe, as well as at the conference venue.

MATHEMATICS POLICY DIGEST

Strengthening ties between UK and US Mathematical Sciences researchers

Research ties between the UK and the US have been further strengthened through a lead agency opportunity that will boost collaboration between Mathematical Sciences communities in the two nations.

The lead agency agreement has been approved by the Engineering and Physical Sciences Research Council (EPSRC), part of UK Research and Innovation (UKRI), and the US National Science Foundation (NSF) Division of Mathematical Sciences of the Directorate for Mathematical and Physical Sciences (MPS/DMS).

Through the agreement researchers will apply to either EPSRC or MPS/DMS depending on where the largest proportion of their research will be supported, and their applications will then be subject to the peer review process of the lead agency. More information is available at tinyurl.com/y68fthl5.

EPSRC appoints new Deputy Executive Chair

The Engineering and Physical Sciences Research Council (EPSRC) has appointed Professor Charlotte Deane as Deputy Executive Chair. Professor Deane joins EPSRC on secondment from the University of Oxford where she is currently Professor of Structural Bioinformatics and was Head of the Department of Statistics from 2015 until earlier this year. More information is available at tinyurl.com/y6r96ul2.

UKRI Chief Executive to retire in 2020

It has been announced that Sir Mark Walport will retire as Chief Executive of UK Research and Innovation (UKRI) in 2020. Sir Mark was appointed in 2017 to create a single, ambitious organisation and provide the UK with a world class funding system to keep it at the forefront of global research and innovation. He has led the first phase of UKRI's transformation programme, established a single operational organisation and secured a significant increase in public funding. More information is available at tinyurl.com/y6zw9eac.

Mathematics remains most popular A-level

The introduction of new GCSE and A-level Mathematics qualifications has not been easy. Students who received their A-level results in August have been test subjects for both. The LMS warmly congratulates students and their teachers for their achievements in these difficult circumstances.

Mathematics is still the most popular A-level and the number of students taking Further Mathematics

has grown enormously in the past decade. However, Further Mathematics A-level is currently very vulnerable. Schools are under pressure to restrict to three A-levels and Further Mathematics was often the fourth for many students. Furthermore, the large drop in AS entries means that many students no longer have a chance to sample Further Mathematics before taking the full A-level. Universities, schools, the government and the broader mathematical community must work together to ensure that the drop in applications is reversed and that confidence in Mathematics and Further Mathematics is maintained.

Digest prepared by Dr John Johnston
Society Communications Officer

Note: items included in the Mathematics Policy Digest are not necessarily endorsed by the Editorial Board or the LMS.

EUROPEAN MATHEMATICAL SOCIETY NEWS

EMS Publishing House

The EMS Publishing House is now moving to Berlin. Its headquarters will be located in the TU Berlin mathematics building and will be headed by André Gaul (CEO) and Vera Spillner (Editorial Director). The new EMS Publishing House leadership team comes with broad and innovative publishing experience and will focus on community and Open Access publishing. See ems-ph.com.

Tuna Altinel: update

Tuna Altinel, EMS member and Professor at the Université Lyon 1 in France, was imprisoned in Turkey on 11 May 2019. At the time, the EMS issued a statement condemning this attack on his human rights. Court hearings related to the case took place in Turkey on 26 and 30 July, following the second of which Tuna Altinel was released after 81 days in prison. Although very welcome, this is not the end: the case against him has not been dismissed, and a further hearing is scheduled for 19 November. The EMS reiterates its demand that these infringements of Tuna Altinel's rights immediately cease, and he be allowed to return to France to resume his teaching and research.

The mathematician Gregory Cherlin attended the second court hearing as an international observer on behalf of the American Mathematical Society, the Committee of Concerned Scientists and the Association for Symbolic Logic. A link to his very thorough report on the proceedings can be found on the EMS News webpage.

Open Letter to the European Commission

For the new European Commission the areas of education and research are no longer explicitly represented and instead are subsumed under the 'innovation and youth' title. An open letter signed by a wide range of prominent European scientists is addressed to the EU Commission demanding the title be revised to 'Education, Research, Innovation and Youth' reflecting Europe's dedication to all of these crucial areas. The letter also calls upon the European Parliament to request this change in name before confirming the nominees for commissioner. The EMS supports this letter which can be seen at indico.uis.no/event/5/.

EMS News prepared by David Chillingworth
LMS/EMS Correspondent

Note: items included in the European Mathematical Society News represent news from the EMS and are not necessarily endorsed by the Editorial Board or the LMS.

OPPORTUNITIES

Nominations for LMS Prizes 2020

The LMS would like to invite nominations for the following prizes in 2020, which are intended to recognise and celebrate achievements in and contributions to mathematics:

- the **Pólya Prize**, which is awarded in recognition of outstanding creativity in imaginative exposition of, or distinguished contribution to, mathematics within the UK;
- the **Senior Anne Bennett Prize**, for work in, influence on or service to mathematics, particularly in relation to advancing the careers of women in mathematics;
- the **Senior Berwick Prize**, which is awarded to the author(s) of a definite piece of research published by the Society between 1 January 2012 and 31 December 2019;
- the **Shephard Prize**, for contributions to mathematics with a strong intuitive component which can be explained to those with little knowledge of mathematics;
- the **Fröhlich Prize**, which is awarded for original or innovative work in any branch of mathematics to a mathematician with fewer than 25 years' experience at post-doctoral level; and
- the **Whitehead Prizes**, which are awarded for work in and influence on mathematics to mathematicians with fewer than 15 years' experience at post-doctoral level (up to six may be awarded).

We have in various years found ourselves with rather few nominations for the Pólya Prize, the Senior Anne Bennett Prize, the Senior Berwick Prize, the Shephard Prize, and the Fröhlich Prize, and would particularly welcome nominations for these. We would also strongly welcome more nominations for women and other underrepresented groups in the mathematical community; we have too few and would very much like to see more. In some cases, our prizes are intended to celebrate contributions to the community, and we intend to place a good deal of weight on this aspect because we consider it to be important. In all cases the Prizes Committee interprets the criteria broadly, so if in doubt please submit a nomination. This is especially the case for the Shephard Prize.

Regulations and nominating forms can be found at tinyurl.com/lmsprizes2020. Please return nominating forms to Katherine Wright, Society Business Officer: prizes@lms.ac.uk.

The closing date for nominations is **31 January 2020**. Any nominations received after that date will be considered in the next prize award round.

Christopher Zeeman Medal 2020: Call for Nominations

The Councils of the IMA and the LMS are delighted to invite nominations for the 2020 award of the Christopher Zeeman Medal, which is the UK award dedicated to recognising excellence in the communication of mathematics. The LMS and the IMS wish to honour mathematicians who have excelled in promoting mathematics and engaging with the general public. They may be academic mathematicians based in universities, mathematics school teachers, industrial mathematicians, those working in the financial sector or indeed mathematicians from any number of other fields.

Most importantly, these mathematicians will have worked exceptionally to bring mathematics to a non-specialist audience, whether it is through giving public lectures, writing books, appearing on radio or television, organising events or through an entirely separate medium. The IMA and LMS want to celebrate the achievements of mathematicians who work to inspire others with their work.

The award is named after Professor Sir Christopher Zeeman, FRS, whose notable career was pioneering not only in the fields of topology and catastrophe theory but also because of his ground-breaking work in bringing his beloved mathematics to the wider public. Sir Christopher was the first mathematician to be asked to deliver the Royal Institution Christmas Lectures in 1978, a full 160 years since they began. His 'Mathematics into Pictures' lectures were cited by many young UK mathematicians as their inspiration. In recognition of both his work as a mathematician and his contribution to the UK mathematics community, Sir Christopher received the IMA–LMS David Crighton Medal in 2006.

The nominations form is available at tinyurl.com/yytghlzv or from Alison Penry at: Institute of Mathematics and its Applications, Catherine Richards House, 16 Nelson Street, Southend-on-Sea, Essex, SS1 1EF (email alison.penry@ima.org.uk). Nominations must be received by 28 February 2020.

Previous winners of the Christopher Zeeman Medal are Dr Hannah Fry (2018), Rob Eastaway (2016), Professor Marcus du Sautoy OBE (2014), Professor John Barrow FRS (2011) and Professor Ian Stewart (2008).

Louis Bachelier Prize 2020: Call for Nominations

The Louis Bachelier Prize is a biennial prize jointly awarded by the London Mathematical Society, the Natixis Foundation for Quantitative Research and the Société de Mathématiques Appliquées et Industrielles. The Prize will be awarded to a mathematician who, on 1 January of the year of its award, has fewer than 20 years (full time equivalent) of involvement in mathematics at postdoctoral level, allowing for breaks in continuity, or who in the opinion of the Bachelier Prize Committee is at an equivalent stage in their career.

The Prize is awarded to the winner for an exceptional contribution to mathematical modelling in finance, insurance, risk management and/or scientific computing applied to finance and insurance. The prize winner will receive €20,000 including £5,000 to organise a scientific workshop in Europe on their area of research interests.

Nominations are now open for the 2020 Louis Bachelier prize; further details are at tinyurl.com/ybdosyyy. The closing date for nominations is 31 January 2020. Nomination forms should be sent to prizes@lms.ac.uk.

European Mathematical Society Article Competition 2020

The European Mathematical Society announces the competition MJAC-2020 for writing a journalistic expository article of philosophical reflection, investigation and expression of ideas on the subject *Mathematics is Everywhere*, open to students in primary or secondary school aged between 10 (on 1 December 2019) and 19 (on 31 March 2020). The deadline for submissions is 15 December 2019. For further details see tinyurl.com/y6bczls5.

LMS Research Schools 2021: Call for Proposals

Grants of up to £15,000 are available for LMS Research Schools which provide training for research students in all contemporary areas of mathematics. The LMS Research Schools support participation of research students from both the UK and abroad. The lecturers are expected to be international leaders in their field. The LMS Research Schools are often partially funded by the Heilbronn Institute for Mathematical Research (http://heilbronn.ac.uk/). Information about the submission of proposals can be found at tinyurl.com/ychr4lwm along with a list of previously supported Research Schools. Applicants are strongly encouraged to discuss their ideas for Research Schools with the Chair of the Early Career Research Committee, Professor Chris Parker (research.schools@lms.ac.uk) before submitting proposals. Proposals should be submitted to Ben Lloyd (research.schools@lms.ac.uk) by 22 February 2020.

Clay Mathematics Institute Enhancement and Partnership Program

To extend the international reach of an LMS Research School, prospective organisers may also wish to consider applying to the Clay Mathematics Institute (CMI) for additional funding under the CMI's Enhancement and Partnership Program. Further information about this program can be found at: tinyurl.com/y72byonb. Prospective organisers are advised to discuss applications to this program as early as possible by contacting the CMI President, Martin Bridson (president@claymath.org). There is no need to wait for a decision from the LMS on your Research School application before contacting the CMI about funding through this program.

LMS Research Schools on Knowledge Exchange: Call for Proposals

In addition to the Research School schemes mentioned above, the LMS is seeking proposals particularly focused on Knowledge Exchange between mathematical researchers and users of mathematics, the LMS offers two grants of up to £15,000 to support LMS Research Schools; one in 2020 and one in 2021. These Research Schools, which will primarily focus on Knowledge Exchange, can be in any area of mathematics. The LMS Research Schools support participation of research students from both the UK and abroad. The speakers are expected to be international leaders with experience relevant to Knowledge Exchange.

Information about the submission of proposals can be found at: tinyurl.com/y33gwcob along with a list of previously supported Research Schools. Applicants are strongly encouraged to discuss their ideas for Research Schools with the Chair of the Early Career Research Committee, Professor Chris Parker (research.schools@lms.ac.uk) before submitting proposals.

Proposals should be submitted to Ben Lloyd (research.schools@lms.ac.uk) by 15 January 2020.

LMS–Bath Mathematical Symposia 2021: Call for Proposals

The London Mathematical Society is pleased to announce its Call for Proposals for the LMS–Bath Mathematical Symposia to be held at the University of Bath in 2021. Subject to confirmed funding, it is hoped that two LMS–Bath Mathematical Symposia can be supported in 2021.

Formerly known as the LMS-Durham Symposia, the LMS-Bath Mathematical Symposia will be held at the University of Bath between 2020 and 2025. The Symposia are an established and recognised series of international research meetings, since their foundation in 1974, that 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 will be held in August, usually lasting for two weeks, with up to 50 participants, roughly half of whom will come from the UK. A novel element of the symposia is that they will be complemented by a summer school, to prepare young researchers such as PhD students, or a 'research incubator', where problem(s) related to the topic of the conference is studied in groups. These events can take up to an additional week. Prospective organisers should send a formal proposal to the Grants Team (Grants@lms.ac.uk) by 15 December 2019. Proposals are approved by the Society's Research Grants Committee after consideration of referees' reports. Proposals should include:

- A full list of proposed participants, divided into specific categories:
  Category A – Scientific organisers
  Category B – Key overseas participants
  Category C – Key UK-based participants
  Category D – Important overseas participants
  Category E – Important UK-based participants
- Proposers are encouraged to actively seek to include women speakers and speakers from ethnic minorities, or explain why this is not possible or appropriate. They should provide 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, or proposed avenues of available funding, should be included.
- Indicative plans for the summer school or research incubator.
- Where appropriate, prospective organisers should consider the possibility of an 'industry day'.

For further details about the LMS Mathematical Symposia, visit the Society's website: www.lms.ac.uk/events/mathematical-symposia. Organisers are welcome to discuss informally their ideas with the Chair of the Research Grants Committee, Professor Andrew Dancer (Grants@lms.ac.uk).

LMS Undergraduate Research Bursaries in Mathematics 2020

The Undergraduate Research Bursary scheme provides an opportunity for students in their intermediate years to explore the potential of becoming a researcher. The award provides £215 per week to support a student undertaking a 6–8 week research project over Summer 2020, under the direction of a project supervisor.

Students must be registered at a UK institution for the majority of their undergraduate degree, and may only take up the award during the summer vacation between the intermediate years of their course. Students in the final year of their degree intending to undertake a taught Masters degree immediately following their undergraduate degree may also apply. Applications must be made by the project supervisor on behalf of the student.

For further information and to download the application form, visit tinyurl.com/ya5stelx. Queries may also be addressed to Ben Lloyd (urb@lms.ac.uk). The closing date for receipt of applications is 5 pm Friday 14 February 2020.

Cecil King Travel Scholarship 2020: Call for Applications

Established in 2001 by the Cecil King Memorial Fund, the Cecil King Travel Scholarship award is made by the LMS Council on the recommendation of the Cecil King Prize Committee. The LMS annually awards a £5,000 Cecil King Travel Scholarship in Mathematics, to a young mathematician. The Scholarship is to support a period of study or research abroad, typically for a period of three months, in any area of mathematics.

As per the terms of the bequest left to the Cecil King Memorial Foundation, which funds the Travel Scholarship, applicants must be nationals of the UK or the Republic of Ireland and either be registered for or have completed a doctoral degree within 12 months of the closing date for applications. The LMS encourages applications from women, disabled and Black, Asian and Minority Ethnic (BAME) candidates as these groups are under-represented in UK mathematics.

To apply complete the application form at tinyurl.com/yarns982 and include a written proposal giving the host institution, describing the intended programme of study or research, and the benefits to be gained from the visit. The application deadline for applications is 31 March 2020.

Shortlisted applicants will be invited to interview during which they will be expected to make a short presentation on their proposal. Interviews will take place at the University of Birmingham in May 2020.

Queries may be addressed to Elizabeth Fisher (ecr.grants@lms.ac.uk).

Due to low number of applications received in previous rounds, there is a high chance of success in this scheme.

EDITOR FOR RUSSIAN TRANSLATIONS

LONDON MATHEMATICAL SOCIETY
EST. 1865

The London Mathematical Society invites expressions of interest for joining the team of Editors responsible for the English Editions of the journals *Sbornik:Mathematics* (Математический сборник), *Russian Mathematical Surveys* (Успехи математических наук) and *Izvestiya:Mathematics* (Известия Российской академии наук, Серия математическая).

This is a paid, part-time position which entails proofreading mathematical articles that have been translated from their Russian original, and in the process ensuring high standards of English. The suitable candidate will be expected to take on the full responsibility of English Edition Editor for one of the journals for a fixed term (usually a five-year period, expected to start in 2021). Prior to that date, work will be offered at the Deputy Editor level with a small workload, typically one article every two months. Preference will be given to applicants who are able to gain experience as a Deputy Editor.

The ideal candidate will command English at the level of a native speaker, have a mathematics background at the PhD level, and be able to read mathematical texts in Russian. For further details about the position, the work involved and remuneration, contact the LMS Editorial Manager, Dr Ola Törnkvist (lmsjournals@lms.ac.uk) before **15 February 2020.**


(1866)


(1936)


(1937)

Published jointly by the London Mathematical Society, the Russian Academy of Sciences and Turpion Ltd.

Heilbronn Institute for Mathematical Research

Heilbronn Research Fellowships

Salary: £38,345-£42,792
3 years fixed term, full-time

The Heilbronn Institute for Mathematical Research invites applications for Research Fellowships to be held either in Bristol, London, or Manchester. Research Fellows divide their time equally between their own research and the research programme of the Heilbronn Institute, which offers opportunities to engage in collaborative work as well as individual projects. We expect to make up to six appointments in Bristol, one appointment at each of the London Colleges (Imperial, Kings, and UCL), and up to three appointments in Manchester.

Research areas of interest include, but are not restricted to, Algebra, Algebraic Geometry, Combinatorics, Computational Statistics, Data Science, Number Theory, Probability, and Quantum Information. These areas are interpreted broadly: Fellows have previously been appointed with backgrounds in most areas of Pure Mathematics and Statistics, and in several areas of Mathematical/Theoretical Physics.

For more information about the application procedure, and to complete our application form, please visit our website: **https://heilbronn.ac.uk/fellowships-2/**

For more information about the Heilbronn Institute, see **http://heilbronn.ac.uk**

Due to the nature of the Heilbronn Institute's work, Fellows must satisfy vetting before appointment. UK resident UK nationals will normally be able to meet this condition: other potential applicants should consult the Heilbronn Manager at **himr-recruitment@bristol.ac.uk** about their eligibility before applying.

There is a salary supplement of £3.5K pa, in recognition of the distinctive nature of these Fellowships. Payment of this supplement is conditional on a finished thesis having been accepted in final form, because we expect Heilbronn Fellows to hold PhDs before working at the Heilbronn Institute. In addition, a fund of at least £2.5K pa to pay for research expenses will be available to each Fellow.

The Fellowship will be for three years, with a preferred start date in October 2020, though another date may be possible by prior agreement.

The Heilbronn Institute is a supporter of the LMS Good Practice Scheme aimed at advancing women's careers in mathematics and we particularly welcome applications from women for this post. Candidates interested in learning more about the working environment at the Institute prior to application are welcome to contact the Associate Chair, Dr Tim Burness, at **assoc-chair-himr@bristol.ac.uk**

In order for applications to be complete, applicants will also need to send a one page statement of proposed research, along with a CV, to the Heibronn Manager **himr-recruitment@bristol.ac.uk**, and arrange for three letters of reference to be emailed to the same address, prior to the closing date.

The application deadline is 11.59pm GMT, Sunday 17th November 2019.

ETH zürich

Assistant Professor of Mathematical Physics

→ The Department of Mathematics at ETH Zurich (www.math.ethz.ch) invites applications for the above-mentioned position (non tenure track).

→ Candidates should hold a PhD or equivalent in mathematics or physics, and should have demonstrated the ability to carry out independent research work. At the assistant professor level, commitment to teaching students of mathematics, physics, and other natural sciences and engineering, and the ability to lead a research group are expected. The new professor will be part of the National Centre of Competence in Research NCCR SwissMAP (www.nccr-swissmap.ch).

→ Assistant professorships have been established to promote the careers of younger scientists. The initial appointment is for four years with the possibility of renewal for a three-year period.

→ **Please apply online: www.facultyaffairs.ethz.ch**

→ Applications should include a curriculum vitae, a list of publications, a statement of future research and teaching interests, and a description of the three most important achievements. The letter of application should be addressed **to the President of ETH Zurich, Prof. Dr. Joël Mesot. The closing date for applications is 31 December 2019.** ETH Zurich is an equal opportunity and family friendly employer, strives to increase the number of women professors, and is responsive to the needs of dual career couples.

www.bristol.ac.uk

Data Science Heilbronn Research Fellowship

The School of Mathematics at the University of Bristol invites applications for one or more Research Fellowships in Data Science, in association with the Heilbronn Institute for Mathematical Research (HIMR).

