



# School of Mathematics Newsletter

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## *In this issue:*

- Student talk success
- More grant successes!
- Outreach update
- Workshops and conferences

## Tomorrow's Mathematicians Today Conference

by AMY TANSELL AND LUCA PANCONI

Whilst compiling a research project as part of our third year undergraduate studies, we received an email from the Institute of Mathematics and its Applications advertising an annual conference at the University of Greenwich on Saturday 9th February, where mathematicians of all backgrounds, from undergraduates to PhD students, gather to present their work. We couldn't have imagined ever volunteering – let alone as our first time ever presenting our work individually to such an audience!

We saw this as an opportunity to get feedback on our third year research papers, one based on Boolean Algebra and the other The Travelling Salesman Problem – and we were overjoyed when the organiser told us our proposals had been accepted; that was until we realised what we'd signed up for. Having never given a real academic presentation, our nerves were rife and unruly. However, daunted by the concept of having to present as part of our coursework, we took this opportunity to get some practice, and collate presentation skills from other up-and-coming mathematicians, regardless of how

terrifying the event may seem to be.

Upon arrival, we realised just how wrong our preconceptions had been. We were immersed in an incredibly positive atmosphere, surrounded by an assortment of brilliant young researchers, both friendly and informed. Despite our initial fears, we found mingling came naturally, and later emerged with lasting friends – one of whom went on to win the GCHQ prize for best presentation, and who we remain in contact with to this day!

As we stepped up to give our respective presentations, we were filled with dread – but with the support of our peers, and some nostalgic memories of presenting our work in previous modules (namely Mathematics in Industry), we were invigorated with the motivation to persevere. From feedback, we later discovered that 25% of the attendees thought the University of Birmingham's presentations were the most enjoyable!

Not only did we gain confidence and social skills, but we now feel like more rounded mathematicians. We were left in awe of the postgraduate attendees, and now we both wish to pursue PhD studies. During the keynote speech, the organiser remarked how the conference has been held at several locations around Birmingham, but never at Birmingham itself. That idea resonated with us, and after some discussion, we have since agreed to look into hosting it! Perhaps, in the not too distant future, other third year mathematicians like ourselves will be presenting their research projects in the lecture rooms here in Birmingham as part of Tomorrow's Mathematicians Today!



*Tomorrow's Mathematicians Today 2019*

## Marie Curie Fellowship success

by ALESSIO MARTINI

The School of Mathematics will be the host department for a Marie Skłodowska-Curie Individual Fellowship, worth more than €200k, that has been recently approved for funding. The MSC Fellowship will bring Dr Gian Maria Dall'Ara (currently at the University of Vienna, Austria) to Birmingham for 24 months, to work with Dr Alessio Martini on the project "Harmonic Analysis on Real Hypersurfaces in Complex Space".

The project, at the interface of harmonic analysis and complex analysis, focuses on two mathematical objects naturally attached to real hypersurfaces embedded in complex manifolds: Cauchy-Szegő projections and spectral multipliers of Kohn Laplacians. The former are higher dimensional incarnations of the classical Cauchy integral, and as such they are of central importance in modern complex analysis in several variables. The project aims at increasing our understanding of the nature of their singularities and mapping properties under general geometric assumptions. Kohn Laplacians are the natural Laplacians in this context and the study of their spectral multipliers fits into a wider set of problems lying at the heart of contemporary harmonic analysis.

Transfer of knowledge is a key aspect of the MSC Fellowship: Dr Gian Maria Dall'Ara will bring a complex-analytic point of view influenced by mathematical physics, in which some of the key questions are interpreted in terms of uncertainty principles for generalised Schrödinger operators, and the diverse expertise in harmonic analysis available at Birmingham will provide fertile terrain for the development of the project.

## Outreach update

by ELEANOR MESTEL

Thank you to all staff that have helped with the School's outreach work so far this academic year. Below are some highlights of the year to date along with details of upcoming events.

This year we have had a strong series of Popular Maths Lectures from Dr Pietro Servi, Dr Samuel Johnson, Dr Fabian Spill and Dr Arnaud Lionnet. These lectures run once a month throughout the autumn and spring terms and are well attended by local schools, families, and the general public, as well as members of the university. We have one more upcoming lecture on Wednesday 27th March with Ben Barber asking "why are soap bubbles round and salt crystals square?" The details of the upcoming lectures are online: [www.birmingham.ac.uk/bpml](http://www.birmingham.ac.uk/bpml), and we will be looking for speakers for next year's series shortly.

The School of Mathematics organises outreach events throughout the year. For example, in October we ran our first year 8 maths day for five local schools with Dr Simon Goodwin and Dr Kat Grover helping to promote maths to younger school students. In February, the School of Mathematics ran the annual Maths Big Quiz joint with the central outreach team. At this huge event, 82 teams of four year 10 students competed with each other through five rounds, including a specialist round on Florence Nightingale. The Quiz was led by Dr Gemma Cupples and Euan Smithers, and in the middle of the day Dr Fabian Spill led an activity on population dynamics. At the end of the day, the prizes were presented by Dr Rosemary Dyson to eight teams. First place this year was won by one of the teams from

Sandwell Academy in West Bromwich.

