# De Morgan Association NEWSLETTER

## UCL, Mathematics and London'

In 2014 UCL launched its 20 year strategy *UCL2034* - see http://www.ucl.ac.uk/ucl-2034. One of 6 principal themes is UCL's relationship with London, in which the stated ambition is to establish UCL at the centre of a cluster of organisations that will make London the premier destination for higher education.

It is indisputable that across London there is much excellence in many areas of mathematics research and teaching and it is not difficult to envisage London becoming the `premier destination' for mathematics. UCL Mathematics is keen to play a prominent role in realizing this ambition, but there are considerable challenges. Chief among these is the cost of living in London; a factor which often makes it difficult to recruit and retain staff and students, and to attract long-term visitors. Moreover, increases in student numbers across UCL have placed severe pressure on the Bloomsbury site with limited prospects for local expansion, and, as the Provost remarked in his October 2015 lunch hour lecture, "we're simply desperate for space". However, in my view, the advantages of being in London are considerable and outweigh these challenges: as the following selection of activities demonstrate, we already have productive links with other London institutions, local industry and businesses, and exploit London's prominence as a European transport hub.

Centres of Doctoral Training are a relatively new way for the Engineering and Physical Sciences Research Council (EPSRC), the main UK funder of mathematical sciences research, to fund and train PhD students. Typically they involve yearly admission of cohorts of 15 students who receive a broad training in the theme of the CDT before going on to complete their usual doctoral research. The London School of Geometry and Number Theory, established in 2014, is an example of a productive partnership between Imperial, King's and UCL, with the first year cohort being based at UCL, and is the only CDT in the country devoted solely to pure mathematics. The combined expertise in both geometry and number theory of the three partners involved is truly world-leading and has proved to be very attractive to leading graduates from the UK and across the world. It is easy to imagine further CDTs shared among London universities covering other mathematical themes where London has a concentration of excellence e.g. mathematical modelling; pure and applied analysis.

The concentration of mathematical sciences researchers in London provides a strong draw for visiting mathematicians and has led to long-running research seminar series, run jointly by King's, Imperial and UCL, in, for example, number theory and analysis (the latter also with QMUL). Over the years these have attracted many eminent speakers including Fields Medallists. The ease of travel between London and Paris and Brussels has led to similarly successful seminar series such as the London-Paris number theory and analysis meetings and the London-Brussels geometry meeting. The department hosts an annual meeting in rotating fluid dynamics which frequently brings audience

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Editor Ted Johnson

Associate Editor Bonita Carboo

and speakers from Paris and from across the UK.

London is a globally-leading centre of finance and, naturally, financial mathematics is a strong discipline in the London universities. For example, Birkbeck, Brunel, City, Imperial, King's, LSE and UCL all offer MSc programmes related to financial mathematics. A joint London graduate school in mathematical finance is run by these institutions: in existence for over 10 years the school provides a programme of advanced courses for London's PhD students in mathematical finance, and makes full use of expertise in London's financial industry. At UCL we maintain close contact with financial mathematicians working in the city some of who hold honorary positions in the department so as to facilitate research and teaching links including city-based alumni who contribute significantly to teaching and project supervision on our financial mathematics programmes and modules. Such close contact with leading industry practitioners is, rightly, appreciated by students and provides a strong draw for prospective students seeking to study financial mathematics with close interaction with London's financial industry.

Other benefits of our London location include our close proximity to government departments which have facilitated exchange programmes with a number of UCL Mathematics PhD students spending secondments in the Department for Business Innovation \& Skills (BIS). The department also has collaborations with the London branch of the Heilbronn Institute of Mathematical Research.

Our engagement with London is set to increase with the arrival of other London-based initiatives based in the so-called "Knowledge quarter" of Kings Cross, Euston and Bloomsbury for which it is anticipated that UCL mathematicians will feature prominently. In particular, the recently launched Alan Turing Institute for Data Science (ATI) is based on our doorstep, as well as is the newly-formed Crick Institute. UCL is one of five academic partners of the ATI and the nature of its activity will mean that UCL mathematicians will be closely involved in its research activities. The Crick Institute, of which UCL is also a founding partner, is devoted to medical research and, again, with our active research group in mathematical biology and medicine we expect new research directions and collaborations to emerge.

It is an exciting time to be a student and researcher in mathematics: long-standing problems are being solved, new conjectures posed, surprising connections across previously disparate areas of mathematics are being revealed and new applications found. With its number and concentration of mathematicians, London, and UCL in particular, is well-placed to play a leading role in this endeavour. With further investment London can become a first choice global destination for students and researchers in mathematics.

- **Robb McDonald**
  Head of Department

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## From the Editor

- **Ted Johnson**
  Professor of Mathematics

## De Morgan Association Dinner 2015

Dr Tadashi Tokieda

After this year's De Morgan dinner, Tadashi Tokieda told tall tales of two-dimensional topology. With sellotape, he spliced paper strips to spawn a selection of surfaces which he subsequently set about with scissors and sliced the spliced strips along their central circles.