Heilbronn Research Fellows divide their time equally between their own research and the research programme of the Heilbronn Institute. Exceptionally, a successful candidate may be able to negotiate up to 80% of personal research time if working on a relevant topic. Broadly speaking, this would include any methodology supporting the exploitation of large-scale, dynamic, and/or complex data. The candidate must demonstrate prior evidence of such accomplishments and/or an outstanding research track-record in a statistical or mathematical discipline (including Mathematical Physics and Theoretical Computer Science), with clearly laid-out plans to transition into Data Science.

HIMR and the Alan Turing Institute have a partnership agreement which enables Heilbronn Research Fellows to carry out some of their personal research as part of the Turing Institute's research programme, if they wish.

For more information about the Heilbronn Institute, see http://heilbronn.ac.uk

Due to the nature of the Heilbronn Institute's work, Fellows must satisfy vetting before appointment. UK resident UK nationals will normally be able to meet this condition: other potential applicants should consult the Heilbronn Manager (see below) about their eligibility before applying.

The Fellowship will be for three years, with a preferred start date in October 2020, though another date may be possible by prior agreement.

We welcome applications from all members of our community. We are particularly keen to encourage women, and other diverse groups, such as members of the LGBT+ and BAME communities, to join us.

Candidates interested in learning more about these Fellowships can contact the Director of the Institute of Statistical Science, Professor Oliver Johnson, at O.Johnson@bristol.ac.uk

Candidates must apply via the online University of Bristol recruitment site, http://www.bristol.ac.uk/jobs/find/ and search by the job number or with the keyword Heilbronn Research Fellowship. Candidates also need to upload via the online application a one page (no more than one side of A4) statement of proposed research, along with a CV, as one document. Candidates should ask three referees to email references to the Heilbronn Manager to: himr-recruitment@bristol.ac.uk prior to the closing date.

The application deadline is 11.59pm GMT, Sunday November 17 2019.

The University of Bristol is committed to equality and we value the diversity of our staff and students

Heilbronn Institute for Mathematical Research

University of BRISTOL

VISITS

Visit of Kimeu Arphaxad Ngwava

Kimeu Arphaxad Ngwava, a PhD student at Moi University, is being supervised by Dr Ian Short (Open University) and Dr Nick Gill (University of South Wales). This supervision was initiated via the LMS Mentoring African Research Mathematicians scheme. Kimeu is visiting the UK for the whole of November, giving seminars at the Open University and University of South Wales. He will work with Nick and Ian to complete his PhD thesis. He hopes to submit his thesis early in 2020. Contact Nick (nick.gill@southwales.ac.uk) for further details. Supported by an LMS Research Grant and EMS-Simons for Africa Grant.

Visit of Angela Pistoia

Professor Angela Pistoia (Universitá di Roma, La Sapienza, Italy) will visit the UK from 5 to 23 January 2020. During her visit, she will collaborate with Monica Musso at the University of Bath on the analysis of blow-up for fast diffusion equations. She will give lectures at the Universities of Bath, Swansea, Nottingham and Imperial College. Her research evolves around Concentration Phenomena in Nonlinear Partial Differential Equations. For further details contact Monica Musso (mmusso@bath.ac.uk). Supported by an LMS Scheme 2 grant.

Visit of Sinéad Lyle

Dr Sinéad Lyle (University of East Anglia) will visit the University of Leeds from 11 to 15 November 2019. Her research interests include the modular representations of the symmetric groups and related algebras. She will give a seminar on Introducing the Transformation Monoid on 12 November. For further details contact Paul Martin (ppmartin@maths.leeds.ac.uk). Supported by an LMS Scheme 4 Research in Pairs grant.

Visit of Vladimir Zeitlin

Professor Vladimir Zeitlin (Sorbonne University/Ecole Normale Superieure, France) is visiting Loughborough University from 28 October to 3 November 2019. His main research interests include geophysical fluid dynamics and magnetohydrodynamics with an emphasis on hydrodynamic instabilities, vortex dynamics, nonlinear waves, wave-mean interactions and wave turbulence. He will give a seminar S*mall is Beautiful: Understanding Dynamics of Tropical Atmosphere with Moist-Convective Rotating Shallow Water Model* on 1 November. For further information contact Karima Khusnutdinova (K.Khusnutdinova@lboro.ac.uk). Supported by an LMS Scheme 4 Research in Pairs grant.

Visit of Hakan Guler

Dr Hakan Guler (Kastamonu University, Turkey) will visit the Department of Mathematics and Statistics, Lancaster University from 20 to 31 January 2020 and the School of Mathematical Sciences, Queen Mary, University of London from 3 to 7 February 2020. His research concerns the combinatorial rigidity of geometric structures. For further details contact Tony Nixon (a.nixon@lancaster.ac.uk). The visit is supported by an LMS Scheme 5 grant.

Visit of Michiya Mori

Michiya Mori (University of Tokyo) will visit the University of Reading from 25 November to 6 December 2019. Michiya works on the theory of von Neumann algebras. He will give a talk at the Pure Mathematics seminar on 27 November. For further information email Gyorgy Geher (G.P.Geher@reading.ac.uk). Supported by an LMS Scheme 4 Research in Pairs grant.

Visit of Nadir Matringe

Nadir Matringe (University of Poitiers, France) will visit Imperial College London from 27 October to 3 November 2019. His research interests include representation theory and the local Langlands programme. He will give a number theory seminar at Imperial College. For further details contact Robert Kurinczuk (r.kurinczuk@ic.ac.uk). Supported by an LMS Scheme 4 Research in Pairs grant.

Annual LMS Subscription 2019-20

Members are reminded that their annual subscription, including payment for publications, for the period November 2019 – October 2020 becomes due on 1 November 2019 and should be paid no later than 1 December 2019. In September, the Society sent a reminder to all members to renew their subscription for 2019-20. If you have not received a reminder, please email membership@lms.ac.uk.

Members can now view and pay their membership subscriptions online via the Society's website: www.lms.ac.uk/user. Further information about subscription rates for 2019-20 and a subscription form may also be found on the Society's website: lms.ac.uk/membership/paying-your-subscription.

The Society encourages payment by direct debit. If you do not already pay by this method and would like to set up a direct debit (this requires a UK bank account), please set up a direct debit to the Society with GoCardless.com via your online membership record: lms.ac.uk/user.

The Society also accepts payment by cheque and credit or debit card. Please note card payments are now accepted online only and can be made via your online membership record: lms.ac.uk/user.

Benefits of LMS membership include free online access to selected Society journals, a complimentary bi-monthly Newsletter, use of the Verblunsky Members' Room at De Morgan House in Russell Square and much more: lms.ac.uk/membership/member-benefits.

Elizabeth Fisher
Membership & Grants Manager

LMS Education Grant Schemes

The LMS Education Committee offers two grant schemes for teachers and other educators: Small Grants for Education and Grants for Teacher CPD. Below are some highlights from recently awarded grants.

Grants for Teacher CPD

CPD-1819-18A: the grant was used to fund accommodation and travel expenses for a teacher attending the MEI Conference at the University of Bath in June 2019. The teacher participated in a workshop explaining key mathematical concepts of which any new year 12 student should have a full understanding and sessions on linking mechanics and pure mathematics. The conference was an important opportunity for the grant recipient to interact with the mathematics community and to increase their awareness and understanding of, for example, awarding bodies and the different types of exam papers.

CPD-1819-32A: the grant was used to fund the registration fee for the June MEI Conference. The teacher in question attended training on use of technology to teach regression, which looked at how the Casio CG50 graphical calculator could be used to help teach reduction to linear form. The candidate was able to see how the data can be input and processed, allowing students to plot graphs and see where regression lines fall. The candidate also attended a session on NRICH, which looked at how tasks could be used at different levels of attainment.

Small Grants for Education

ED-1819-06: the grant contributed towards costs of construction, transport and exhibition of the Mirror Pillar, an event run by MathsWorldUK involving a 2m mirrored steel cylinder, 75cm in diameter, which reflects and distorts images from the ground around it to create anamorphic artworks. Six schools from the local area attended with groups of year 9 and year 10 students. Students learned about the mathematics of reflection and contributed to a large drawing of Leonardo da Vinci and some of his most well-known achievements. The event also included a discussion of the career paths students taking maths might follow, and a talk from Katie Steckles on the mathematics of paper.

ED-1819-21: the grant was spent on development of several mathematics experiments and expenses for two mathematics talks at the student-run event 'Crash! Bang! Squelch!', part of the 2019 Cambridge Science Festival. The event was attended by over 1500 people and included talks such as 'Are you smarter than a computer programme?', which looked at the meaning behind artificial intelligence, machine learning and big data through a series of demonstrations; and 'Emperors, Spies and Seaweed', which looked at the mathematics of cryptography and included demonstrations on Diffie–Hellman key exchange using food colouring and LEDS and decoding a scytale cipher using pipe installation.

Further information about LMS Education grants, including details on how to apply, can be found at lms.ac.uk/grants/education-grants.

Kevin Houston
LMS Education Secretary

Report: Aitken Lecture Tour 2019

John Tucker and Bakh Khoussainov with the algorithmic notebooks of New Zealander Leslie John Comrie FRS in Swansea's History of Computing collection

Oxford (from Pavel Semukhin)

The first lecture of this tour, titled *Automata and Algebraic Structures*, was given at the Mathematical Institute, University of Oxford on 26 June. It was well attended by students, postdocs and faculty members from the Mathematical Institute and the Department of Computer Science.

Bakh Khoussainov is one of the founders of the research area called automatic structures. Automatic structures are algebraic structures, such as graphs, groups and partial orders, that can be presented by automata. By varying the classes of automata (eg finite automata, tree automata, omega-automata) one varies the classes of automatic structures. It appears that the class of all automatic structures is robust in the sense that it is closed under many natural algebraic and model-theoretic operations.

In his talk Professor Khoussainov gave an introduction to automatic structures, intended for the general audience, and motivated their study. He also presented many examples and explained several fundamental theorems in this field. The lecture was concluded by the statement and motivation of several important and long-standing open problems in the area of automatic structures.

London

On 28 June, as part of the LMS Graduate Student Meeting and LMS General Meeting, Professor Bakh Khoussainov spoke on the question of in which circumstances one can (or, indeed, cannot) find finitely presentable expansions of a given algebra. A report on this can be found in the September issue (484) of the *Newsletter*.

Durham (from Iain Stewart)

As part of his tour as Aitken Lecturer, Professor Bakh Khoussainov gave a lecture at Durham University on 3 July 2019 on *Algorithmically Random Structures*, with the University hosting Bakh for an extended stay before he left Durham for St Andrews to continue his tour. The talk began with a recent history of algorithmic randomness in relation to strings, and the work of Kolmogorov, Chaitin, Schnorr, Levin and especially Martin-Löf, before it moved on to a reconsideration of algorithmic randomness but in relation to Bakh's motivating question of what it means for an infinite algebraic structure to be algorithmically random. After elucidating what we might expect from an algorithmically random structure, Bakh developed a theory of algorithmic randomness so as to tackle concepts relating to the computability and the immunity of algorithmically random structures and to the algorithmic randomness of finitely presented structures. Bakh's talk was a masterclass in presenting the history, key notions and state of the art methodologies and results regarding his subject. Bakh's lecture attracted a full house at Durham, with standing room only and including attendees from not only Durham but also Newcastle University and Teesside University. The lecture was followed by tea at which informal conversations in relation to Bakh's talk were actively participated in, with Bakh subsequently taken out to dinner having expressed a desire to sample traditional Tyneside food. Perhaps Bakh's visit to Hadrian's Wall the day before had left him with an appropriate appetite!

Swansea (from John Tucker)

Bakh's lecture on *Semigroups, Groups, Algebras, and their Finitely Presented Expansions* took place on 15 July in the Computational Foundry, a new building for mathematics and computer science at Swansea, opened in October 2018.

What algebraic structures can be finitely presented? Necessary but not sufficient conditions are that they are finitely generated and computably enumerable. However, Jan Bergstra and John Tucker, in studying how to model and specify data types in the 1980s, showed that every finitely generated computable algebraic structure can be finitely presented by adding 6 extra operators and 4 equations, posing the open problem: *Can finitely generated, computably enumerable structures be finitely presented by adding operators?* Bakh introduced the subject and showed how a subtle blend of algebraic and computability methods spanning the 20th century — by Max Dehn, Anatoly Malcev, Emil Post — enabled him to answer no. Adding the Golod-Shafarevich Theorem, he made groups without finite presentations with extra operators. During his visit Bakh saw the books and papers of a fellow New Zealand mathematician, the pioneer computational scientist Leslie John Comrie FRS (1893–1950), in Swansea University's History of Computing Collection.

London (from Michael Zakharyaschev)

On 17 July, Professor Bakh Khoussainov gave an invited lecture *Games Played on Finite Graphs* at the annual meeting of the London Logic Forum (nms.kcl.ac.uk/llf/). The lecture first provided a background to the parity games problem and its solutions, and then discussed in detail the author's quasi-polynomial algorithm that solves the problem. The presentation was informal, with many examples and more emphasis on ideas rather than formal details. The meeting was hosted by the Department of Computer Science and Information Systems at Birkbeck, University of London (dcs.bbk.ac.uk). The whole programme of the meeting with abstracts of the given talks is available at nms.kcl.ac.uk/llf/seminars.html.

Report: The State of Mathematics in Eastern Africa

The Eastern Africa Universities Mathematics Programme (EAUMP) was launched in the year 2002. It is composed of five Mathematics Departments from five different countries: Dar Es Salaam University, Tanzania; Makerere University, Uganda; University of Nairobi, Kenya; University of Rwanda, Rwanda; and University of Zambia, Zambia. The network EAUMP is supported by the International Science Program (ISP) which is based in Sweden under the leadership of Professor Leif Abrahamsson, the Program Director at the ISP.

Participants of the 2019 EAUMP-ICTP Summer School hosted by the Department of Mathematics, Makerere University

Its major aim is to alleviate the poor state of mathematics in the Eastern Africa Region. This has been done among other things, through training PhD and MSc students, and organising mathematics conferences and summer schools. Since inception, EAUMP has been organising annual summer schools in the area of pure mathematics on a rotational basis within the member countries.

The Department of Mathematics, Makerere University was privileged to host the 2019 EAUMP–ICTP summer school which took place from 15 July 2019 – 3 August 2019.

The summer school was made possible with support from the London Mathematical Society, International Science Programme, International Centre for Theoretical Physics, Centre International de Mathématiques Pures et Appliquées, Foundation Compositio Mathematica, African Mathematics Millennium Science Initiative, Oxford University and Makerere University among others.

The 2019 theme was: Algebraic Topology and its Applications (Topological Data Analysis). The school attracted 44 participants from 12 different countries: Botswana, Egypt, France, Kenya, Nigeria, Norway, Rwanda, Sudan, Tanzania, Uganda, United Kingdom and Zambia. Among the 44 participants were six facilitators, namely; Balázs Szendrői (University of Oxford), Ulrike Tillmann (University of Oxford), Tomas Zeman (University of Oxford), Claudia Scheimbauer (NTNU, Trondheim), Jean-Baptiste Gatsinzi (Botswana International University of Science and Technology) and Venuste Nyagahakwa (University of Rwanda).

These annual schools have played a crucial role in exposing participants from the region to new emerging areas of research. On several occasions, MSc

students have taken on research projects from the topics covered in these schools.

David Ssevviiri, Overall Coordinator, EAUMP
Department of Mathematics, Makerere University

Report: LMS Prospects in Mathematics Meeting

Participants at the Prospects in Mathematics meeting

The LMS Prospects in Mathematics meeting 2019 welcomed about 36 undergraduate students and 14 speakers from across the country on 6 and 7 September on the campus of Lancaster University. We were hosted in the luxury Lancaster House Hotel, part of the university's conference centre. The meeting started with a gentle introductory talk on the history and activity of the LMS, before diving straight into the mathematics of cloaking and its applications. Then, we enjoyed a talk in which group theory meets fractal dimensions, followed by an introduction, by a current PhD student, to some vital epidemiology concepts. After such a start, some refreshments were highly appreciated, also because the next 'talk' was given by almost 50 mathematicians — the whole audience — a first of its genre! Indeed, one of the speakers could not make it, but kindly sent their slides beforehand, and we all worked through these happily. We ended the series of talks on the first afternoon with inspiring presentations on topics including studies in mathematical ecology, the question of why it all has to be so complicated, and the use of operational research to solve real world problems. We were also introduced to Conception X, a programme that creates deep tech start-ups from PhDs, during PhDs.

The dinner took place in the spacious Grizedale Bar and its terrace. As ice-breakers to the evening social time (though in view of the atmosphere, this wasn't needed!), two current PhD students from Lancaster's CDT (STOR-i) revealed the inside student's story of such centres; some students did not even know of the existence of the CDTs, and so were absorbing every word. A friendly and tasty BBQ enabled everyone to replenish themselves before the next day.

Zoltan Kocsis

We had an early start on Saturday morning, hearing about the use of statistical inference in the study of fighting lizards. Later we saw the proof that proof theory is bananas used to bridge the gap between the study of finite and infinite topological spaces, and complemented with a mention of Doctor Who's sonic screwdriver. The meeting certainly demonstrated the originality and spread of the use of mathematical sciences in all sectors of life, and edged at times into fantasy worlds. Another feature of the meeting was the enthusiasm and dynamism of the speakers, even in more down-to-earth presentations, including those on some ongoing research at the MRC Biostatistics Unit in the use of probability to break the curse of dimension in quantum mechanical computations, and in the use of applied probability to model various kinds of networks. The wide variety of presentations also included a talk in which abstract algebra met analysis, and an intriguing introduction to a rigidity zoo: that rigidity theory is a mathematical field concerned with questions that relate extrinsic shape to intrinsic metric information, and has applications in many areas, including machine learning.

Overall, this eclectic mix and celebration of research in mathematics went very well: first and foremost for the students who had the opportunity to talk with other students and with academics, create useful contacts, and also to learn about the many opportunities they have to study for a PhD... and of course to learn about the great work that the LMS does.

Nadia Mazza, Organiser
Lancaster University

Report: LMS Midlands Regional Meeting and Workshop

Nina Snaith

The theme of the LMS Midlands Regional Meeting in Nottingham on 11 September 2019 was *Zeta Functions in Number Theory and Mathematical Physics*. There were three well-attended talks presenting three different types of such zeta functions. The first talk was by Nina Snaith from Bristol who gave a very interesting overview on the connection between random matrix theory and the distribution of zeroes of the Riemann zeta function and how they have to be adapted for certain L-functions. After the coffee break John Coates (Cambridge) presented the second talk on leading term formulae for L-function of elliptic curves as they appear in the Birch and Swinnerton-Dyer conjecture and how one approaches them for a particular family of curves via p-adic methods. Mark Pollicott from Warwick concluded the talks with an overview of dynamical zeta functions and how the concrete determination of an abscissa of convergence solved the Zaremba conjecture on continued fractions.

The talks were followed by a wine reception at which the participants, including many young researchers, engaged in lively discussions. These continued during the walk to the local pub where we had dinner.

The meeting continued on the following two days with a workshop on "elliptic curves and friends and family". Elliptic curves take a particular place in number theory: On one hand, they are easy enough to work with as they have explicit equations and many good algorithms are known to test and prove partial results on conjectures as for instance those related to their L-functions. On the other hand, elliptic curves are more subtle and interesting than number fields as they exhibit already the mysterious behaviour (like the finiteness of the Tate–Shafarevich group) that we expect to appear for a wide range of arithmetic objects.

John Barrett (Nottingham) welcomed the Society's members

Talks were given by Vladimir Dokchitser (UCL), Yukako Kezuka (Regensburg), Jaclyn Lang (Paris), Giada Grossi (UCL), Kazim Büyükboduk (Dublin), Nirvana Coppola (Bristol), Henri Johnston (Exeter) and Werner Bley (München). Some of them were directly about the arithmetic of elliptic curves often centred on the Birch and Swinnerton-Dyer conjecture. Other speakers presented their work on ideas analogous or related to elliptic curves such as general Galois representations, abelian varieties and on the equivariant Tamagawa number conjecture.