People from the School of Mathematics have contributed to centrally organised outreach events and to other events on campus. Thank you to Dr Sara Jabbari, Dr Rosemary Dyson, Dr Richard Mycroft, Dr Galane Luo, and Dr Allan Lo who led sessions for teachers and students in years 10 –13. We also have a number of people who have agreed to go and visit schools in the next few months.

A full list of our mathematics-specific Outreach events can be found here. Upcoming events in the summer will be:

- Maths Taster Day for year 12 students (I'm looking for a 20 minute introductory talk).

- Discovery Day for year 10 students (I'm looking for a 60 minute workshop, run three times).

Please let me know if you would like to get involved with these events, or any other one. I am always looking for more help with outreach, and am very happy to talk about your outreach and public engagement ideas, just send me an email ([mathsoutreach@contacts.bham.ac.uk](mailto:mathsoutreach@contacts.bham.ac.uk)) or see me in Room 227 in the Watson Building.

If anyone has taken part in any outreach and I haven't mentioned your name, it is because I don't know about your visit, please do let me know about any outreach work you have done by filling in the online outreach recording form: [intranet.birmingham.ac.uk/recordepsoutreach](http://intranet.birmingham.ac.uk/recordepsoutreach). This allows us to keep track of the outreach work which is going on in the School of Mathematics.

## British Combinatorial Conference in Birmingham!

From July 29th to August 2nd the School of Mathematics will host the 27th British Combinatorial Conference. This biennial meeting covers research in all areas of Combinatorics and its applications. The conference series has been running since 1969 and is the focal event in the UK Combinatorics calendar.

Nine world-experts in their fields will give plenary talks at the conference. There are also invited mini-symposia concerning six important branches of Combinatorics. All participants are encouraged to submit an abstract on a topic related to the conference and give a 20-minute presentation.

The 27th BCC is being organised by members of the School of Mathematics; Allan Lo, Richard My-

croft, Guillem Perarnau and Andrew Treglown. The conference is also organised in partnership with the Clay Mathematics Institute, the Heilbronn Institute, Institute of Combinatorics and its Applications and the London Mathematical Society.

More details about the event can be found on the conference webpage.

## Workshop on Scientific computation using machine-learning algorithms

Alex Bespalov, Daniel Loghin and their colleague from Nottingham, Kris van der Zee are organising a workshop on "Scientific computation using machine-learning algorithms: recent mathematical advances and applications". The event will take place 25-26th April at the University of Nottingham.

The aim of this workshop is to discuss recent advances in mathematical foundations of machine learning and artificial neural networks as well as the application of these methodologies in computational science. The workshop will bring together experts in such diverse areas as approximation theory, PDEs, scientific computing, networks, computer science, and uncertainty quantification to facilitate the exchange of results and ideas and to initiate new collaborations.

More details about the workshop are available on its webpage.

## British Young Mathematicians' Colloquium in Birmingham!

The 4th British Young Mathematicians' Colloquium (BYMC) will be hosted at the University of Birmingham on the 17th of April.

This one-day event is aimed at mathematicians from all areas at early stages of their careers. The majority of the conference will be made up of talks contributed by participants, but there will also be a series of (semi-)plenary talks. All attendees are encouraged to submit an abstract for a short talk, and we have funding to aid the attendance of participants from MAGIC universities.

Our (semi-)plenary talks fall roughly into two categories, "pure" and "applied", and the main speakers for each section are as follows:

**Pure:** David Beltran (BCAM), Scott Harper (Bristol), Katherine Staden (Oxford).

**Applied:** Gemma Cupples (Birmingham), John Pearson (Edinburgh), Oliver Sutton (Nottingham).

This year, we have made a particular effort to make the conference as accessible as possible – for information on this, as well as registration and abstract submission, please visit <http://web.mat.bham.ac.uk/BYMC>.

This edition of the BYMC is being organised by Gianmarco Brocchi, Alexander Brune, Rory Duncan, Cara Neal, Jack Saunders and Karoline van Gemst, and we are supported by the MAGIC network and the School of Mathematics at the University of Birmingham.

## Postgraduate Group Theory Conference in Birmingham!

The School of Mathematics will be hosting the 21st Postgraduate Group Theory Conference, an annual conference for postgraduate students in group theory and related areas, from the 23rd of July to the 25th. This will be the third time the conference has been hosted in Birmingham, with previous instances being in 2002 and 2014.

The opening and closing talks will be given by Professor Martin Liebeck and Professor Colva Roney-Dougal, respectively, but the bulk of the conference shall be made up of short contributed talks from postgraduate speakers. As such, all participants are encouraged to give a talk. There are also satellite training days for the GAP computer algebra system on the 22nd and 26th of July, led by Dr. Alexander Konovalov from the University of St. Andrews, with both beginner and more advanced sessions.