The atmosphere during the meeting was very pleasant. The coffee breaks lead to interesting discussions and exchanges of ideas. The touristically unavoidable visit to Ye Olde Trip to Jerusalem and the meal in the city centre concluding the workshop provided good opportunities for the younger participants to interact and to create new connections to other researchers in close areas.

Of the 11 speakers five were women and four visited from outside the UK. The meeting and the workshop were attended by young researchers from abroad, as well as by postdoctoral, PhD and postgraduate students from the UK. In summary, the meeting provided the audience with an informative perspective on some of the many facets of zeta functions in number theory and physics as well as in depth understanding of cutting-edge research on the arithmetic of elliptic curves.

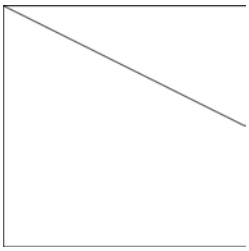
Christian Wuthrich
University of Nottingham

LETTER TO THE EDITOR

Perigal artefacts

In the recent *LMS Newsletter* (484 September 2019) Mark McCartney asked for information about some of the Perigal artefacts.

The bottom left corner illustrated what I believe are five complete copies (plus an extra triangle) of the two-piece tangram (or two-piece jigsaw).



I worked with the two-piece tangram (left) during my teaching career in secondary schools in which I developed the work with a number of classes of different ages.

For the youngest students I asked them to use the two pieces to make (and name) shapes that occur when two sides of the same length are joined together. The next step was for them to explain why there are only eight such polygons and to prove the properties of the shapes they made.

Older pupils were asked to be more specific, such as finding and proving which shapes were cyclic quadrilaterals and determining, where possible, both the radius of the circumscribing circle and the fraction of the circle covered by the quadrilateral.

When I did this, I always provided sufficient pieces for the students, so there were always extra bits left over that I kept for future use and I imagine that Perigal also kept spare bits, which is why all those bits are shown. I expect Perigal kept the pieces in the decorated envelope and one of the quadrilaterals has gone missing.

Anyone who wants a copy of the seven pages of teaching notes I wrote in December 2002 on the subject of the two-piece tangram can email me at ransompeter687@gmail.com and I will be happy to send them.

Peter Ransom MBE FIMA

Letters may be edited for style and space.

Records of Proceedings at LMS Meetings
Ordinary Meeting: 11 September 2019

The meeting was held at the Physics Building, University of Nottingham, as part of the Midlands Regional Meeting & Workshop on *Zeta Functions in Number Theory and Mathematical Physics*. Over 35 members and guests were present for all or part of the meeting. The meeting began at 1.30 pm with The President, Professor Caroline Series, FRS, in the Chair.

There were no members elected to Membership at this Society Meeting.

Two members signed the Member's Book and were admitted to the Society.

Professor John Barrett, Professor of Mathematical Physics at the University of Nottingham, welcomed the Society's members and guests to the University and thanked the Society for its support of the Department.

Dr Sven Gnutzmann, University of Nottingham, introduced the first lecture given by Professor Nina Snaith (University of Bristol) on *Random Matrix Theory, The Riemann Zeta Function and Elliptic Curves*.

After tea, Dr Sven Gnutzmann, University of Nottingham, introduced the second lecture by Professor John Coates (University of Cambridge) on *L-values and the Exact Birch-Swinnerton-Dyer Formula*.

Dr Sven Gnutzmann, University of Nottingham, introduced the third lecture by Professor Mark Pollicott (University of Warwick) on *Dynamical Zeta Functions and their Applications*.

Professor Series thanked the speakers for their excellent lectures and then expressed the thanks of the Society to the organisers, Dr Gnutzmann, Dr Wuthrich and Dr Strömberg, of the University of Nottingham, for a wonderful meeting and workshop.

Afterwards, a wine reception was held in the atrium of the Maths building. The Society dinner was held at the Victoria in Beeston.

Teaching Ethics in Mathematics

MAURICE CHIODO AND PIERS BURSILL-HALL

In the previous issue of the *Newsletter* we addressed why mathematicians should consider the ethics of what they do. Here we outline, based on our experiences, three key elements for *teaching* Ethics in Mathematics (EiM): (1) a lecture series on ethical issues in mathematics; (2) exercises with an ethical component in problem sheets of other maths courses; and (3) a supportive environment so students perceive value in this teaching.

Why is this an issue now?

While some may argue that mathematicians will inevitably develop ethical skills when they begin to work in industry, it is our opinion (see [2]) that the mathematical community actively encourages mathematical professionals to either regard mathematics as beyond ethics (Platonism), or that social and ethical consequences are just "not a mathematician's problem" (exceptionalism). Compare this to law, medicine, physical sciences, etc., which all teach profession-specific ethics. We suggest that because mathematicians engage in sophisticated technical work which lies well above the level of public scrutiny, they should be actively trained to deepen the awareness of their social and ethical responsibilities (see [1]). But why hasn't it been done before?

Firstly, until the middle of the 20th century most people studying mathematics at post-secondary institutions in the West also received a robust training in philosophy, and thus were equipped with enough philosophical and ethical literacy to deal with professional, ethical questions. The second reason is more profound and lies in the newfound immediacy of the work of mathematicians. Until recently there was a genuine separation between people who did abstract mathematics (mathematicians), and those who applied such work in the physical world (physicists and engineers). There was a discernible professional and temporal gap between those who produced new theorems, and those applying them decades, even centuries, later. This reduced the appearance of ethical responsibility of mathematicians and gave everyone more time to consider the ethical issues. However, the digital revolution has reduced this gap.

The amount of pure mathematics used in finance, surveillance, big data, and decision-making systems, is vast and growing rapidly. Mathematics has not only become their foundation, but it is being 'brought to market' and has a potential social impact within months or even weeks. The power of new mathematics in ethically-laden industries means the professional and temporal gap between its creation and its application has reduced so much that the ethical consequences of mathematical work cannot be obscured or blamed on someone else. For the *first time ever*, mathematicians are *uniquely* responsible for the immediate social consequences of their work.

Constructing a course in EiM

Teaching Ethics in Mathematics (EiM) turns out to be non-trivial. Since no-one has done it before, there is no body of precedent, resources, textbooks or lecture notes from others to build on.[1] Introducing it as an undergraduate course is necessarily a complex process: its ideas are new to your university, it is unlike theorem-based courses, and sometimes it is hard to argue that EiM should supplant any given traditional maths course as teaching time and resources are already limited. What follows is only indicative, based on our experiences and conversations with colleagues around the UK and elsewhere in Europe. There is no unique or established way to teach EiM, and you will need to tailor the discussions here to your situation. Treat what follows as suggestions, not rules. We have introduced EiM in Cambridge as an informal, non-examinable course (of which there are already well-attended examples in our Faculty). Students were used to this format, but it might not be the right model for your institution; seminars, compulsory modules or project courses might work better.

It may be best — and easiest — to introduce EiM in a slow, evolutionary way, starting with 1–2 lunchtime seminars, before developing it further. It helps your colleagues to get used to the idea, and if it proves to be popular, this may provide its own rationale for the course to be accepted into the curriculum.

[1]We have constructed a website ethics.maths.cam.ac.uk hosting resources for anyone who wants to construct an EiM course.

You will need to consider your audience carefully. Are your students studying mostly maths, or maths with physics or computer science? Different allied disciplines will suggest different case studies.

Teaching EiM is quite different from ethics courses in other disciplines. They do not follow the same exceptionalism and are already aware of the existence of ethical issues. Unfortunately, as mathematicians, we do not have this luxury. Indeed, you probably need to assume that most of your audience does not initially and intuitively accept the premise that there are ethical issues in mathematics. Thus, we strongly suggest not starting an EiM course with generic philosophical discussions on ethics because you can lose your audience as a result. We have found that most of our students are generally not receptive to the conceptual structures, language and approach of 'real' philosophy; what philosophers talk about is not always easily translated to an undergraduate mathematician. Hence, we strongly recommend resisting the temptation to ask a philosopher to teach this. Students need to see profession-specific ethical issues and discussions in a familiar language. Of course, engage with philosophers and ethicists to help design your course, and go to other disciplines (law, social sciences, engineering, etc), to get advice and insight. However, we believe that such a course needs to be delivered by mathematicians even if they are not a professionally trained ethicists, just like linear algebra lecturers need not be experts in algebra. You probably know more about it than your students, and you speak the same professional language.

A natural structure for such a course would be to split it into two sections: "*There exist* some ethical issues in mathematics", and then "*For all* mathematics that we do, there are ethical issues". It may seem pedestrian, but an array of case studies prove existence. To get students to appreciate it you only need to present explicit and varied examples of work that mathematicians have done which have raised ethical issues. Your audience must reach the point where they accept that there are indeed ethical issues in *all* branches of mathematics. Giving just one example may lead them to think that it was a one-off. You can find a long list of case studies at ethics.maths.cam.ac.uk/cases; such mathematicians were probably not deliberately acting maliciously, but instead overlooked ethical consequences. It is important to emphasise this; teaching EiM should not be a platform for criticising others, or you risk putting your students on the defensive.

Now you are ready to move to the second stage: "*For all* mathematics that we do, there are ethical issues". Such generalisation is harder to accept. Students may think that "there are places X, Y, Z where mathematicians might do unethical things, so if I just avoid those, I'm safe." We have had this reaction from our students regularly. You need to dispel this and show them that there is nowhere to hide, not even in academia. Obviously *for all* statements cannot be proved by example but require more profound arguments. These can build on the lack of sufficient 'external' control mechanisms (weak regulation) and on the fact that mathematicians are trained and encouraged to strip away non-mathematical aspects of problems (which inevitably leads to issues). It can also include more social aspects such as there are people who will deliberately set out to exploit others and their labour, playing on their unwillingness to think about ethical consequences. Your students are about to enter an industrial economy which is set up and organised to work in ways that can obscure the ethical context and can enable moral disengagement.

This is your 'proof for ethics'. No matter how supposedly pure your (mathematical) work is, someone is inevitably paying you to do this work for their interests. When working mathematicians ask: Who is paying me? Why are they paying me? How will they use my work? How will they use me?[2] ...then an ethical self-examination has begun.

The course we give

Our course involves 20 contact hours, divided between lectures, interactive exercises, and often lively and challenging discussions. We recommend you encourage interaction so students explore and digest these new ideas. Discussions are useful and necessary to develop an ethical understanding. We cover eight topics. The first half illustrate the existence of ethics in mathematics before we move on to argue for its universality, where we have found ourselves appealing to other disciplines (psychology, law, social science) to understand the inner-workings of mathematical community and its interactions with the world. On many occasions these extra-mathematical observations proved to be the most interesting and persuasive for our audience. Descriptions, and a recording, of our lectures, are available at ethics.maths.cam.ac.uk. In our lectures we cover the following.

(1) *Introduction to EiM.* All mathematics is done in a

[2]As the now-resigned director of the MIT Media Lab, Joi Ito, recently found out; tinyurl.com/yyowldy9.

social context. It sits at the heart of technological advancement and industrial progress. Understanding that it can be used for good, and ill, is the first step to ethical awareness.
(2) *Mathematics and modelling.* Mathematical models are necessary to understand the world. We draw on examples from fields such as finance to teach the process of modelling and its limitations. The global financial crisis demonstrates that poorly understanding models can have devastating consequences.
(3) *Cryptography, surveillance and privacy.* Mathematicians can enable the infringement of privacy by breaking strong encryption, collecting troves of personal data or through carelessness.
(4) *Fairness and impartiality in algorithms and AI.* We talk about the ethics behind automated decision-making systems and related problems of fairness and impartiality by drawing on examples from predictive policing, prison sentencing, targeted advertising and mathematical fairness measures.
(5) *Regulation, accountability, and the law.* Industrial mathematics is very close to its social impact (e.g. credit scoring via machine learning) and hence mathematicians need to reconsider their responsibility, understand laws and regulations, and learn to self-regulate when lawmakers are behind the times.
(6) *Understanding the behaviour of the mathematical community.* All fields, including mathematics, have a sense of community, conventions and values. Abstraction and the art of mathematical thinking may not necessarily lead to ethical solutions to industrial or social problems.
(7) *Psychology 101 — how to survive as a mathematician at work.* Mathematicians encounter other issues, conflicts, and dangers arising in the workplace. Their focused and dedicated nature means they may overlook instances of exploitation and manipulation of them and their work. Students must learn to identify these and to protect themselves.
(8) *A look into the future, what are the next steps?* Being aware of the ethical issues is not the last step to take. We talk about ways to engage in moral behaviour by talking to colleagues, getting involved with decision-making processes, and by identifying and calling out unethical and harmful mathematics.

Be interactive!

We found it extremely fruitful to engage students in interactive demonstrations to show that, even though they are very logical in their thinking, and the problems they work on are well-defined with 'exact' solutions, they are still people, with vices, shortcomings, and weaknesses. When mathematicians do maths, they do not suddenly become perfect Platonic logical machines. It is essential to dispel the myth that "we're not people, we're mathematicians". For example, you can ask the audience to break up into groups, each to produce an impartial plagiarism testing algorithm. Get them to present it to the class, and then proceed to pick apart all the value-judgements presented. If you are lucky, a few students will notice that there is no impartial plagiarism tester! The literature on the psychology of groups is full of valuable (and entertaining) tests and exercises to show how easily one can yield to unspoken social pressures.

Another activity is the 'oil pipe problem' [3, p.124]. Start by drawing an oil rig in the ocean and a refinery on a straight shoreline, giving the cost of piping under water and on land. Then ask your students to discuss and compute the optimal pipe path from the rig to the refinery. They may treat it as a first-year calculus problem at which point you should ask what other information might be relevant; are there coral reefs or protected habitats in the vicinity? It teaches students to include soft constraints alongside time and money. Our students quickly became engaged in lively discussions in these examples.

Teaching EiM: Politics or not?

Will you try to explain what the 'right' ethical conclusions are, expound on moral frameworks, or restrict yourself to only raising ethical awareness without offering answers or solutions? We regularly have students ask us, unsurprisingly, for the 'right answer' or the 'axioms and algorithms of ethics'. While we tried to avoid drawing ethical conclusions, this desire comes up regularly. We strongly suggest aiming to avoid ethical conclusions, and instead getting students to face the difficult job of coming to their own conclusions for their own reasons. By making it political, an (anti/pro)-capitalist rant, or a mission for social justice, you risk alienating students and colleagues. Many are simply not interested in a political agenda, but do care about not harming people.

Some mathematicians realise that maths has ethical consequences; others do not particularly care whether they cause harm. But most just lack well-developed ethical awareness. They may want to do maths, have fun in the process, and earn a living, without causing harm to others; you can thus raise *their* ethical consciousness, as well as change how they view their work. You do not have to teach them political conclusions; this isn't part of mathematics,

but part of the ordinary political discourse citizens have about their political world.

One reason mathematicians shy away from ethical discussions is that mathematics seeks timeless, absolute truths. The apparent perfection of mathematical truth can be its primary attraction. But ethics doesn't have the same binary clarity or timelessness. Different people may come to different conclusions or hold different moral values which are all reasonable, and mathematicians facing profession-specific ethical challenges have no universally-agreed ethical framework to use, because there isn't one. Unsurprisingly, suggesting that mathematicians need to be aware of ethical issues sometimes gets the response that ethics is imperfect and a matter of opinion, and moreover "*Whose ethics?*" which we would answer with "*Yours!*" We do not suggest that teaching EiM should give all the answers to ethical problems, but we do suggest that it is our duty to educate our students about it. The hard work of solving the questions remains and is an individual's social responsibility. The political debate that follows is part of what informed citizens frequently do.

Resources, exercise sheets, and assessment

Setting assessment will depend on your course and department. If you do (we didn't), we would suggest setting essay(s) with an emphasis on analysis, reasoning, identification and exploration of ethical issues and (mathematical) sources. Judge contextualisation and line of reasoning, rather than the final conclusion. You can even ask students to present several solutions or options to a particular scenario (hypothetical, or drawing from real-life).

There is something more important than assessment. Mathematics is not a spectator sport; every day, maths students go home after lectures and spend many hours on traditional exercise sheet questions. We all know that the value of doing this is to understand the mathematics at a deeper level by 'doing it for yourself'. In the same vein, students need to 'go home and practice' thinking about the ethical issues that can arise when 'doing' mathematics. What we propose is to give students mathematical exercises with *real* mathematical content, which also have an *ethical component*. One could assemble a collection of such questions into a set of dedicated sheets, and one might even make this the system of assessment of an EiM course. However, this still compartmentalises the learning process. ***So let us make a modest proposal:*** Beyond exercises for an EiM course, we believe it would be more effective if, when doing mathematical exercises in *other courses*, students encountered questions that require ethical considerations. This could help normalise ethical awareness in everyday mathematics. Its impact could be as large, or larger, than a stand alone EiM course. While this is a different order of ethical engagement on the part of the department, it requires minimal effort on the part of your colleagues. If some of the exercise sheets in some of the courses contained a problem or two with an ethical flavour, this might serve to painlessly normalise the ethical engagement and awareness for many students. For first and second-year courses, we have prepared such a collection of questions, which can be found at ethics.maths.cam.ac.uk.

Students need to train their ethical reasoning just like they train mathematical reasoning via exercises. This proposition has the benefit that it requires no alteration to the core lecture content, beyond simply highlighting in lectures that some example sheet questions are designed to train not only technical and abstract understanding but also the interpretation of mathematics. However, whatever the mechanism your institution uses to give feedback on exercise sheets, you would need to instruct your teaching assistants about these questions. Don't expect them to instantly understand it; they are, after all, mathematicians who probably haven't had much training in ethical awareness. Providing written explanations helps. If example classes are predominantly led by graduate students, then as well as attending your EiM lectures, they can get involved with these EiM questions through teaching them.

Faculty support

Faculty support is critical to setting up an EiM course, but it can be hard to get. You do not necessarily need your colleagues' time or energy, you just need them to acquiesce to an experiment in EiM, even though it isn't about theorems or applications. In academia where resources are stretched so thinly that we struggle to teach all the mathematics we would like to, you will need to give good arguments to allocate resources to training in ethics. If we are trying to produce the best mathematicians possible and not just maximise the number of theorems taught, we have a duty to teach our students how to use this power and their mathematics responsibly. Otherwise, why are we teaching it to them at all?

Dismissive colleagues can damage the effectiveness of teaching EiM. Phrases such as "Why waste your

time going to EiM lectures?", or even more subtle assertions ("Oh, don't worry about question 4; it's one of those ethics questions.") are damaging as they're quickly picked up by students, and it is essential to get departmental leadership on board to encourage colleagues to avoid (directly, or indirectly) undermining the credibility of this teaching.

The objections can be orthogonal. One person might say "There is no EiM, so no need to teach it" and another might say "It is obvious that there is EiM, so no need to teach it". However, the most significant objection is an entirely reasonable argument: "We're a maths department, why are we teaching ethics? It's not precise; it's a matter of opinion". As we have repeated ad nauseum, other fields teach profession-specific ethics within their university training. Medical ethics is not medicine, but it makes doctors better doctors. Ethics *is* a matter of opinion, but that does not mean it cannot be addressed. Mathematicians deal with matters of opinion all the time. We discuss the beauty of mathematics, the elegance of proofs, letters of reference, partial marks on exams, and promotions. When refereeing papers, we fill our reports with value-judgements and opinions beyond mathematical accuracy. When every other profession faces ethical issues and trains professionals to deal with these issues, how can we exclude ourselves from it?

Concluding remarks

To be eligible for funding for a Centre for Doctoral Training (CDT) from EPSRC, applicants must demonstrate the provision of appropriate training in ethics for all doctoral students. An EiM course would give a convincing response to any such application, demonstrating that the applicants and department genuinely care about ethics and take it seriously. Referees will likely give more weight to an established EiM course than a simple statement of intent to teach ethics, or a reference to an external provider of such 'Responsible Research and Innovation' training (with no specific focus on mathematics).

We have had students from our EiM course tell us they had spoken to large tech companies who were extremely impressed that mathematicians were learning about ethics. It is a highly desirable skill, and as part of your teaching, you may consider providing students with a 'letter of participation'. This may not seem like much, but to employers, a mathematician with *any* ethical training can be a real asset in today's data-driven economy.

Recently a major UK broadsheet published an editorial arguing that mathematicians *need* to consider ethics [4]. And the 2019 Royal Institution Christmas lectures, to be delivered by Hannah Fry, will essentially focus on 'ethical issues in mathematics'. If the editors of a newspaper, and the general public, are aware of these issues and of the social responsibilities of mathematicians, surely the time has come to start teaching it to our students.

Acknowledgements

We wish to thank Dennis Müller for his valuable discussions on this article, and Toby Clifton for his careful editing and many contributions to our work.

FURTHER READING

[1] M. Chiodo, R. Vyas, The role of ethics in a mathematical education, Ethics in Mathematics Discussion Papers, 2018/1 (2018).
[2] M. Chiodo, T. Clifton, The Importance of Ethics in Mathematics, LMS Newsletter 484 (2019) 22–26.
[3] B. Schulman, Is There Enough Poison Gas to Kill the City?: The Teaching of Ethics in Mathematics Classes, College Math. J. 33 (2002) 118–125.
[4] The Guardian view on ethics for mathematicians: an essential addition, theguardian.com, August 18th 2019.
[5] M. Chiodo, P. Bursill-Hall, Four levels of ethical engagement. Ethics in Mathematics Discussion Papers, 2018/1 (2018).

Maurice Chiodo

Maurice is a Fellow and Teaching Officer at King's College, Cambridge. He is the lead investigator of the Cambridge University Ethics in Mathematics Project, developing a programme to teach mathematicians about the ethical implications of their work.

Piers Bursill-Hall

Piers has taught history of maths and science in the mathematics faculty in Cambridge for over 40 years. He has worked extensively on mathematical culture and the status of mathematics in past communities.

Yael Naim Dowker and the Birth of Ergodic Theory

MARY REES

Yael Naim Dowker's life and work effectively spans the twentieth century. She introduced and nurtured the subject of ergodic theory in Britain, where she spent most of her professional life. We tell the story of how one individual mathematician, a woman, helped to shape mathematical research today.

The early years

Yael Naim was born in 1919 in Tel Aviv, which, having been founded in 1909 on the outskirts of Jaffa by Jewish immigrants, was then quite a new settlement. Her parents emigrated to Palestine from eastern Europe, probably just before the first world war, part of the emigration known as the second Aliyah, which was largely an escape from economic deprivation and persecution. Yael's father, Avraham Na'im, came from Bialystok, Poland, He was an agronomist who had studied in Naples, and a prominent figure in their new homeland, involved in the development of the Jaffa orange. Her mother, Rachel Golomb Naim, a handicrafts teacher, was from Vilna (now Vilnius). Both Bialystok and Vilna were under Russian domination at this time. Yael was an extremely bright child, still remembered by her extended family in Israel, even after the passing of almost all her generation. A photograph from about 1930 shows her gazing intently from the centre of quite a large family group, mostly her father's family, just one other child in the group. All but one of her father's siblings, and his parents also, emigrated between 1913 and 1930. Yael attended the first Hebrew high school: Herzliya Hebrew Gymnasium, Tel Aviv. At the age of seventeen, she started university. For a few months, she studied at the Hebrew University of Jerusalem. In 1937, Yael's parents decided to send her to study in the U.S.. She went to Johns Hopkins University, which had one of the best mathematics departments in the U.S.. There, bypassing the undergraduate degree, Yael studied for her master's degree with Oscar Zariski.

Zariski is regarded as one of the founders of modern algebraic geometry, a field which underwent a revolution in the 1950's with the work of Alexander Groethendieck. But the work done by Zariski at Johns Hopkins, in particular in the period when Yael Dowker was working with him, was absolutely fundamental. Modern algebra was being developed. A basic concept such as vector space would have been unknown to an undergraduate of the time. In the late 1930's and into the 1940's, Zariski was giving rigorous algebraic proofs of the staple results of algebraic geometry. When I talked to Yael nearly seventy years later, and asked her if she enjoyed her studies at Johns Hopkins, she said "I hated it." While this was probably a simplification, she was in her teens and early twenties, far from her family, in a foreign country, an unknown subject, a small department with a handful of graduate students. Throughout the war, she was, of course, unable to return home. The only communication with her family was by letter. It was difficult for her family to send her money and so she was often short.

At Johns Hopkins, Yael met the man she was to marry. The Canadian topologist Hugh Dowker (1912–82) was appointed an instructor in 1940. From 1943 until 1946, Yael and Hugh were working together at the Radiation Laboratory at MIT. They married in 1944. Hugh was from a farming family in western Canada and not Jewish but a protestant Christian. He was an unknown quantity for Yael's family when they first heard about him. It is not clear when they first met Hugh, but the couple is thought to have visited them at least once in the years immediately following the war. When the two families, Dowker and Naim, did make contact, they got on well.

Doctoral study

Yael completed her formal studies in Cambridge, Massachusetts. It seems quite likely that she originally considered doing a doctorate at Johns Hopkins, until personal circumstances, and the war, led her and Hugh to move to Massachusetts. She also moved mathematically. Probably she realised that her mathematical tastes were more towards analysis than algebra. By 1946, before she formally registered for a PhD programme, she already had results, at least the bones of her thesis, working largely independently, but under the direction of Witold Hurewicz (1904–56). Her request to Johns Hopkins for the award of a PhD

Dowker's PhD thesis

The classical ergodic theorems of G.D. Birkhoff and W. Neumann — the individual and Mean Ergodic Theorems — are for measurable transformations T preserving a finite measure μ, and are about convergence for an L^1 (respectively L^2) function f of the *ergodic averages*

$$S_n(f)(x) = \frac{1}{n}\sum_{i=0}^{n-1} f(T^i(x))$$

μ almost everywhere (respectively in L^2 norm). It is natural to be interested in the converse problem: if μ is a measure and T a measurable transformation, then what is a *necessary* condition for the ergodic averages $S_n(f)(x)$ to converge μ a.e., that is, for μ almost every x to be a *mean point*?

The result from Dowker's thesis that was published is that, for this classical ergodic theorem to hold μ must be absolutely continuous with respect to a finite invariant measure m, what she called *potentially invariant*. A similar result was proved for L^2 convergence, that is, the converse of the von Neumann ergodic theorem. In another paper, in 1951, she dealt with the analogous result for σ-finite measure, using Hurewicz' ergodic theorem.

on the basis of this research was refused on the grounds that the research had been done away from the University, and with someone not connected with the University. It was suggested that she should register at Radcliffe College for a PhD from Harvard, and, with her MA from Johns Hopkins, should be able to complete her PhD in two years. From Yael's point of view, it was a waste of time (at least two years, and possibly more if the MA were not recognised) and money to register at a new institution for a PhD for which the work was already effectively done. But she did take this route.

At this time, Harvard was not admitting women graduate students, or at least very few of them, and similarly at MIT, where Witold Hurewicz had a position from 1945. Instead, the women students usually enrolled at the affiliated Radcliffe College with thesis advisors — men — at Harvard. Yael's official advisor from Harvard was Garrett Birkhoff (1911–1996), an interesting mathematician, an algebraist, who co-wrote a famous textbook in algebra, which is still in use today, so he might have initially seemed a good match for Yael's background at Johns Hopkins. But Yael's thesis was in ergodic theory — a complete break from her masters work in algebra. Garrett Birkhoff's father was the famous ergodic theorist George David Birkhoff (1884–1944), also a professor at Harvard, but recently deceased at this time. He proved the Individual (Birkhoff) Ergodic Theorem in 1931. He also wrote an article in the American Mathematical Monthly in 1942 *What is the Ergodic Theorem?*, giving simple and appealing applications [2] of the theory. Possibly Witold Hurewicz saw this article, and Yael also. Most of Hurewicz' work was in topology. His research interests overlapped wth those of Hugh Dowker — whom he might first have met through war work — and they wrote two papers together, the first in 1948. But, in his only work in ergodic theory, Hurewicz proved the best possible generalisation of the Birkhoff ergodic theorem, subsuming Hopf's generalisation of Birkhoff's theorem. Hurewicz's hypotheses did not include an invariant measure, and his result was published published in 1944 [10]. Yael learnt her subject largely by reading as directed by Hurewicz, including, of course, the work of George D. Birkhoff and E. Hopf. References in her papers suggest she made a close study of work of Krilov and Bogoljubov, published in 1937 in French. Later on, she certainly read works of the growing Russian school. She translated papers herself, with no prior knowledge of Russian. Yael Dowker obtained her doctorate in 1948 with her dissertation *The ergodic theorems and invariant measure*, deposited with Radcliffe College. See "Dowker's PhD thesis."

The move to the UK

Properties of potentially invariant measures and mean points informed Yael Dowker's research in ergodic theory and topological dynamics for the next decade or so. (See "The existence of an equivalent invariant measure" and "Mean points and ergodic measures".) There was also a wider effect, long-term. While her mathematical journey might have had quite a natural smooth progression, Yael's geographical movement was more abrupt and dramatic. In 1948 her father died. When the news reached her, Yael departed, alone, to visit her family and her homeland. The plane she was on developed engine problems, a terrifying experience which, for a while, it looked as if they would not survive. The passengers were not reassured by a stewardess saying "The situation

is very serious. But we must keep smiling." But the plane managed to make an emergency landing in Tunisia. The mostly Jewish passengers were hosted overnight by the local community in Tunisia. They were then able to continue their journey. According to one account, the plane might now have had a cargo of guns in it. The 1948 Arab-Israeli War, following the statement of the creation of the state of Israel on 14 May, had now broken out, and this was the last plane to land in Israel before the closure of airports because of the war. Yael's stay with her family was longer than anticipated, but after some time she was able to return to the US.

In 1948, Yael moved on to a fellowship in the name of Emmy Noether (1882–1935) at the Institute for Advanced Study (IAS) in Princeton. Work on the second main paper arising from her thesis was started at IAS. But the next move came soon, and it was a big one. Some of the Dowkers' friends were being harassed by the House UnAmerican Activities Committee. There was a risk that they themselves might come under pressure to testify to the Committee and to name communist friends. This led them to emigrate to Britain in 1950. This was a tough move for the young couple, although more so for Hugh. Yael found work in the mathematics department at Manchester University, under the leadership of Max Newman — one of the first groups, anywhere in the post-war world, to be involved in the development of computers.

At some point in the 1950's, before they were both settled in permanent jobs, Yael and Hugh spent several months as volunteers on a kibbutz in Israel. Hugh got a position at Birkbeck College, London,

Mean points and ergodic measures

Given a homeomorphism T of a compact metric space X, the *mean points* are the points x for which the ergodic averages $S_n(f)(x)$ with respect to T converge for every continuous function on X. A standard result in functional analysis implies that, if x is mean, there is an invariant probablity measure μ such that $S_n(f)(x)$ converges to $\mu(f)$. An invariant measure for T is called *ergodic* if the only T-invariant sets have full or zero measure. A mean point x for μ is *transitive* if μ is ergodic. The *support* of a probability measure μ on X is the smallest closed set of full measure (which does exist). If the measure μ is ergodic a mean point for μ in the support of μ is called *transitive dense* by Yael Dowker. The Birkhoff Ergodic Theorem ensures that there are regular points corresponding to any ergodic invariant measure. Transitive dense points and ergodic invariant measures always exist. The sets of mean points corresponding to different measures are disjoint, by definition. The set of mean points for μ has full measure for μ and is clearly invariant under T.

Yael Dowker showed, among other things, that the cardinality of the set of transitive (or mean) points in an infinite compact locally connected metric space is at least that of the reals [4].

The existence of an equivalent invariant measure

In 1955, Yael Dowker explored conditions for the existence of a T-invariant finite measure equivalent to a finite measure m, where T is a *nonsingular* measurable transformation of (X, m), that is T preserves sets of measure 0. One result was that a necessary and sufficient condition for the existence of an equivalent invariant finite measure is that $\liminf_{n\to\infty} m(T^n A) > 0$ for any measurable set with $\mu(A) > 0$. Averages of measures were also studied. For a probability measure m in the equivalence class of an invariant measure μ the Birkhoff ergodic theorem implies that

$$\lim_{n\to\infty} \frac{1}{n} \sum_{i=0}^{n-1} m(T^i A) = \mu(A).$$

If μ is an *infinite invariant* σ-infinite measure in the equivalence class of m then the averages do not exist in general, again a consequence of the Ergodic Theorem — Hopf's this time. In the same 1955 paper Yael Dowker showed that for $0 \le \alpha \le \beta \le 1$ there exists a set A such that

$$\liminf_{n\to\infty} \frac{1}{n} \sum_{i=0}^{n-1} m(T^i A) = \alpha,$$

and

$$\limsup_{n\to\infty} \frac{1}{n} \sum_{i=0}^{n-1} m(T^i A) = \beta.$$

Yael moved briefly to Westfield College, and then to Imperial College. She was the first woman to gain a readership in the department. At this time she was probably the only researcher in ergodic theory in the country. It was probably her study of mean points that led her to her into topological dynamics, in which pioneering work was being done in the 1950's. See "Invariant sets" and "How many measures?" for details of some of Yael's publications in this area. Her last paper on topological dynamics, with J. Auslander, was published in 1979.

The British school of ergodic theory

Gradually, starting in the 1950's, a British school of ergodic theory came into existence. The seed was planted by Yael Dowker, an immigrant who came to Britain almost accidentally. Altogether, she had four graduate students: Donald Cowell (PhD 1967), George Lederer (PhD 1963), William (Bill) Parry (PhD 1960), Ralf Trottnow (PhD 1975). Bill Parry was the first. The circumstances of Bill's arrival were unusual. Bill was a masters student at Liverpool, where he had become great friends with a research assistant called Jal Choksi, who worked under the direction of the head of department Professor Geoffrey Walker, a renowned geometer. Jal Choksi himself was following inclinations towards analysis. Bill and Jal talked a lot together, and Jal advised Bill to try and do his PhD thesis in Ergodic Theory, a subject in which he himself had become interested, and planned to work. He also identified Yael Dowker as a potential supervisor, in fact probably the only possibility for this study. So Bill Parry wrote to Yael Dowker. Yael was pleased to have this approach, she knew nothing about Bill Parry, but there were some good indications, including the fact that his masters dissertation actually included some original work that generalised part of the thesis of his friend Jal Choksi. Yael instinctively felt that this would work. But first they had to solve the perennial problem of funding. In 1957, the department at Imperial had grants for six PhD students and six first-class applicants for these places. Bill Parry had graduated from University College London with a II.1. Yael's solution was to get on the train to Liverpool, and ask the head of department if Bill Parry could have one of Liverpool's two PhD grants, to come and work with her in London. Geoffrey Walker said yes.

Bill Parry wrote his thesis with Yael on β transformations $x \mapsto \beta x \bmod 1 : [0,1] \to [0,1]$, a class of examples which has continued to interest and absorb researchers to the present day. Any subject has examples as the bedrock from which the theory develops.

Invariant sets

In [4], Yael Dowker states and proves a result, which she calls simply, "K", which she attributes to Bela Kerekjarto in 1934. Kerekjarto was a Hungarian topologist whose written work was very influential but also very hard to read. "K" is about a homeomorphism T of a compact space Ω, and a proper closed set $A \subset X$ satisfying $T(A) = A$. The result is that either there are arbitrarily small open neighbourhoods V of A satisfying $V \subset T(V)$ or there is a compact set K properly containing A satisfying $T(K) \subset K$, possibly both. In modern terminology such a set V would contain a *repeller*, while K might be termed a *stable set*. This extraordinarily general result seems not to be very well-known nowadays, but is clearly related to subsequent work on stable and unstable sets for homeomorphisms. It was a basic tool in some of Yael Dowker's work. It was used in [4] and [9], in essence to prove the existence of many ergodic invariant probability measures, via showing the existence of many closed invariant sets. In [5], the nonexistence of K satisfying $T(K) \subset \text{int}(K)$ is explored, a property which the authors call *T-connectedness.*

The theoretical basis of ergodic theory was now expanding rapidly, and Yael Dowker was crucially involved in this. The late fifties and early sixties were an extraordinarily busy time for Yael, both mathematically and personally. An indication of a broadening of her outlook can be found in a review she wrote in 1959 [8] for the *Bulletin of the American Mathematical Society* of Paul s *Lectures on ergodic theory*, published in Tokyo in 1956. Yael considered this to be the first book on the subject since E. Hopf's *Ergodentheorie* in 1937. She liked the style of Halmos's book but found the content a bit limited. There was little on the work done in the last decade, and nothing on recent work related to number theory, probability theory, abstract ergodic theory, dynamical systems: in particular, geodesic flows. Yael herself published a paper with Paul Erdős in 1959 [6] — which solved a problem posed by Halmos in a paper some ten years earlier. Yael and Hugh Dowker knew Erdős well — he visited the family quite often and their daughter knew him as "Uncle Paul".

How many measures?

A non-empty closed invariant set (under T) is called *minimal* if any proper closed invariant subset is empty. A minimal set clearly contains the support of an ergodic measure μ, if it intersects this support. Oxtoby showed, in a paper published in 1952, that if all points of X are mean points, then any minimal set is the support of exactly one ergodic measure. Yael Dowker and George Lederer [9] showed in 1964 that every point of X is a mean point (for some measure) and X properly contains a single minimal subset, then there is either just one ergodic measure, or infinitely many.

Ergodic theory from the Soviet Union

A. N. Kolmogorov is generally regarded as the founder of modern ergodic theory. But many sources describe him first and foremost as a probability theorist. It is not clear when it was first recognised that many cases of the Strong/Weak Laws of Large Numbers coincide with cases of the Individual/Mean Ergodic Theorems: the Laws of Large Numbers, in some forms, go back hundreds of years. But by the late 1950's, with L. M. Abramov, Y. G. Sinai and others joining the group round Kolmogorov, fruitful connections were being made and progress was rapid along several avenues. It was with this younger group that Yael Dowker made connection.

In 1959, Yael and Hugh spent at least six months in the Soviet Union, a visit organised by the London Mathematical Society, in cooperation with Russian colleagues. Hugh went first, to Moscow in October 1958. Yael followed about two months later. This was a very unusual research venture at a time when researchers in the same subject but different countries, especially on opposite sides of the Iron Curtain, often never met in person, communicating only by the occasional letter across the East–West divide, and often not even that. But Yael met members of the Russian school, in Moscow: L.M. Abramov, V. A. Rohlin, Y. G. Sinai among others, and attended their seminars. One of the main topics was Kolmogorov's new theory of entropy, and this was one of the topics that Yael Dowker helped to disseminate on her return to London. She published a paper in Russian [7] on a condition for an invariant σ-finite measure in a given measure equivalence class. In the early 1960's, Yael reviewed at least 13 papers by her Russian colleagues for *Mathematical Reviews*. The subjects included entropy, K-automorphisms, spectrum of unitary operators associated to measurable transformations, geodesic flows. She also translated some of the key papers for the LMS's *Russian Mathematical Surveys*.

Yael Dowker in 1961. (Image courtesy of Archives of the Mathematisches Forschungsinstitut Oberwolfach. Photographer Konrad Jacobs.)

In 1960 Yael gave birth to her daughter Ann, her only child. The following year she made a brief visit to New Orleans to attend a conference on ergodic theory. Hugh and Ann remained in London. (The Dowkers' fears, some ten years earlier, about their choice of friends and unremarkable left-leaning politics having attracted the unwelcome notice of the American establishment, were probably justified, as Yael was questioned by immigration officials on arrival in the US.) Bill Parry completed his thesis, and moved to a teaching post at Birmingham. He started to develop a centre there, with graduate student Peter Walters and a working seminar on entropy. His subjects of studies were influenced not only by his PhD but by the new work in the field disseminated from the Russian school by Yael Dowker.

Type II and type III von Neumann algebras

The classification of factor von Neumann algebras (factor essentially means irreducible) was a major work in the 1970's, with Alain Connes being a principal player, but important examples were created much earlier. A type I factor is simply the algebra of bounded linear operators on a Hilbert space (of varying dimension). The prime examples of type II and type III use ergodic theory. Hyperfinite type II examples use any ergodic measure-preserving transformation. Ergodic non-singular measurable transformations T of (X, μ) where μ is *not potentially invariant*, in Dowker's terminology, provide examples of type III factors, with the Araki-Woods *ratio set*, as described by W. Krieger, providing examples of types III_λ for $\lambda \in [0, 1]$. The ratio set can be regarded as a refinement of the conditions found by Yael Dowker for a μ to be not potentially invariant with respect to T.

The legacy of Yael Naim Dowker

The late 1960's and early 1970's were a golden age in mathematics in Britain. At least, so it seemed later, to the mathematicians who started their research careers at this time, not least in dynamics and ergodic theory. And so the subject which had effectively arrived in Britain with Yael Dowker became more widely established and flourished, especially in Warwick in the 1970's, with Bill Parry's group. This group included Peter Walters, who obtained his doctorate with Bill Parry in Birmingham, and Klaus Schmidt, who was encouraged by Bill Parry to move to Warwick from Vienna.