PGTC 2019 is being organised by several postgraduate Mathematics students here in Birmingham: Mark Butler, Ollie Jones, Andrea Pachera, Jack Saunders and Martin van Beek. The conference is being supported by the Heilbronn Institute and the London Mathematical Society.

For more details, see the conference website.

## Harmonic Analysis workshop

by MARIA CARMEN REGUERA

From June 10th to June 13th, the School of Mathematics will be hosting the workshop “Harmonic Analysis in non-homogeneous settings and

applications”. The workshop will focus on recent developments on homogeneous and especially non-homogeneous Harmonic Analysis. More precisely, the workshop will aim to investigate problems related to sparse domination for rough operators, the matrix A2 conjecture, the two-weight characterization of singular integral operators and the David Semmes conjecture beyond co-dimension 1 among others.

The workshop will differ from typical conferences in some regards. Participants will be invited to suggest open problems, and these will be discussed during break-out sections. These include specific problems on which there is hope of making some progress during the workshop, as well as more ambitious problems which may influence the future activity of the field. Lectures at the workshop will be focused on familiarizing the participants with the background material leading up to specific problems.

The workshop will bring together a diverse group of researchers, leading senior researchers in the area as well as younger researchers. The workshop should be especially good for the second group. A particular goal will be to acquaint these researchers with the foundational questions and techniques in modern homogeneous and non-homogeneous Harmonic Analysis. A call has been opened for PhD students and postdocs to apply for funding that will support their participation.

This workshop is funded by the EPSRC First grant “Harmonic Analysis in rough environments”, the London Mathematical Society (via the Research Workshop Grant scheme), the Heilbronn Institute and the School of Mathematics at the University of Birmingham.

## Paper of the month award

*At the end of 2018, Dr Hong Duong won the College’s paper of the month prize for his paper “On the distribution of the number of internal equilibria in random evolutionary games” (view the paper online here).*

*In what follows, Hong describes his work.*

Random evolutionary games in which the payout entries are random variables form an important subclass of evolutionary game theory. They are necessary to model social and biological systems in which very limited information is available, or where the

environment changes so rapidly and frequently that one cannot describe the payouts of their inhabitants' interactions. How to determine the distribution of internal equilibria in random evolutionary games is an intensely investigated subject with numerous practical ramifications in ecology, population genetics, social sciences, economics and computer science providing essential understanding of complexity in a dynamical system, such as its behavioral, cultural or biological diversity and the maintenance of polymorphism. Existing papers in the literature are restricted to games with less than five players since they analytically solve a polynomial equation derived from the replicator dynamics to find an internal equilibrium.

In our paper we provide for the first time a closed-form formula for the probability that a multi-player two-strategy random evolutionary game has a certain number of internal equilibria. Our results are applicable to games with an arbitrary number of players. We develop further connections between evolutionary game theory and random polynomial theory, which was discovered in our previous work, and employ recent techniques from the latter to the former. Furthermore, we also present universal upper and lower bound estimates for those probabilities using Descartes' rule of signs and combinatorial methods.

## News in Brief

- In February, Dr Guillem Perarnau left the School of Mathematics to take up a position at UPC in his homeland of Catalonia. Guillem was an immensely popular member of the School of Mathematics, both amongst staff and students, so he will be greatly missed! He will still likely be a regular visitor to Birmingham though, particularly as he is involved in the running of the British Combinatorial Conference in July (see article above)!
- Tom Montengro-Johnson has been awarded an H2020 Future Emerging Technologies Grant, "H-Reality", as a Co-PI (c. 3 million eu-

ros). H-Reality is an interdisciplinary project across three European countries to develop the next generation of "haptic" systems, providing touch feedback from virtual content. The project combines elements of soft-tissue mechanics and experimental tribology, with the physics of perception and research on User Interfaces, and involves two industrial partners. Joining the project for two-years in the School of Mathematics will be James Andrews, to work on theoretical and computational models of vibrotaction in the human hand.

- Congratulations go to Frederik Garbe for winning the Ratcliffe Prize. The prize is awarded to the best postgraduate students undertaking programmes in Science Schools on the basis of high achievement.

Frederik Garbe completed his PhD under the supervision of Richard Mycroft on the topic of "Extremal Graph Theory via Structural Analysis". Richard states that 'the most significant results relate to the complexity of the Hamilton cycle problem in dense uniform hypergraphs, where Frederik proved the existence of a 'complexity gap' for 2-overlapping cycles in 4-uniform hypergraphs whilst also demonstrating that for all  $k$  there is no such gap for  $(k - 1)$ -overlapping cycles in  $k$ -uniform hypergraphs'. This research was published in the *Journal of Combinatorial Theory, Series B*. Since completing his PhD, Frederik has taken up a research fellowship position at the Czech Academy of Sciences.

- On the 28th March (3–6pm), the Birmingham University Mathematics Postgraduate Society (BUMPS) will be hosting a poster competition for postgraduate researchers. Prizes will be awarded for the best applied and best pure mathematics posters, as well as ones for overall 2nd and 3rd place. So please come along to the Physics Bridge and see the amazing research Birmingham's own postgraduates accomplish.