Functional Analysis had a high profile in the 1960's and 1970's, in particular the classification of von Neumann algebras. Yael Dowker's interest throughout her career, in (non)-existence of equivalent invariant measures had a role to play in this classification, with an extension of properties she found to the definition of type II and II measurable transformations. See "Type II and type II von Neumann algebras".

Yael Dowker remained at Imperial until her retirement in the 1980's. She remained close to the community she had engendered: the "Mother of Ergodic Theory in Britain", as she is sometimes known. In addition, the Dowkers and Parrys were lifelong personal friends. Through Bill Parry, in particular, Yael Dowker has many mathematical descendants, and the subject she nurtured and promoted continues to flourish to the present day.

Acknowledgements

I am indebted to Yael's daughter Ann Dowker, and to Liora Bernstein, daughter of Yael's cousin, and to Yael's friend Dona Strauss, for their help in filling in the picture of Yael Naim Dowker's fascinating life.

FURTHER READING

[1] en.wikipedia.org/wiki/Yael_Dowker Wikipedia, Yael Dowker 1919–2016.
[2] G. D. Birkhoff, What is the ergodic theorem? Amer. Math. Monthly 49 (1942) 222–226.
[3] Y. N. Dowker, Invariant measure and the ergodic theorems, Duke Math. J. 14 (1947) 1051–1061.
[4] Y. N. Dowker, The mean and transitive points of homeomorphisms, Ann. of Math. 58 (1953) 123–133.
[5] Y. N. Dowker, F. G. Friedlander, On limit sets in dynamical systems, Proc. London Math. Soc. 4 (1954) 168–176.
[6] Y. N. Dowker, P. Erdős, Some examples in ergodic theory, Proc. London Math. Soc. 9 (1959) 227–241.
[7] Y. N. Dowker, On mappings without finite invariant measure, Soobš. Akad. Nauk Gruzin. SSR 23 1959 391–396.
[8] Y. N. Dowker, Book Review: Lectures on ergodic theory, Bull. Amer. Math. Soc. 65 (1959) 253–254.
[9] Y. N. Dowker, G. Lederer, On ergodic measures, Proc. Amer. Math. Soc. 15 (1964) 65–69.
[10] W. Hurewicz, Ergodic theorem without invariant measure, Ann. of Math. 45 (1944) 192–206.

Mary Rees

Mary Rees is an emeritus professor of mathematics at the University of Liverpool. Her PhD advisor was Bill Parry, the first PhD student of Yael Dowker. Her main mathematical interests are in dynamical systems, especially in holomorphic dynamics and in systems with a strong geometric structure, and in related geometry. Outside mathematics, she now spends a lot of her time running.

The Oldest Mathematics Chair in England

ROBIN WILSON

Since 2006 the London Mathematical Society has shared an annual joint lecture with Gresham College in the City of London. But Gresham College has been presenting free public lectures for over 400 years, and its Professorship of Geometry is the oldest mathematical chair in England, predating those in both Oxford (1619) and Cambridge (1663). Here we outline the history of Gresham's Geometry Professors and feature some distinguished people who have held this position.

The founding of Gresham College

The Gresham professorships arose from the will of Sir Thomas Gresham (Figure 1). Born in 1519, he was admitted to London's ancient livery company of Mercers in 1543. Edward VI appointed him Royal Agent in Antwerp in Belgium, one of Europe's major commercial centres, where he amassed a vast fortune. Impressed by Antwerp's financial Exchange, Gresham offered to fund a similar stock exchange in London if the City Corporation would provide the site. This Royal Exchange, as it became, opened in 1566.

Figure 1. Sir Thomas Gresham

In 1575 Sir Thomas willed half of the Royal Exchange to the City of London and the other half to the Mercers. These groups were to provide £50 per year for each of seven professors to give free public lectures within his dwelling house in Bishopsgate Street. The professors were required to be unmarried, and a suite of apartments was provided for each one. These professorships, in Geometry, Divinity, Astronomy, Music, Law, Physic and Rhetoric, exist to this day, and others have been added recently.

Gresham died in 1579, but his wife survived him until 1596, when the beneficiaries came into possession of Gresham's house, which became known as Gresham College (Figure 2). As the *Ballad of Gresham College* later described it:

> If to be rich and to be learn'd
> Be every Nation's cheifest glory,
> How much are English men concern'd,
> Gresham to celebrate thy story
> Who built th'Exchange t'enrich the Citty
> And a Colledge founded for the witty.

Early days

From the beginning Gresham College encouraged the practical sciences of navigation, trade, commerce, manufacturing and medicine, rather than the Aristotelian studies still pursued at the ancient universities. The College statutes laid down that the lectures were to be read twice every week, with geometry on Thursdays at 8 am (in Latin) and 2 pm (in English):

> The geometrician is to read as followeth, viz. every Trinity term arithmetique, in Michaelmas and Hilary terms theorical geometry, in Easter term practical geometry.

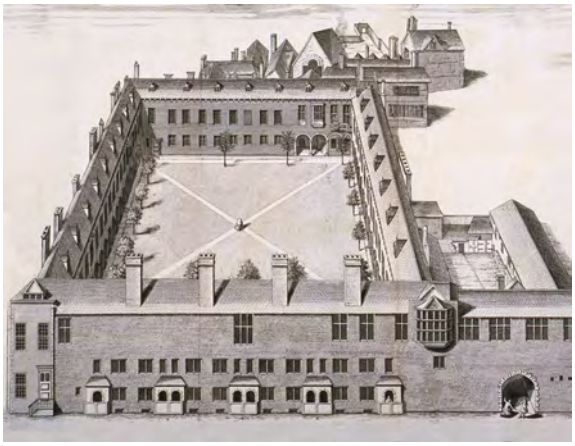


Figure 2. The original Gresham College

The first Gresham Professor of Geometry was Henry Briggs, who was appointed in March 1597 and worked on navigation and on constructing tables for the height of the pole star. By 1610 he was studying eclipses, and five years later became involved with logarithms, lately discovered by John Napier of Edinburgh who, in Briggs's words:

> set my head and hands a work with his new and remarkable logarithms … I never saw book, which pleased me better, and made me more wonder.

Unfortunately, Napier's logarithms were cumbersome — in particular, $\log 1$ was not equal to 0, and $\log ab$ was equal to $\log a + \log b - \log 1$. As Briggs continued:

> I myself, when expounding this doctrine publicly in London to my auditors in Gresham College, remarked that it would be much more convenient that 0 should be kept for the logarithm of the whole sine.

Briggs made two extended visits to Napier to discuss such matters. The result of these deliberations was that, while still at Gresham College, he devised his new base-10 logarithms, with $\log 1 = 0$. His *Arithmetica Logarithmica* of 1624, completed in Oxford where he had been appointed the first Savilian Professor of Geometry, contains his logarithms of $30,000$ numbers, calculated by hand to 14 decimal places. These proved to be an invaluable aid for mariners and navigators.

Gresham College and the Royal Society

In 1657 Christopher Wren was appointed Gresham Professor of Astronomy, while Lawrence Rooke, its previous occupant, became Professor of Geometry. In his inaugural address, Wren praised Henry Briggs, describing the invention of logarithms as "wholly a British art which at Gresham College received great additions".

Rooke had earlier spent some years in Oxford, assisting Robert Boyle in his "chymical operations" and attending meetings of "learned and curious gentlemen" in the rooms of Dr Wilkins, Warden of Wadham College. When Rooke moved to Gresham College, many of his Oxford associates — Boyle, Robert Hooke, John Wallis and others — attended his London lectures. On 28 November 1660, following a Gresham lecture by Wren, the Oxford group proposed the formation of a society. This new society, later the Royal Society, met weekly in Rooke's rooms at Gresham College.

In 1662 Rooke died, and was succeeded by the Cambridge mathematician Isaac Barrow, one of the earliest to investigate the fundamental theorem of calculus. Barrow held the Gresham Geometry Chair for two years, before returning to Cambridge as the first Lucasian Professor of Mathematics, the position later occupied by Isaac Newton and Stephen Hawking.

Robert Hooke, the ninth Gresham professor, is best remembered for his work with Boyle on the air pump, for his invention of the microscope and the universal joint, and for "Hooke's law" on the extension of springs. As the Royal Society's Curator of Experiments, he was required to design and present them to the public on a regular basis. In spite of bitter disputes with Newton and others, he seems to have carried out his Gresham responsibilities conscientiously for over 35 years, making the College an important centre for scientific research and debate. The Royal Society appreciated "the conveniency of making their experiments in the place where their curator dwells and the apparatus is at hand".

Shortly after Hooke's appointment, much of the City of London was destroyed in the Great Fire of 1666, including Gresham's Royal Exchange. The College narrowly escaped and became a temporary exchange, with the Lord Mayor living in the Divinity professor's lodgings, the Mercers' Company displacing the Law professor, and so on. Rebuilding the Royal Exchange proved costly, and proposals were made to save money by rebuilding the College on a smaller scale. Parliament was petitioned for approval, with only Robert Hooke, now frail and the only professor resident in the College, holding out against the plans. The bill failed, but further attempts were made after Hooke's death in 1703. Isaac Newton, who had became President of the Royal Society, petitioned Queen Anne for land on which the Society could build, and around 1710 the Royal Society moved from Gresham College to Crane Court.

The 18th and 19th centuries

The Gresham residence survived for a further 60 years before being demolished (Figure 3), but the

Figure 3. An 18th-century view of Gresham College

next two centuries proved to be largely a time of inaction. Few Gresham Professors are remembered from this period, and it is remarkable that the College survived.

In 1768, the Gresham College Bill finally passed through Parliament, and the house was pulled down. The lectures were transferred to the Royal Exchange, where they were presented for the next 70 years. These years proved to be another low period in the history of the Gresham lectures, as attendances declined and several professors were less than conscientious about their lectures, as they became uncooperative and unwilling to change their ways, while frequently causing difficulties for the Gresham committee who were trying to improve the situation.

In 1838 the Second Royal Exchange was destroyed by fire, with the total destruction of the lecture room. It was time for a new Gresham College, and this opened in 1843. Built at a cost of £7000 in the enriched Roman style, with its entrance on Basinghall Street, its lecture room was capable of holding 500 people.

Although most Geometry professors from the 19th century are largely forgotten, the 19th professor was one of the most distinguished. This was the applied mathematician, later statistician and biologist, Karl Pearson, who in 1884 became professor of applied mathematics and mechanics at University College, London, where he spent the rest of his working life. A highly effective teacher, his Gresham lectures were beautifully presented with graphics, models and slides, and his first highly successful series on applied mathematics led to a popular and influential book The Grammar of Science.

Pearson was greatly influenced by Francis Galton's book on natural inheritance, and he soon turned to statistics. His Gresham lectures on the geometry of statistics provided a comprehensive treatment of the graphical presentation of statistical data from the biological, physical and social sciences. His subsequent series, Laws of chance, discussed probability theory and correlation, and his Gresham lecture of 31 January 1893 introduced the terms "standard deviation" and "histogram" for the first time.

The 20th century

In 1894 Pearson resigned the Gresham Chair due to ill health, and was replaced by Henry Wagstaff, who held the post for 45 years, giving over 500 lectures. Meanwhile, Pearson co-founded the journal Biometrika and was its principal editor for 36 years.

In December 1939, shortly after the outbreak of the Second World War, the lectures were suspended, resuming in Autumn 1946. The new professor was the applied mathematician L. M. Milne-Thomson, who was well known for his books on theoretical applied mathematics and his Standard 4-figure Mathematical Tables with L. M. Comrie. At Gresham College he lectured for ten years on such topics as the geometry of configurations, and the measurement of aesthetic values, and was succeeded by T. A. A. (Alan) Broadbent, who had been President of the Mathematical Association and editor of the *Mathematical Gazette* for 25 years.

Broadbent's successor, Sir Bryan Thwaites, was the Founding Director of the School Mathematics Project (SMP), and his lectures on "Ways ahead in school mathematics" attracted substantial audiences. Thwaites was an early enthusiast for the use of computers in applied mathematics, and computers featured in several of his Gresham lectures.

The next Gresham Professor was the applied mathematician and historian of mathematics Clive Kilmister, who held the position for 16 years. A bold experiment to link Gresham College with the new City University in London aimed to attract audiences from both the University and the general public, but this arrangement eventually broke down, and Kilmister found himself lecturing in an unsuitable cinema in the Barbican and, more pleasantly, at the new City of London School buildings by the river. His successor, Sir Christopher Zeeman, also lectured at the School during his six years with the College, and his lectures regularly attracted hundreds of young people.

Figure 4. Barnard's Inn Hall in High Holborn

Barnard's Inn Hall

Finally, in 1991, everything changed yet again to what is essentially the current arrangement. Gresham College moved to Barnard's Inn Hall in High Holborn (Figure 4), one of the ancient Inns of Chancery, and for several years the geometry lectures were given in its fine hammer-beamed hall.

The Geometry professors are now elected for three or four years and give six lectures per year on any chosen branch of mathematics. Recent holders have included well-known popularisers of mathematics, such as Sir Christopher Zeeman, Ian Stewart and Sir Roger Penrose. Penrose's successor, Harold Thimbleby, focussed on the role of computers in the modern world, while my own Gresham lectures featured pure mathematics (especially combinatorics) and its history. Since then, the lectures have been given by John Barrow on a range of topics from applied mathematics, by Raymond Flood on the work of mathematicians from the 19th and 20th centuries, and currently by Chris Budd on the importance of mathematics in the world in which we live.

Because of their increased popularity, most lectures are now given at the Museum of London, and there are annual joint lectures with the London Mathematical Society and the British Society for the History of Mathematics. Gresham lectures can now be viewed on the College website, gresham.ac.uk, which holds an archive of around 2000 former Gresham lectures, and transcripts of many of them can be downloaded. With about 6 million downloads of Gresham College lectures per year, and with material from them used in teaching institutions around the world, it is probable that the state of the Gresham College Professorship of Geometry has never been as strong as it is has become in recent years.

Acknowledgement

An earlier version of this article appeared in the European Mathematical Society's Newsletter [2], and we are grateful for permission to adapt it here. The pictures are reproduced courtesy of Gresham College.

FURTHER READING

[1] R. Wilson, 400 years of Gresham College Professors of Geometry, 1, 2, BSHM Bulletin 32 (2017) 125–135 and 136–148.
[2] R. Wilson, The oldest mathematical chair in Britain, Newsletter of the European Mathematical Society, 64 (2007) 26–29.
[3] V. Shrimplin, Sir Thomas Gresham and his Vision for Gresham College, Gresham College, 2017.

Robin Wilson

Robin is an Emeritus Professor at the Open University, and was Gresham Professor of Geometry from 2004–08. He is currently a Visiting Professor at the London School of Economics. A former President of the British Society for the History of Mathematics, he has written and edited over 40 books on mathematics and its history.

Mathematical Societies: African Mathematical Union

The African Mathematical Union (AMU) was founded in July 1976 at the first Pan African Congress of Mathematicians, held in Rabat, Morocco. Its creation was the culmination of several meetings of African mathematicians that took place inside and outside of Africa throughout the early 1970s. The AMU was founded to coordinate and promote the quality of teaching, learning, research and awareness activities in all areas of mathematical sciences throughout Africa. The AMU's work in advancing mathematical research and education includes efforts and contributions towards the economic, social and cultural development of the continent.

In 1986 the AMU established four Commissions: "Pan African Mathematics Olympiads", "African Women in Mathematics", "Mathematics Education in Africa", and "History of Mathematics in Africa". In 2009 a new commission on "Research in Mathematical Sciences and Innovation" was created. Through these, the AMU has run the Pan African Mathematics Olympiads 27 times, and has organised and supported a large number of conferences, workshops, and symposia in various African countries.

AMU General Assembly held in September 2018 at the Sciences Faculty in Rabat

One of the most important events run by the AMU is the Pan African Congress of Mathematicians (PACOM). This is held every four years in an African country. It is organised in collaboration with the host country, and with the scientific and financial support of several international organisations including the LMS, EMS, IMU, CIMPA, ICTP, UNESCO. The 10th PACOM will be hosted by the Republic of Congo, in Brazzaville, from the 1st to 8th July 2021.

The AMU has run the journal *Afrika Matematika* since 1978. It provides a platform both for presenting high-level mathematical research done in Africa, and for bringing international mathematical research to Africa, and is open to authors worldwide. *Afrika Matematika* is currently undergoing a substantial relaunch, under Editor-in-Chief, Prof. Jacek Banasiak of the University of Pretoria. Its Editorial Board has been restructured and widened to include distinguished mathematicians from various African countries, and from the other continents.

Morocco, the country winner of PAMO 2019 Gold Medal, in South Africa

Forty-three years after the creation of AMU, the current Executive Committee is working to define a new vision for the AMU, to better meet the requirements and expectations of the AMU in the 21st century. We are updating the goals of the AMU, and developing a better strategy for enhancing the development of mathematics in Africa. For this a draft of our revised statutes and internal regulations will be presented for approval at the AMU General Assembly, on the 1st July 2021 in Brazzaville.

Furthermore, a database of African mathematical associations, societies, foundations etc. is nearing completion, and all these African organisations will be invited to join AMU to help us achieve our common goals. International mathematical organisations are of course welcome to join the AMU — partnership and collaboration are deeply wished for and would be valued. More about the AMU can be found on its website www.africamathunion.org.

Nouzha El Yacoubi
AMU President

Talking Maths in Public

Talking Maths in Public (TMiP) is a conference for maths communicators, by maths communicators. One of the organisers tells us about the conference, and several attendees share some of their highlights of the 2019 conference and offer some tips for those new to maths communication.

Samantha Durbin *is the Clothworkers' Associate in Mathematics at The Royal Institution.*

TMiP was born from a desire to have a regular UK-based opportunity for professional development and networking with other maths communication and outreach practitioners. The four organisers are Samantha Durbin (myself), Kevin Houston, Ben Sparks and Katie Steckles, largely doing this in our "spare time". We have tried our best to create something we would enjoy and find useful: an event where we hope to learn from each other, share ideas and have the space to create new things and make new friends. There are many excellent conferences in adjacent fields, including maths education and science communication — and existing maths communication conferences which run in different places, such as the MATRIX conference. We've borrowed our favourite bits, asked the community what they would like to see, worked on having a variety of things each year and the result is TMiP. We've tried hard to balance the sessions and keep a focus on inclusivity and accessibility throughout.

TMiP 2019 took place in sunny Cambridge, generously hosted by the Isaac Newton Institute. We had several days packed with a range of different sessions, hoping there would be something for everyone no matter the type of maths communication they do — or want to do — followed by a Saturday morning of fun maths-related activities (I mean, important networking) such as crafts, board games and a Treasure Punt (a boat-based treasure hunt, organised by the wonderful *Chalkdust* team from UCL). We had an amazing range of attendees from many backgrounds and areas, and thanks to generous funding from the LMS we were able to offer attendance bursaries to seven people. It was great to have so many different people doing different types of 'talking maths in public' all in one place, including practitioners from more general science communication looking to improve the M in their STEM outreach, and it was a truly collaborative environment.

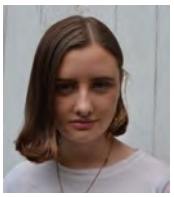
We would like to say a huge "thank you" to everyone who made TMiP 2019 such a success and we hope you can join us again in 2021! If you weren't involved and would like to join us or find out more, please sign up to our newsletter via eepurl.com/gkcB6X.

Chris Attenborough *is a PhD student at the University of York.*

One highlight of TMiP for me was a workshop run by Andrew Sharpe, who delivers NRICH's Maths Roadshow. This was a great session with a variety of hands-on Maths puzzles, which I failed to take advantage of because I spent almost the entire hour working with a Maths teacher to complete an activity aimed at KS3 students. We were very proud of our final product, and sagely concluded that it is a lot easier to find solutions to a problem when you have already found one.

James Grime spoke about error correction and drilled a hole in a CD. James went into a lot of detail about how he has developed the demo and discussed the contingencies he has in place in case certain aspects don't go as planned. I think the best aspect of James's demo is how it also indirectly demonstrated the value of thinking things through.

I also attended a session run by Duncan Yellowlees on giving and getting good feedback. Duncan made a point that we should refrain from giving unsolicited feedback, so I won't include any of the nice things I have to say about it.



Martha Bozic *is a recent graduate and aspiring maths communicator.*

Ending Friday is a keynote by magician Neil Kelso. He starts with a magic trick, then breaks it down in front of us. Not giving away the trick itself, but instead the tricks behind the trick. How to make

your audience feel comfortable and how to get them to trust you. It is the first time I have considered a power dynamic controlled by the speaker and not the audience.

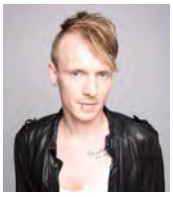
On Saturday I choose Chalkdust's Treasure Punt. We punt down the river Cam in teams, picking up clues along the way, in order to solve a puzzle and discover the code which unlocks a box of 'treasure'. The activity itself is frankly genius and I would happily do it again, punting included. That said, I am firm in my belief that punting is the worst method of boating I have ever encountered. 10/10 for *Chalkdust* and boats on the Cam, 3/10 for whoever invented punts.

Sarah Cosgriff *is a freelance science communicator.*

Talking Maths in the Public was the first maths communication event I had ever been to, so I wasn't sure what to expect. To my delight, I gained quite a lot from the conference and felt welcomed by attendees and the organisers.

The conference involved a broad mixture of sessions, for example how to design activities, using Twitter to engage others, writing books and blogs, producing videos and presenting to an audience from a magician's perspective. I was really impressed with the maths communication I saw and it encouraged me to think more creatively about my own practice. I felt the sessions were accessible to anyone brand new to maths communication.

The organisers made me feel well supported as a speaker and had really thought about how to make the event inclusive. For example, they had a video walkthrough of the space, a quiet room and code of conduct. For those who were newer to maths communication, there was a lunchtime meet up for those to meet others and network. I'd recommend TMiP to anyone interested in maths communication but also to science communicators who would like a different perspective.



Tom Crawford *is a maths communicator with Tom Rocks Maths and the University of Oxford.*

Talking Maths in Public was hands-down the BEST conference I have ever attended. The incredible skill, passion and experience of the attendees was second only to the welcoming and friendly atmosphere across the 3 days.

The keynote given by magician Neil Kelso was particularly inspiring. The way in which he was able to control his audience through every little detail of his performance on stage was mesmerising to watch and hearing him break down these movements to explain exactly what role each one played within his show was fascinating. I will certainly be trying to use as many of his tips as possible in my next show!

If you're thinking about whether maths communication might be for you, my advice is simple: just give it a go! No one expects you to be perfect (or in fact even functional) on your first try, the most important thing to remember is that you learn from experience, so take that first step and hopefully in a few years' time you can look back with fondness at that first video/performance/article and see just how far you've come.

Zoe Griffiths *is a Maths Communicator for Think Maths.*

Here are a few things I heard over the course of the TMiP conference that resonated with me.

Brady Haran told us to "do the thing other people won't". In Brady's case this was making a video about *every single* chemical element, whereas Jen of Primrose Kitten voluntarily taught her GCSE students via YouTube immediately after the birth of her baby, and Tom Crawford is willing to remove items of clothing to help communicate mathematics.

Simon Singh gave us the sobering but realistic message that we should go into writing a maths book "assuming it will be a financial loss". We must do it "for the love of it". He also told us the way to improve our writing is to "practise and get feedback".

And my favourite piece of advice from the whole conference encourages us to try out new things, even though we know the result will not be polished: magician Neil Kelso told us "if you always have the pressure of being good, you will learn less".

And thus my TMiP take-aways are to: try things out, take risks, be different and do it for the love of it.

Alison Kiddle *is Secondary Teacher Associate at NRICH, and a freelance maths communicator.*

I found the Talking Maths in Public conference invigorating and revitalising. The Lightning Talks session gave a fantastic overview of lots of amazing maths education, communication and outreach initiatives that are changing perceptions of mathematics. I particularly appreciated the Guided Development workshop in which we were given advice on what to consider when planning a project or event, and then given time and space to explore a particular idea with others who were interested in the same things. Most important for me though was the sense of community that I felt, spending two and a half days talking to like-minded people, and having the space to think creatively about how to talk about mathematics. I came away from the conference bubbling with ideas, and I can't wait to implement some of them!

Matthew Scroggs *is a postdoc in the Department of Engineering, Cambridge.*

On a cold damp mid-winter day in early 2015, a group of PhD students gathered in a room in UCL. On that day, *Chalkdust* was born. *Chalkdust* is a magazine for the mathematically curious that is published every six months. *Chalkdust* was my point of entry into the world of maths communication.

A few (or to be more precise, two) years after we began producing *Chalkdust*, I heard about TMiP and went along. I met a ton of people and encouraged them to write an article for *Chalkdust*; and a ton of people met me and encouraged me to be a guest host on their podcast, appear in their YouTube video, or write for *The Aperiodical*. There are many great maths communication projects out there that regularly feature content from people like you: my first piece of advice to anyone looking to get into maths communication would be to submit something to one of these, and get your work out there.

My second piece of advice is to ignore everyone except *Chalkdust*, and send us your articles.

Adam Townsend *is a postdoc in the maths department at Imperial College London, and an associate of the AMSP.*

I like to balance my research role (currently looking at the maths of sperm swimming through mucus) with outreach at enrichment events and in schools (where I talk slightly less about sperm and more about chocolate). I'm also one of the editors of the maths magazine *Chalkdust*, where I get away with publishing the world's worst maths puns every six months.

What I value most about TMiP is the opportunity to have honest discussions with people at all levels about their experiences; getting into the technical detail of preparing slides or interacting with audiences, as well as big-picture stuff in outreach areas I don't participate in. For example: How much work does it take to create a good YouTube video? (A few days per video; make sure you have good sound.) How do you involve an audience member without overwhelming them with pressure? (Pick two, or direct focus elsewhere while they're working.) How can you make a career in maths outreach sustainable? (Marry well...?)

In case you were wondering where a good place to start writing might be, I noted that Simon Singh mentioned a niche magazine called *Chalkdust*...

Esmee te Winkel *is a PhD student at the University of Warwick.*

Before the conference I was not sure what to expect. I had not attended a maths conference before that was not topic specific.

The organisers were very aware of accessibility and inclusivity issues. The feeling that everyone was welcome led to a comfortable environment, which aided respectful and fruitful discussions. I specifically enjoyed the discussion session on giving and receiving feedback. I became aware that being able to tailor your feedback is a very valuable skill.

I did not expect to get to know so many new people in a short conference like this. I had a great experience and I would love to come again next time.

Microtheses and Nanotheses provide space in the Newsletter for current and recent research students to communicate their research findings with the community. We welcome submissions of micro and nanotheses from current and recent research students. See newsletter.lms.ac.uk for preparation and submission guidance.

Microthesis: Modelling Purification of Flue Gas in Porous Catalytic Media

KRISTIAN KIRADJIEV

In the drive to protect the environment, reducing the concentrations of harmful chemicals that are released into the atmosphere has become a priority for industries. My DPhil project aims to develop a multiscale mathematical model that describes and helps optimise the performance of a filtering device for toxic gases.

Introduction and motivation behind the project

Sulphur dioxide (SO_2) is a major component of flue gas. However, due to its toxicity, its concentration needs to be sufficiently reduced before it is released in the atmosphere. Common methods for achieving this are very expensive and complicated to install.

What W. L. Gore & Associates, Inc. (Gore), the producer of Gore-Tex, propose is to use a special filtering device that converts gaseous SO_2 into liquid sulphuric acid (H_2SO_4). This filter consists of numerous millimetre-thick porous sheets folded into a series of open channels (see Figure 1).

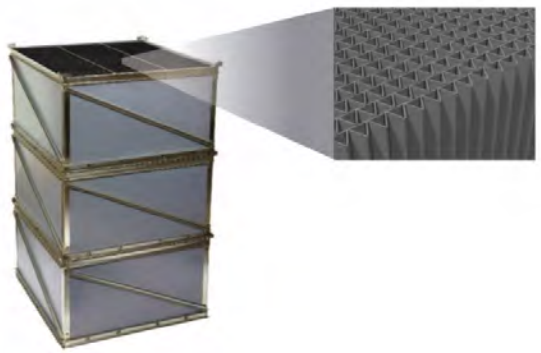


Figure 1. Three modules of Gore's device

The flue gas flows through the channels and diffuses into the sheets, where, together with oxygen and water vapour from the surroundings, SO_2 reacts on the surface of microscopic catalytic pellets, held together by fibres, to produce liquid sulphuric acid. The benefits of this purification method include lower total cost of ownership of the device, easier installation, and production of sulphuric acid "for free".

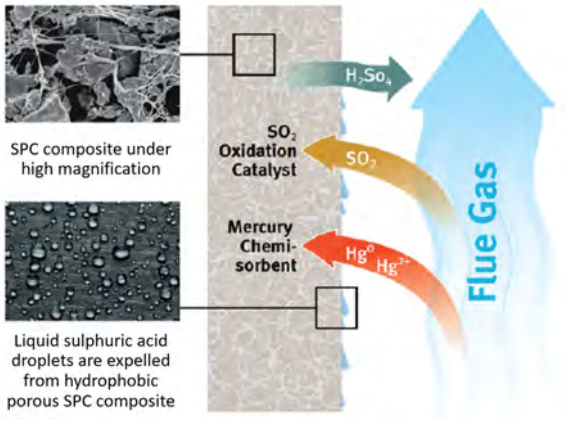


Figure 2. Schematic of the filter operating mechanism

Challenge and need for a mathematical model

The problem with this filter is that over time liquid H_2SO_4 accumulates, preventing further SO_2 from entering the device. This in turn reduces its efficiency.

My project focuses on a multiscale mathematical model that can give insight into the transport mechanism of gas and liquid within the filter, and so can aid in making predictions about the optimal operating regime by simply manipulating certain system parameters. Without such a model, testing new filter designs or performing full numerical simulations by Gore is very expensive and time-consuming.

To begin with, I focused on the microscale at the scale of a single catalytic pellet. The idea was to solve the flow problem locally and then upscale the results

to the whole filter. I formulated a fundamental fluid mechanics problem concerning the spreading of a thin liquid film (of thickness h) with fluid generation in a finite region of the underlying substrate. This mimics the liquid production on the surface of the pellets due to reaction and the subsequent liquid flow over a fibre attached to the pellet. I derived a corresponding fourth-order thin-film equation with a source term f that is applied on part of the domain and represents the fluid generation

$$\frac{\partial h}{\partial t} + \frac{1}{3}\frac{\partial}{\partial x}\left(h^3\frac{\partial^3 h}{\partial x^3}\right) = f(x,t).$$

We found that, in the case of constant injection $f = \text{const}$, at large time the film thickness evolves like $h \sim t^{3/7}$, whereas the position of the film front, a, evolves like $a \sim t^{4/7}$. We also considered a time-dependent injection, $f = t^k$, and found the critical exponent $k = -3/4$, such that, for $k > -3/4$, the film thickness increases with time, and otherwise it decreases. We further investigated the cases of point-source ($f = \delta(x)$) and thickness-dependent ($f = h^k$) injection. More details of our findings can be found in our paper [1].

Homogenisation

The theory of homogenisation is a powerful mathematical technique that is often used to upscale a local microscale model. This is usually done by introducing both microscale, x, and macroscale, X, variables related by

$$X = \epsilon x,$$

where ϵ is the ratio of the characteristic microscopic and macroscopic length scales, and is small. Homogenisation provides a systematic and rigorous way of averaging over the complicated microstructure while still capturing its effect on the overall system dynamics. An example is modelling fluid flow through porous media.

Next I moved on to the macroscale, i.e., the scale of the whole device, incorporating the effects of the microscale. I am now working on a macroscale model using the theory of homogenisation (see "Homogenisation"), first ignoring the effect of the fibre network, i.e, just modelling the fluid generation around each pellet. The aim is to obtain averaged equations for the concentration of SO_2, S, and amount of liquid H_2SO_4, $\mathcal{V}$, that still capture the effect of the underlying porous microstructure. The set of dimensionless equations that I obtained has the following general form

$$\frac{\partial S}{\partial t} = \frac{1}{\mathcal{V}}\nabla\cdot(\mathcal{V}D(\mathcal{V})\nabla S) - g_1(S,\mathcal{V}),$$
$$\frac{\partial \mathcal{V}}{\partial t} = g_2(S,\mathcal{V}),$$

where g_1, g_2 are non-linear functions, and $D(\mathcal{V})$ is the effective diffusivity tensor.

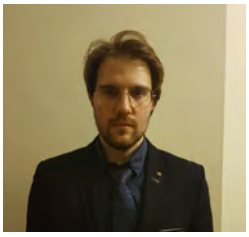
Currently, I am varying parameters and looking at possible asymptotic regimes to optimise the filter efficiency. In the future, I would like to incorporate the effect of the fibres on the liquid transport, and more specifically, the capillary effects from the local thin-film analysis mentioned above. Our model so far accurately describes the beginning of the filtration process as confirmed by experimental data and gives Gore insight into optimising filter performance.

Acknowledgements

This publication is based on work partially supported by the EPSRC Centre For Doctoral Training in Industrially Focused Mathematical Modelling (EP/L015803/1) in collaboration with W. L. Gore & Associates, Inc.

FURTHER READING

[1] K. B. Kiradjiev, C. J. W. Breward, I. M. Griffiths, Surface-tension- and injection-driven spreading of a thin viscous film, J. Fluid Mech. 861 (2019) 765–795.



Kris Kiradjiev

Kris Kiradjiev is a DPhil student at the InFoMM CDT, University of Oxford. His main research interest is in mathematical modelling of industrial processes using tools such as asymptotic analysis, but he is also very much interested in fluid dynamics, mathematical geoscience and application of complex analysis. Kris is passionate about learning new languages, reading, and playing the piano.

LMS Early Career Fellowships: How to Write a Good Application

HENRI JOHNSTON

To support early career mathematicians in the transition between PhD and a postdoctoral position, the LMS offers fellowships of between three and six months to mathematicians who have recently or will shortly receive their PhD. This article gives some advice on how to write a good application.

What is an LMS Early Career Fellowship?

The Early Career Fellowships follow on from the 150th Anniversary Postdoctoral Mobility Grants, which ran from 2014 to 2017. In March 2019, 46 applications were considered for the first round of the new scheme and 11 fellowships were awarded.

At least eight fellowships of between three and six months are awarded each year to mathematicians who have recently or will shortly receive their PhD. The award will be calculated at £1,200 per month plus a travel allowance of £800. The fellowships may be held at one or more institutions but not normally at the institution where the fellow received their PhD.

Full details including eligibility criteria, conditions of award and how to apply can be found here: lms.ac.uk/grants/lms-early-career-fellowships.

Advice on how to write a good application

The first point should go without saying: the applicant should carefully read all the information on the website above before preparing their application.

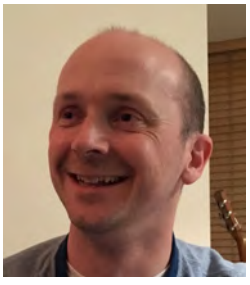
The proposed project should be explained for a non-specialist reader while, at the same time, it should demonstrate novelty and be of a high mathematical level. Moreover, a good case should be made as to why the proposed host institution(s) make sense and why the fellowship would be transformative. The applicant should also explain how the fellowship fits into their longer term career plans. It helps to be specific where possible. In particular, a clear explanation of the timing of the fellowship in relation to the award of the PhD and to any future position should be given. Note that plans to apply for grants or positions are more convincing if the schemes or institutions are named and deadlines are given.

A letter of support from an academic host at each institution where the proposed fellowship will be held should be included. In addition to giving the formal assurances required by the guidelines, it would be useful if such letters contained some specific information about the applicant, their work and support for the suggested project.

Applicants with circumstances that make moving impractical should explain these circumstances briefly in the covering letter. Reasons that have been accepted in the past include caring responsibilities and access to specialist medical care.

Students coming towards the end of their PhDs would be well advised to prioritise publishing articles (or at least posting preprints on the arXiv) over other activities. Articles 'in preparation' are less convincing; if they are listed on an application, then it would be useful to indicate the stage of preparation including the number of pages actually written.

Finally, the committee was disappointed that some applicants were let down by their letter writers; the following guide on avoiding gender bias may be useful tinyurl.com/yyjtqtds.



Henri Johnston

Henri Johnston is a senior lecturer in pure mathematics at the University of Exeter. He has been a member of the LMS Early Career Research committee since autumn 2017. His main research interests are in algebraic number theory. He enjoys telling really bad jokes, as those who attend his lectures will attest.

2020 HEILBRONN FOCUSED RESEARCH GRANTS

Heilbronn Institute for Mathematical Research

Call for proposals

The Heilbronn Insititute for Mathematical Research is offering a number of grants of up to £7.5K to fund focused research groups to work on adventurous and challenging mathematical problems, or to discuss important new developments in mathematics.

These grants will support travel and local expenses for groups to come together to focus intensively on a problem or to discuss a significant new development in mathematics. We expect these groups to be normally 8 or fewer people. Groups are encouraged to include international participants, but should also involve a substantial UK-based component.

Open to all mathematicians and to any department in the UK.

Proposals from these areas of research, interpreted broadly, will be given priority: Pure Mathematics, Probability and Statistics, and Quantum Information.

Proposals of no more than one page of A4 should be sent by 9am, Thursday 16th January 2020 to: heilbronn-manager@bristol.ac.uk. For further particulars and additional information, please visit our website: http://heilbronn.ac.uk/opportunities.

Halima Cassell, Eclectica-global inspirations

Manchester Art Gallery, until 5 January 2020, free entry

Review by Mike Prest

Flame and *Nuages (Dreams)*. Photograph by Mike Prest

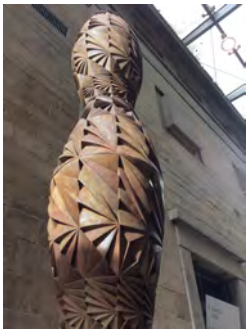
Halima Cassell was born in Pakistan and grew up in Manchester. She makes abstract sculputures which boldly embody complex geometries. In the video accompanying the exhibition she talks about the influences on her work: architecture, mathematics and symmetry in particular. Natural forms, living and mineral, are inspirations. Some of her ideas for new works occur in dreams or in a state between dreaming and full consciousness.

The centrepiece, Virtues of Unity, is a collection of bowls, arranged in three concentric circles. They vary, in colour, shape, tactile qualities (as judged by the eyes only!). Their clays come from a wide range of countries. They are deeply incised and have crisp edges. Some flow, some are static. All embody multiple symmetries. Individually, each is fascinating and together they are stunning.

Virtues of Unity developed, after a visit to Pakistan, from her thinking about immigration and the basic virtues that connect us all. Each bowl is associated to a virtue and to a country from which she collected, or was sent, its clay.

A second exhibition room has more of her intricate, beautiful and fascinating works in a wide variety of materials (terracotta, wood, glass, marble, bronze). They very successfully combine surface — colour and texture — and solid form.

Some of the pieces on display are frozen and crystalline while some are dynamic, caught in mid-flow and full of the tension of arrested movement. Many are, at least in parts, triangulated. Some express deviations, intended or not, from symmetry and perfection.



Fan Structure. Photograph by Mike Prest

Cassell's early works were influenced by the repeated geometric patterns of Islamic design and the architecture of the North West of England. For example, Mancunian Roofscapes, inspired by terraced-house rooftops, is very regular and angular; it contrasts sharply with the complexity and fluidity of most of the other, later, pieces on display. In the video, Cassell talks about the influences which have changed her work. On a visit to Italy she learned to work in marble, a calm process compared to working with clay where drying and firing can lead to irreparable damage. While in Japan, she learned to embrace asymmetry and imperfection, for example employing Kintsugi techniques to fill cracks that appear on drying.

The video and the accompanying notes tell us something about Cassell's vision and what goes into conceiving and developing these works. She talks about loving mathematics and problem-solving; indeed, in planning and execution she shows a remarkable ability to transfer flat designs to 3-dimensional objects and their surfaces. Some works, especially those based on spheres, are quite astonishing - finely-judged, highly symmetric structures with intertwining patterns emerging from deep within the solid body.

A couple of large-scale items are on display in the centre foyer of the gallery. There's a tall wooden column, deeply incised with clusters of triangles, spi-

ralling upwards, and a massive bronze 'fragment' (a few pieces creatively reflect the difficulties of working with not-entirely-predictable materials). Bow Wave, a beautiful piece in white marble, just partly-carved and showing the design guide lines, is on display in the front foyer.

Back to those bowls. There are almost 40 of them. Some are smooth white marble, some rich reds and browns, others rough-surfaced, black and volcanic. There's a family resemblance but each is fascinating and individual in its design. Too much perhaps to appreciate in one session, so have a break and wander round the gallery - there's a set of De Morgan (son of Augustus) tiles upstairs and plenty more to see - before returning for another look.

Mike Prest

Mike is a Professor of Pure Mathematics at the University of Manchester. His research is in algebra and model theory.

Report of British Science Festival, 2019

Warwick and Coventry, 10–13 September

Report by Peter Giblin, Treasurer for the Mathematical Sciences Section of the British Science Association

The British Science Festival (britishsciencefestival.org) was hosted this year by the University of Warwick and the city of Coventry, with over 100 events taking place on the campus of the University during the afternoon and in the city centre during the evening.

What is the connection between a Penrose tiling and a crowd of football fans? In fact both were topics of maths lectures organized by the Mathematical Sciences 'Section' of the British Science Festival this year. Aoife Hunt, associate director of Movement Strategies (tinyurl.com/yxhwryyn) and this year's President of the Section, gave a lecture 'Moving with the crowd' on simulating crowd behaviour and movement for safety and security—for example avoiding a crush, allowing safe and speedy evacuation and minimising waits in queues. She spoke about flow along a corridor, where, as with traffic flow, congestion produces shock waves, nodes and antinodes, in the context of designing spaces and routes to maximise flow. Modelling crowds travelling to an event, such as the Commonwealth Games, presents different problems such as scheduling of buses and trains. Besides large scale 'crowd behaviour', understanding smaller scale individual behaviour of different people is needed—spacing, hand-holding, purposeful walking etc., according to the type of event, and now this new understanding can underpin the modelling of different crowds at large stadiums such as Wembley stadium. Many mathematical techniques have been used: purely mechanical, cellular automata, agent-based information sharing, game theory utility calculations, Monte Carlo methods and Markov chains to name a few. Emergency decision making, including 'pre-evacuation decision delay' and 'getting dressed time' is the subject of current research, and new 'real-time' crowd modelling techniques are being developed to enhance safety and security in live environments.

Aoife's talk was followed by a wine reception kindly sponsored by the Operational Research Society and held in 'The Dome', a marquee on a nearby piece of lawn. The Dome was used throughout the Festival as a meeting place and refreshments tent for all visitors.

The second Section lecture was by Priya Subramanian, who now works at Oxford with previous postdoc positions in Göttingen and Leeds. Her topic was 'Forbidden symmetries', referring to patterns in 2 and 3 dimensions exhibiting rotational symmetry other than order 2,3,4,6 as for regular wallpapers and crys-

tals, but having no translational symmetry. One of the most famous examples is the 1977 Penrose tiling with kites and darts and 5-fold symmetry (the possibility of tiling with a single shape is still an open question). But equally famous is Dan Shechtman's 1983 discovery using diffraction of a metallic alloy with 10-fold rotational symmetry, something hotly disputed by the great scientist and peace activist Linus Pauling until his death in 1994. The official definition of 'crystal' was amended to embrace these 'quasi-crystals' in 1992 and Shechtman was awarded the Nobel Prize in Chemistry in 2011. Priya went on to describe applications and more recent developments such as non-stick pans made of quasi-crystals, the search for non-metallic instances and the discovery in 2015 that meteorites from Siberia contained quasi-crystals. She asked what a minimal recipe for generating 2 or 3 dimensional patterns could be and showed that strong nonlinear interactions governed by two incommensurable length scales were sufficient to form both 2 and 3 dimensional quasicrystals.

l to r Nicholas Jackson (Warwick representative), Tony Mann (Recorder/Chair of the Section), Kevin Houston (LMS representative), Aoife Hunt (President), Peter Giblin (Treasurer)

Two lectures organized by other Sections involved medical applications of mathematics. One, 'AI for cancer diagnosis' was given by Prof Nasir Rajpoot, Wolfson Fellow of the Royal Society and Turing Fellow of the Turing Institute, describing his work at the University of Warwick and with national and international hospitals. Nasir described the process of taking a biopsy, slicing into sections 2 or 3 microns thick and visual examination of the sections by a pathologist, a lengthy and subjective process. But digitising the images and using recent AI algorithms trained on an image database speeds the process enormously. Expert pathologists are still needed to outline a likely tumour and in the training process but algorithms can then perform better on new images than even the pathologist. Nasir went on to talk about oncology, that is treatment of tumours, and to raise important questions about consistency and bias in algorithm design and ethical questions about security and privacy of data.

The second lecture on medical applications concerned diagnosis and treatment for couples who have experienced multiple miscarriages: every year there are 14,000 couples have been through this trauma compared with 700,000 annual live births. Siobhan Quenby who is Professor of Obstetrics, and Deepak Parashar from the Statistics and Epidemiology Unit at the University of Warwick spoke about theories advanced to explain miscarriages and, crucially, testing theories in a statistically robust way through randomized trials. Thus scratching the lining of the womb was found to have no significant effect, but those with a high level of inflammation in the womb had a decreased probability of a successful pregnancy. Inflammation in the lining of the womb could be reduced with antibiotics and inflammation may be a preventable cause of miscarriage. Deepak described in detail the design of trials including methods for deciding when to halt the trial at the halfway stage if there is no prospect of a definite outcome. Surprisingly, it is not hard to recruit the large number of couples, about 500 per year per site for a total of 3000, needed for a statistically significant trial.

There were also a number of mathematical events during the Family Day on Saturday 14 September, by Nicholas Jackson, Kyle Evans and Zoe Griffiths, including maths busking, cut-and-build polyhedra, experiments with Möbius strips and other entertainments.

Next year's Festival will be held from 8 to 12 September 2020 at Anglia Ruskin University in Chelmsford.

Peter Giblin

Peter Giblin OBE is Emeritus Professor of Mathematics at the University of Liverpool where his research interests are in singularity theory and its application to computer vision and differential geometry. In his spare time he serves on several committees, including the mathematical sciences section of the British Science Association, and enjoys taking part in outreach to schools.

The Prime Number Conspiracy: The Biggest Ideas in Math from Quanta

Edited by Thomas Lin, MIT Press, 2018, paperback, pp336, £14.99,
ISBN: 978-0-26253-6356

Review by Gavin M Abernethy

This book consists of a selection of articles, generally concerned with developments in mathematics, from online science publication *Quanta*, and is published in tandem with a parallel volume for physics (*Alice and Bob Meet the Wall of Fire*, MIT Press, 2018). As a reviewer who has never read *Quanta*, I found this to be a mostly-entertaining collection of 37 short articles, compiled into seven chapters. Whilst not necessarily a mathematician, the reader would need to be scientifically literate. The text is entirely prose, and concepts such as chromatic polynomials are always given an intuitive rather than technical explanation, but you will need to know what geometry, parabolas and equilibria are in order to keep up.

The first chapter, documenting a series of recent developments in prime number theory that lend the book its title, seems to be intended for a linear reading and is arranged in such a way as to construct a structured narrative. However, subsequent chapters act as independent collections of articles in a general subject area: order and patterns hidden in biology and physics; brief histories of how an important proof was obtained; biographical sketches of mathematicians with unusual backgrounds; or recent research on the continuum hypothesis. The final chapter does not address the provocative question of its own title ("Is mathematics good for you?"), being more of a gathering of articles concerned with some social aspects of higher education and public engagement. Most chapters include an interview with a prominent researcher in the subject area, with some more focussed on the subject's research, while others (for example with Freeman Dyson) dwell on their personality and circumstances.

The very loose structure leaves the book mostly open for readers to dip in and out of, and I would recommend digesting its content in this manner. Reading the entire book cover-to-cover will result in some redundancy, with the definition of prime numbers and the reputation of the Fields Medal being explained on numerous occasions, and you will be introduced to a host of characters who make only brief appearances. I also found in the later chapters on computing and infinity that it is not always clear how the ideas discussed in adjacent articles relate to each other.

Despite the diverse nature of the subject matter (and eight contributors), strong themes emerge regarding the surprising and highly-connected nature of mathematical reality. Many articles, especially in the first half of the book, highlight the relationships that are being discovered between different fields of mathematics and physics — for example between groups and spectral functions; between motives in algebraic geometry and Feynman diagrams in particle physics; or between different paradigms for contemplating movement on random geometric surfaces. Second, the brief narratives demonstrate how often the problem or puzzle's answers (or the precursors to them) are inspired by forgotten research papers that were published in other fields. Arguably one goal of mathematics and physics is to uncover deeper underlying theories that unify seemingly-unrelated topics, and this selection of articles highlights how frequently these strides occur as a result of a researcher noticing a small connection by chance. Finally, certain concepts such as the prime numbers and the Riemann Zeta function arise often in various contexts in this book, hinting at their pervasive role in connecting branches of mathematics.

Most of the articles are nicely digestible at around eight pages. Of course, combined with the variety of topics touched on, this brevity means you will not learn a great deal about any particular subject. Furthermore, the exact contents are not easily inferred from the article titles, so you cannot really look for information on a specifc topic. With that in mind, this book would mainly be of use to those (for example, upper secondary-level students) who seek a glimpse into the diverse research experiences of professional mathematicians, or for motivating a downcast researcher with bite-sized human tales of struggle, perseverance, inspiration, collaboration and eventual success. However, the true success of *The Prime Number Conspiracy* is showcasing the quality of reporting on mathematics that can be found in *Quanta*, and any mathematician would likely enjoy dipping into this collection of reflections and developments from the mathematical front.

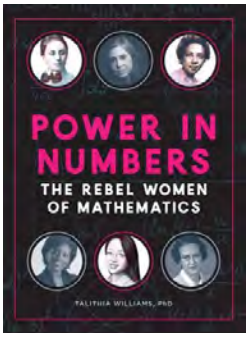
Gavin M Abernethy

Gavin is a lecturer in engineering mathematics at Sheffield Hallam University. His research interests include eco-evolutionary food web models and complex systems. An avid PC gamer, he is currently playing *American Truck Simulator*.

Power in Numbers: The Rebel Women of Mathematics

by Talithia Williams, Race Point Publishing, 2018, ISBN: 978-1-63106-485-2

Review by L. Angela Mihai



Power in Numbers: The Rebel Women of Mathematics is a celebration of the temerity of women mathematicians who made history through their contributions to mathematics, while breaking down barriers that stood in the way of equal opportunity and freedom from discrimination, in science and beyond. From Hypatia's conic sections and violent death in 415, to 19th century first PhD graduates, to WWII code breakers and modern day leaders, the list was bound to be whittled down. And the selection could not have been easy.

The first part concentrates on "The Pioneers", who laid the foundation of modern university education and made significant mathematical breakthroughs. It begins with brief biographical sketches of Marie Crous, the French mathematician who introduced the decimal system in the 17th century, Émilie du Châtelet (1706–1749), who published *Institutions de Physique* (Foundations of Physics), where she explained and analysed the mathematical ideas introduced by Gottfried Leibniz, and Maria Gaetana Agnesi (1718–1799), who wrote *Instituzioni Analittiche* (Analytical Institutions), an early textbook on calculus, which includes also an illustration of the curve known today as the 'Witch of Agnesi' (p. 13). In recognition of their work, du Châtelet was elected to the Academy of Science of the Institute of Bologna (1746), and Agnesi was appointed by Pope Benedict XIV to the chair of mathematics and natural philosophy at the University of Bologna (1750).

The short biographical profiles continue with Philippa Fawcett (1868–1948), the first woman to score a top mark in the Mathematical Tripos exam at the University of Cambridge, England, though she was not offi-

cially ranked, then Isabel Maddison (1869–1950) and Grace Chisholm (1868–1944), who earned the equivalent of a first-class degree at Cambridge, but were not allowed to receive a degree, and later continued their education abroad. More extensive biographical portraits commence with Wang Zhenyi (1768–1797), who studied astronomy and mathematics, and whose scientific work included a five-volume guide, *The Simple Calculation Principles*, a paper on gravity, and the article *The Explanation of a Lunar Eclipse*. Zhenyi was also an accomplished poet, concerned with important social issues, such as the gap between rich and poor, and equal opportunities for women and men. Portrayed next is Sophie Germain (1776–1831). Germain used a male pseudonym to sign her work before Joseph-Louis Lagrange, and then Carl-Friedrich Gauss, with whom she corresponded anonymously, met with her in person. Then, follow Winifred Edgerton Merrill (1862–1951), the first American woman to graduate with a PhD in mathematics, and the celebrated Sophia Kovalevskaya (1850–1891) and Emmy Noether (1882–1935), who need no introduction. It is noted that Kovaleskaya also published anonymously (p. 31), while her personal profile emerges as romantic and passionate. Noether, who "lived for mathematics", is described as "warm, caring and tough" (pp. 40-41). There is also a picture of a postcard scribbled with algebra, which she sent to Ernst Fisher in 1915, looking very much like tweet or an email message today (p. 38). This part concludes with a spotlight on Euphemia Haynes (1890–1980), the first African-American woman to earn a PhD in mathematics, who denounced the segregated system, and remained an advocate for equal education throughout her life as well. She also spoke of the connection between the pursuit of mathematics and world peace.

The second part, "From Code Breaking to Rocket Science", is probably the heart of the book, and is dedicated to those glorious times when the door was thrown wide open with a blast. Unfortunately, it was not peace but war that made this happen. Featured first is the American Navy officer and creator of the first computer compiler, Grace Hopper (1906–1992), whose team came up with the terminology 'bug' and 'debugging' in computer software (p. 59). Then, the Cherokee-American rocket scientist Mary Golds Ross (1908–2008), and the African-American 'human computers' and Hidden Figures, Dorothy Vaughan (1910–2008), Katherine Johnson (b. 1918), and Mary Jackson (1921 –2005), who, until their contribution proved vital, endured both gender discrimination and racial segregation at the NASA of the time. In recognition of her life-time work, Katherine Johnson was awarded the Presidential Medal of Freedom by Barack Obama in 2015. However, the spotlight here is on the Indian writer, and extraordinary 'mental calculator', Shakuntala Devi (1929–2013), who, in 1977, beat a Univac computer by extracting the 23rd root of a 201-digit number in under a minute, and, in 1982, made it into the *Guinness Book of World Records* after multiplying two 13-digit numbers in her head. Concluding this part is the Apollo scientist Margaret Hamilton (b. 1936), who coined the expression 'software engineering' (p. 93), a field which she helped to create, and who was awarded NASA's Exceptional Space Act Award in 2003. A picture also shows Barack Obama awarding her the Presidential Medal of Freedom in 2016.

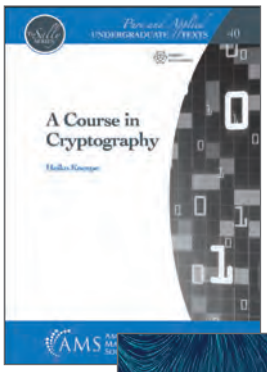
The book's third and final part is devoted to the "Modern Math Mavens", where the list, though quite extensive, is naturally open to new additions. Portrayed here are, among others: the first African-American Section Governor in the Mathematical Association of America Sylvia Bozeman (b. 1947); the mathematician and pianist Eugenia Cheng (b. 1976), who authored several popular books and appeared also on television shows; the only female winner of the 2016 European Mathematical Society Prize, Iranian-born Sara Zahedi (b. 1981); and the first, and so far, the only woman Fields Medallist Maryam Mirzakhani (1977–2017). Although this part's spotlight is on Daina Taimina's research (b. 1954), and her out-of-this-world 'crochet models of hyperbolic planes' (p. 137), the mathematical contributions of these contemporary women range across all different areas, including: algebraic geometry, Bayesian networks, dynamical systems, mathematical biology, probability theory, quantum mechanics, wavelet analysis, and much more.

This beautifully printed and well documented book provides inspiration for all who strive to live in a world free from bias, while honouring the creative spirit of women mathematicians throughout history. Talithia Williams' new book is definitely a most welcome contribution that will educate and encourage many aspiring mathematicians.

L. Angela Mihai

Angela is a reader at Cardiff University. Her main research is in the mathematics and mechanics of solids and structures at the interface with physical and life sciences.

AMS American Mathematical Society



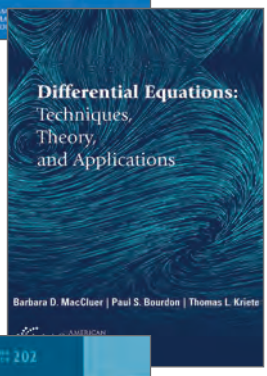
A COURSE IN CRYPTOGRAPHY

Heiko Knospe, TH Köln

Provides a compact course in modern cryptography. The mathematical foundations in algebra, number theory and probability are presented with a focus on their cryptographic applications. The text provides rigorous definitions and follows the provable security approach. The most relevant cryptographic schemes are covered, including block ciphers, stream ciphers, hash functions, message authentication codes, public-key encryption, key establishment, digital signatures and elliptic curves. The current developments in post-quantum cryptography are also explored, with separate chapters on quantum computing, lattice-based and code-based cryptosystems.

Pure and Applied Undergraduate Texts, Vol. 40

Oct 2019 323pp 9781470450557 Hardback £91.95



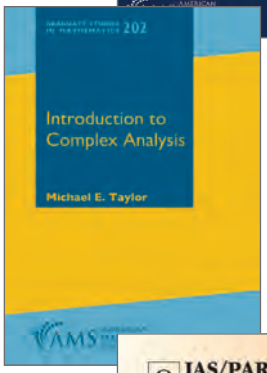
DIFFERENTIAL EQUATIONS

Techniques, Theory, and Applications

Barbara D. MacCluer, University of Virginia, Paul S. Bourdon, University of Virginia & Thomas L. Kriete, University of Virginia

Designed for a modern first course in differential equations either one or two semesters in length. The organization of the book interweaves the three components in the subtitle, with each building on and supporting the others.

Nov 2019 880pp 9781470447977 Hardback £123.00



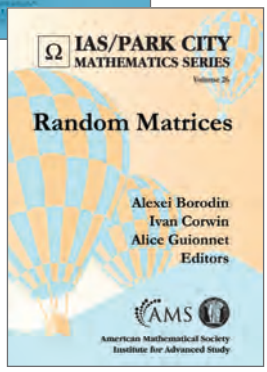
INTRODUCTION TO COMPLEX ANALYSIS

Michael E. Taylor, University of North Carolina

In this text, the reader will learn that all the basic functions that arise in calculus - such as powers and fractional powers, exponentials and logs, trigonometric functions and their inverses, as well as many new functions that the reader will meet - are naturally defined for complex arguments. Furthermore, this expanded setting leads to a much richer understanding of such functions than one could glean by merely considering them in the real domain.

Graduate Studies in Mathematics, Vol. 202

Nov 2019 480pp 9781470452865 Hardback £83.95



RANDOM MATRICES

Edited by Alexei Borodin, Massachusetts Institute of Technology, Ivan Corwin, Columbia University & Alice Guionnet, CNRS, ENS Lyon

Random matrix theory has many roots and many branches in mathematics, statistics, physics, computer science, data science, numerical analysis, biology, ecology, engineering, and operations research. This book provides a snippet of this vast domain of study, with a particular focus on the notations of universality and integrability.

IAS/Park City Mathematics Series, Vol. 26

A co-publication of the AMS and IAS/Park City Mathematics Institute

Nov 2019 508pp 9781470452803 Hardback £102.00

Obituaries of Members

Andrew Keith Jobbings: 1951 – 2019

Andrew Jobbings, who was elected a member of the London Mathematical Society on 19 February 1982, died on 11 July 2019 at his home in Baildon, Yorkshire.

Gerry Leversha writes: Andrew attended Aireborough Grammar School and Grey College in the University of Durham, graduating with first class honours in 1972. He achieved a PhD in 1976 for a thesis, under the supervision of Mark Armstrong, entitled *Topological Problems in Concordance and Entropy*.

He then taught mathematics for 28 years, including fourteen as Head of Department at Bradford Grammar School, before retiring to found his own company Arbelos. In the school magazine, an old pupil recalls 'the epic youth hostelling cycling trips around Yorkshire, the Lake District and the Highlands and Islands of Scotland led by Dr Jobbings'. He continued to be an avid mountain walker and scrambler until shortly before the onset of the ill health which eventually claimed his life.

In the early 1990s, Andrew was recruited by Tony Gardiner to work on the Senior Mathematical Challenge, and it became clear that he had a real gift for problem-setting. When the UK Mathematics Trust (UKMT) was formed in 1996, Andrew was responsible for the introduction of the Intermediate Mathematical Olympiad suite of papers. The setting meetings in York were fruitful both in terms of the detailed discussions of problem proposals, including those which none of us could do, but also for the pleasant evening meal in a local bistro where Andrew, a kind, gentle and clever man with a wicked sense of humour, would make everyone welcome. He contributed to the Maths Circles and Summer Schools run by the Trust as well as marking the Senior Olympiad.

Andrew was also one of the key figures in the *Association Kangourou sans Frontières* since the 1990s and attended the annual international conference, which he brought to the UK in 2013. He was an inspirational chair of the Cadet group for many years. Under the Arbelos imprint, he published and co-authored *Knots Unravelled* with Meike Akveld.

As a typographer Andrew's skills were in great demand. For the UKMT, he turned winning designs at the Team Mathematics Challenge into beautifully produced posters that now grace the walls of hundreds of schools. When I took over as Chair of Publications at the Trust, Andrew designed a consistent format for our range of books which made them much more attractive and easy to read. I can remember in particular a splendid diagram showing sixteen incircles and excircles all tangential to the nine-point circle which has been reproduced in publicity material. He was also a prolific author of UKMT books, including *First Steps for Problem Solvers*, with Mary Teresa Fyfe, and *A Problem Solver's Handbook*, as well as three collections of problems from the competitions administered by the Trust.

Andrew was a member of The Mathematical Association, and a supporter of its theoretical journal *The Mathematical Gazette*. He wrote incisive contributions, nearly always of direct use in the classroom, and with intriguing titles such as *Sudoku is four-dimensional* and *Folding a Triangle*. In 2016 he joined the editorial team as a proof-reader, and he was also a reliable referee, particularly of submissions about tessellations and geometry.

Andrew was held in high esteem by everyone he met, and his contributions to problem setting and solving were recognised at a global level. At IMO held in Bath, England, members of the Jury, consisting of the leaders of all the competing teams, stood in silence in his memory.

Margaret E. Rayner: 1929 – 2019

Margaret Rayner, who was elected a member of the London Mathematical Society on 18 June 1953, died on 31 May 2019, aged 89.

Irene Ault writes: Margaret's parents farmed near Stratford-upon-Avon. All her relations farmed except for an aunt who was the headmistress of a village school. With her aunt's encouragement, she went from the King's High School for Girls, Warwick to Westfield College, London where she took her first degree and an MSc by Research. From there, she moved to a Lectureship in Mathematics at St Hilda's College, Oxford. She immediately embarked on a D Phil, which she obtained in 1960, her thesis being on *Some problems*

in unsteady heat flow. In the same year, she was elected to a Tutorial Fellowship in Mathematics at the College which she held until her retirement in 1989.

In an interview with The Oxford Times in 1984, she explained that she loved to see things work, and this was exemplified throughout her life whether in research, teaching, fund raising or administration. To students, her naturally dignified presence precluded frivolity but she was always completely approachable, giving support and care for their welfare. Not just within the College but more widely in the academic community, she was valued for her calmness, her willingness to take on extra burdens, her staunch common sense, elegant drafting, and ability to keep objectives clearly in mind.

Her principal contributions to research were jointly with others. A collaboration with Lawrence Payne of Cornell University resulted in the Payne-Rayner inequality, an isoperimetric inequality for the first eigenfunction of the Laplacian. This and their extension of it to higher dimensions stimulated further advances in isoperimetric problems. Other joint work with Graeme Wake, now Professor Emeritus of Massey University, New Zealand, produced their paper *Variational Methods for Nonlinear Eigenvalue Problems associated with Thermal Ignition* which was an early forerunner of the now common path-following techniques for such problems. It led Graeme, with others, to develop algorithms to characterize, and estimate, thresholds for self-ignition.

During the 1970s, she moved away from research. She had never lost an interest in school education and her concern for it was maintained by membership of the Oxford University Delegacy for Educational Studies which brought connections with local teacher training colleges. She served on various committees of the Mathematical Association including the Schools and Industry Committee, and the Finance and General Purposes Committee, and was President of the Association for 1987-88. For many years she was chief mathematics examiner for the International Baccalaureate and so became aware of developments in curricula and in assessment in Europe and North America. It was an experience of the greatest value when she later joined the Secondary Examinations Council and, later still, the Schools Examination and Assessment Council concerned with curriculum development.

The award of a CBE in 1990 recognised her work as Vice Chairman of the Schools Examination and Assessment Council and as Vice-Principal of St Hilda's.

This same period also saw a move into university administration. During a ten-year stint on the University's Hebdomadal Council, her main interests were the Staff Committee and the Accommodation Committee, on both of which she served as chairman. For the Oxford Colleges, she chaired the Admissions Office Committee and this, again, brought her in constant contact with schools. In addition, she served as Chairman of the Board of Governors of Oxford Polytechnic (now Oxford Brookes University) and, after retirement, as a lay member on the Council of the University of Reading.

Retirement in 1989 brought another change of direction — with her customary energy, thoroughness and organisation, she produced, on time, a definitive and succinct *Centenary History of St Hilda's College*. It led on to contributions to the *Oxford Dictionary of National Biography* and to a chapter on 20th century mathematicians in *Oxford Figures* (edited by Fauvel, Flood and Wilson).

The characteristics that come to mind most immediately when thinking about Margaret are her intellectual curiosity, her energy, her gift for making enduring friendships and her generous hospitality. She cared about people and, in return, they cared about her and were fond of her. She will be much missed.

Elmer Rees: 1941 – 2019

Professor Elmer Rees, who was elected a member of the London Mathematical Society on 18 April 1974, died on 4 October 2019. Over the years he served the Society in several capacities notably as Vice President (1994-96) and as a member of LMS Council. Professor Rees was also the LMS–NZMS Forder Lecturer in 1995.

Professor Rees was born in Wales and undertook his undergraduate studies at the University of Cambridge before moving to the University of Warwick for his postgraduate studies. In his long career he held academic positions at a number of institutions including University of Hull, the Institute of Advanced Studies, Princeton, Swansea University and St Catherine's College, Oxford, before becoming a professor at the University of Edinburgh in 1979, where he remained until retiring from the post in 2005. From 2005-09 he was Director of the Heilbronn Institute of Mathematical Research. He was awarded a CBE in 2009 Queen's Birthday Honours.

A longer obituary will be published in a future issue of the *LMS Newsletter*.

LMS Computer Science Colloquium

Location: De Morgan House, London
Date: 13 November 2019
Website: tinyurl.com/cscoll19

The theme of this event will be 'Mathematics of Security'. The event is aimed at PhD students and post-docs, although others are welcome to attend. It is free for students and £5 for others. Limited funding for travel is available. Register at tinyurl.com/cscoll19.

LMS/BCS-FACS Evening Seminar

Location: De Morgan House, London
Date: 21 November 2019
Website: tinyurl.com/yyc9oyse

Professor Marta Kwiatkowska (University of Oxford) will give a talk titled *When to Trust a Self-Driving Car....* The seminar is free of charge; to register your interest, email Katherine Wright, Society & Research Officer: lmscomputerscience@lms.ac.uk. See the website for an abstract and speaker biography.

LMS Meeting

LMS–IMA Joint Meeting: Mathematics of Planet Earth

Thursday 21 November 2019, University of Reading

Website: tinyurl.com/yyvehkjv

Speakers: Katrin Padberg-Gehle (Luneburg), Sandro Vaienti (Marseille), Michael Ghil, (CERES, ENS), Beth Wingate (Exeter), Peter Ashwin (Exeter), Jacques Vanneste (Edinburgh).

This joint event is run by the LMS and the Institute of Mathematics and its Applications. These lectures are aimed at a general mathematical audience. The goal of this joint meeting is to showcase some recent developments in pure and applied mathematics that contribute to a better understanding of the Planet Earth.

All interested, LMS/IMA members and non-members, are welcome to attend this event. The meeting is free to attend. Visit the website for further details and how to register.

LMS Meeting

LMS Graduate Student Meeting

29 November 2019: 9.30 am – 2.00 pm, Goodenough College, Mecklenburgh Square, London WC1N 2AB

Website: lms.ac.uk/events/meeting/agm

The speakers will be Viveka Erlandsson (Bristol) and David Singerman (Southampton). The meeting will include student presentations of their current work, with a prize awarded for the best talk. This meeting is intended as an introduction to the AGM later in the day. Travel grants of up to £100 are available for students who attend both the Graduate Student Meeting and the LMS AGM. The AGM will be followed by a wine reception. The Society's Annual Dinner will be held at 7.30 pm at Goodenough College. The cost of the dinner will be £58.00, including drinks; email AnnualDinner_RSVP@lms.ac.uk to reserve a place.

LMS Meeting

Annual General Meeting of the LMS

Goodenough College, Mecklenburgh Square, Holborn, London WC1N 2AB, 29 November 2019; 2.30 – 6.00 pm

Website: lms.ac.uk/events/meeting/agm

The speakers will be Marc Lackenby (Oxford) *The Complexity of Knots* and the LMS President, Caroline Series (Warwick) *Presidential Address: All about the Riley Slice.* The meeting will include the presentation of certificates to all 2019 LMS prize winners and the announcement of the annual LMS election results. The meeting will be followed by a reception, to be held at Goodenough College, and the Society's annual dinner at 7.30 pm. The cost of the dinner will be £58.00, including drinks. To reserve a place at the dinner, please email AnnualDinner_RSVP@lms.ac.uk.

Integrable Day in Loughborough

Location: Loughborough University
Date: 29 November 2019
Website: tinyurl.com/y6ddooxl

A half-day workshop on *Various Aspects of Integrability* is part of a collaborative workshop series on Classical and Quantum Integrability, supported by the LMS.

Cohomology and Mackey Functors for Profinite Groups

Location: Senate House, London
Date: 16 December 2019
Website: tinyurl.com/y4mnkdjx

This is the final meeting in 2019 of the Research Group Functor Categories for Groups (FCG). Limited funding is available for PhD students; email Brita Nucinkis (brita.nucinkis@rhul.ac.uk) to register.

MathsJam Gathering 2019

Location: Yarnfield Park, Staffordshire
Date: 30 Nov – 1 Dec 2019
Website: tinyurl.com/y4gx6pku

Fifty lightning talks, a host of games, puzzles, and more. MathsJams let adults re-connect with the playful side of mathematics, welcoming people from a wide range of backgrounds, education, and ability.

Statistical Aspects of Geodesic Flows in Nonpositive Curvature

Location: University of Warwick
Date: 20 – 23 January 2020
Website: tinyurl.com/sagfWS20

Geodesic flows are among the classical examples in dynamics. Much is known for negatively curved manifolds, but for nonpositive curvature the theory still misses some fundamental pieces.

LMS Meeting

LMS South West & South Wales Meeting & Workshop

15 January 2020; 1:30 pm University of Bristol

Website: tinyurl.com/yyz2kuc6

The meeting forms part of the South West & South Wales Regional Workshop on *Interactions between Geometry, Dynamics and Group Theory*. Funding is available for partial support to attend the meeting and workshop. The meeting will be followed by a reception and dinner; to reserve a place email lms-bristol2020@gmail.com.

Interactions Between Group Theory, Number Theory, Combinatorics and Geometry

Location: INI, Cambridge
Date: 16 – 20 March 2020
Website: tinyurl.com/y5pmw926

Finite group theory has very close connections with many areas of mathematics and other sciences. This workshop will focus on problems that have influenced group theory significantly, and on where group theory has led to fundamental advances. Areas of focus will be number theory, combinatorics and geometry. Application deadline: 15 December 2019.

Algebraic K-theory, Motivic Cohomology and Motivic Homotopy Theory

Location: INI, Cambridge
Date: 23 – 27 March 2020
Website: tinyurl.com/y4vsxojr

The workshop will cover advances in computation of the basic structure constants of motivic homotopy, and analyzing properties of topological Hochschild homology and topological cyclic homology by various methods; theory of non-reduced schemes; constructing and analysing higher structures in motivic homotopy theory. Application deadline: 29 December 2019.

LMS Meeting

LMS Invited Lecture Series 2020

30 March – 3 April 2020, Brunel University London

Website: boguslavsky.net/lms2020

The invited Lecturer will be Professor Yulia Mishura (Taras Shevchenko National University of Kyiv), who will talk on *Fractional Calculus and Fractional Stochastic Calculus, Including Rough-Paths, with Applications*. Accompanying Lecturers will be Elena Boguslavskaya (Brunel University London), Vassili Kolokoltsov (Warwick University), Nikolai Leonenko (Cardiff University), Joseph Lorinczi (Loughborough University), Hao Li (UCL) and Enrico Scalas (Sussex University). Funds are available for partial support to attend; email the organiser, Dr Elena Boguslavskaya (Elena.Boguslavskaya@brunel.ac.uk) with an estimate of expenses. Visit the website for further details and to register.

Arithmetic Geometry, Cycles, Hodge Theory, Regulators, Periods and Heights

Location: INI, Cambridge
Date: 30 March – 3 April 2020
Website: tinyurl.com/y6dset29

This workshop will explore the various conjectures on special values of zeta-functions and their generalisations, including that by Birch and Swinnerton-Dyer on the behaviour at s=1 of L(E, s) for an elliptic curve E over a number field, where L(E, s) is the analogue of the zeta-function in this context. The workshop will also cover Hodge theory. Application deadline: 5 January 2020.

Joint BMC/BAMC Meeting

Location: University of Glasgow
Date: 6 – 9 April 2020
Website: tinyurl.com/y26mdwyd

This is the 5-yearly joint BMC and BAMC meeting, bringing together the two main UK annual events in pure and applied mathematics. The scientific programme covers a wide range of the mathematical spectrum. More information can be found on the conference webpage. Registration is now open, with a reduced rate for PhD students.

Membership of the London Mathematical Society

The standing and usefulness of the Society depends upon the support of a strong membership, to provide the resources, expertise and participation in the running of the Society to support its many activities in publishing, grant-giving, conferences, public policy, influencing government, and mathematics education in schools. The Society's Council therefore hopes that all mathematicians on the staff of UK universities and other similar institutions will support mathematical research by joining the Society. It also very much encourages applications from mathematicians of comparable standing who are working or have worked in other occupations.

Benefits of LMS membership include access to the Verblunsky Members' Room, free online subscription to the Society's three main journals and complimentary use of the Society's Library at UCL, among other LMS member benefits (lms.ac.uk/membership/member-benefits).

If current members know of friends or colleagues who would like to join the Society, please do encourage them to complete the online application form (lms.ac.uk/membership/online-application).

Contact membership@lms.ac.uk for advice on becoming an LMS member.

Society Meetings and Events

November 2019

13 Computer Science Colloquium, London
21 LMS/BCS-FACS Evening Seminar, London
21 Joint Meeting with the IMA, Reading
29 Graduate Student Meeting, London
29 Society Meeting and AGM, London

January 2020

15 South West & South Wales Regional Meeting, Bristol

March 2020

3-13 Apr Invited Lecture Series 2020, Brunel University

April 2020

8 Society Meeting at the Joint BMC–BAMC, Glasgow

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.

November 2019

4-8 Edge Days 2019: Fano Varieties, Cone Singularities and their Links, University of Edinburgh (484)
6-8 Young Researchers in Algebraic Number Theory, University of Warwick (484)
13 Computer Science Colloquium 2019, De Morgan House, London (485)
18-19 Category Theory and its Applications Postgraduate Conference, University of Leicester (484)
21 Joint LMS Meeting with the IMA, Reading (485)
21 LMS/BCS-FACS Evening Seminar, De Morgan House, London (485)
29 Integrable Day in Loughborough, Loughborough University (485)
29 Graduate Student Meeting, London (485)
29 Society Meeting and AGM, London (485)
30-1 Dec MathsJam Gathering 2019, Yarnfield Park, Staffordshire (485)

December 2019

6 PDE Models for Cancer Invasion, Queen's University Belfast (484)
9-10 Probabilistic Coupling and Geometry Workshop, University of Warwick (484)
9-13 Computational Complex Analysis, INI, Cambridge (484)
13 Integrability, Algebra and Geometry, University of Glasgow (484)
16 Cohomology and Mackey Functors for Profinite Groups, Senate House, Royal Holloway, University of London (485)

January 2020

8-10 British Postgraduate Model Theory Conference 2020, University of Leeds (484)
15 LMS South West & South Wales Regional Meeting, Bristol (485)
20-23 Statistical Aspects of Geodesic Flows in Nonpositive Curvature, University of Warwick (485)

March 2020

16-20 Interactions between Group Theory, Number Theory, Combinatorics and Geometry, INI Cambridge (485)

23-27 Algebraic K-theory, Motivic Cohomology and Motivic Homotopy Theory, INI Cambridge (485)

30-3 Apr LMS Invited Lecture 2020, Brunel University London (485)

30-3 Apr Arithmetic Geometry, Cycles, Hodge Theory, Regulators, Periods and Heights, INI Cambridge (485)

April 2020

6-9 Joint BMC/BAMC Meeting, University of Glasgow (485)

July 2020

5-11 8th European Congress of Mathematics, Portorož, Slovenia

12-19 14th International Congress on Mathematical Education Shanghai, China

August 2020

17-21 IWOTA 2020, Lancaster University (481)

Proceedings of the World's Largest & Most Prestigious Event in Mathematics

International Congress of Mathematicians (ICM 2018)

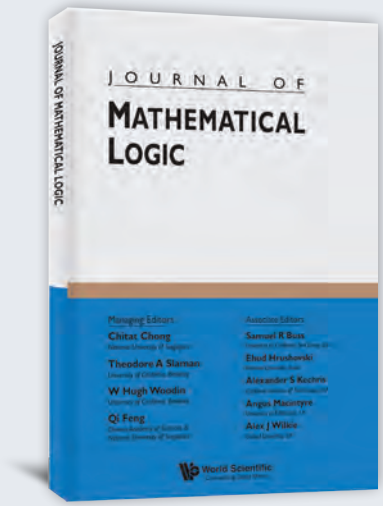
The proceedings of the International Congress of Mathematicians (ICM) capture the spirit of the congress. It provides the most extensive and comprehensive set of review and advanced research lectures in Pure and Applied Mathematics. Not only does it feature the talks by invited speakers, it also includes the Fields Medal and Nevanlinna, Gauss and Leelavati Prizes and the Chern Medal laudatios. The book is unique, by the scope and breath of the subject material treated.

Mar 2019 | 978-981-3272-87-3 (Set) | **£750**

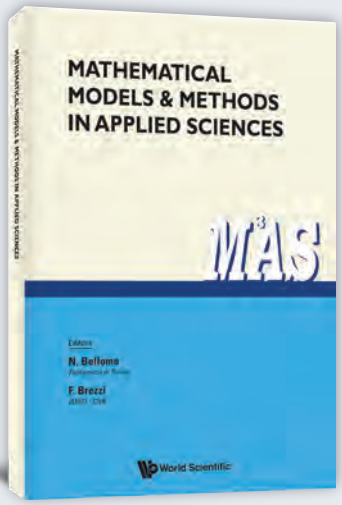
Recommend to your librarian today!

JOURNALS COLLECTION
MATHEMATICS
25 leading Mathematics journals

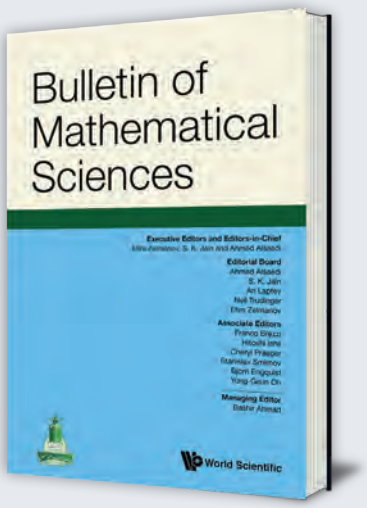
FREE 7-day Access to our Mathematics journals at www.worldscientific.com/page/math-journals



TOP
JOURNAL IN LOGIC
(Journal Citation Reports)



5-YEAR IMPACT FACTOR: 3.395
#12 OUT OF 254
in Applied Mathematics



TOP25
IN MATHEMATICS