The simple Moebius strip, of course, when sliced, yields a cylinder (albeit twisted twice in space).

Two cylinders, when spliced at ninety degrees to one another, and slit along their core circles, yield a square frame.

We topologists in the audience nodded sagely to ourselves; to us this is a procedure called surgery, and we do it all the time, often in higher dimensions, but always under controlled conditions. However, when he started splicing Moebius strips at ninety degrees to one another, we started to sweat. What would he get when he sliced? Has anyone ever actually tried this before outside of a blackboard? Might it cause disturbances in the space-time continuum?

The result was very beautiful. You can try it for yourself, or see an abridged version of Tadashi Tokieda's talk on Youtube here:

https://www.youtube.com/watch?v=5xLFf_SwaK4

-- Tadashi Tokieda is based at Trinity Hall, Cambridge.

- **Jonny Evans**
  Lecturer, Department of Mathematics

**Dr Tadashi Tokieda speaking at the De Morgan Association Dinner**

**Guests at the De Morgan Association Dinner**

## De Morgan Association Dinner

**Friday ? June 2016**

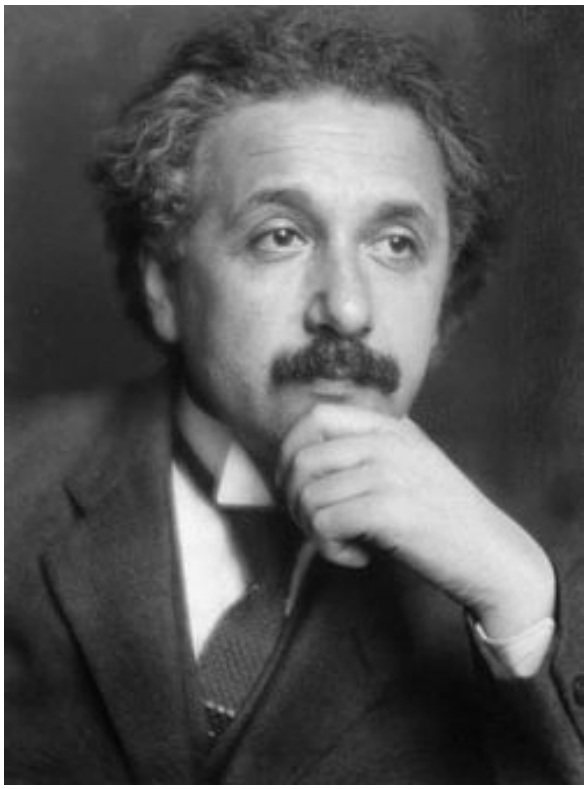
**Senate House**
**Sherry at 6.45pm and Dinner at 7.30pm**

**Guest of Honour and After Dinner Speaker:**

All those on the UCL Alumni database will be sent an invitation to the next De Morgan Association Dinner. Please send us addresses of anyone else who may want to receive an invitation and remember to keep the Department and Alumni Relations Office of UCL informed of any changes of your address.

Guests at the De Morgan Association Dinner

# Standing the Test of Spacetime



**Albert Einstein. Picture from 1921**

The famous Scottish biologist D'Arcy Wentworth Thompson once said that Aristotle was the first person who "made [biology] a science, and won for it a place in Philosophy", and in a recent book on Aristotle's biological work Armand Leroi even credits him with being the world's first scientist, while disparaging Plato and modern physicists who come up with theories unjustified by experimental observation.

He has a point, yet quiet contemplation and thought experiments can play a huge role in physics, and Einstein was a master at it. Justifications can be sought later, and applications may appear later still. The modern GPS system is a great example. Facilitated by satellites orbiting the earth it is essential their clocks be harmonised with those on earth, taking into account a 38 microsecond difference per day, otherwise you could soon find yourself standing in a muddy field rather than Piccadilly Circus. Why 38 microseconds? The clocks go 7 microseconds slower because of the satellite's speed — a consequence of Einstein's Special Relativity — and 45 microseconds faster because of the weaker gravitational field — a consequence of his General Relativity. This begs the question of why there are two Relativity theories. But actually there is only one: the General subsumes the Special in the absence of gravity, but in order to explain both let us start at the beginning.

Aristotle formulated a theory, extended by the astronomer Ptolemy, and much loved by the Medieval Church, with the earth at the centre of the universe. Extraterrestrial bodies existed on various concentric spheres surrounding the earth, and the strange motion of the planets was explained using epicycles — each planet orbiting an invisible point that orbited the earth. Lovely stuff, but slight discrepancies with observation enforced added complications, and apart from divine dictate there was no obvious reason for this explanation.

During the Renaissance attitudes started to change. Copernicus in Poland explained planetary motion as being centred on the sun, and the superbly detailed observations by Tycho Brahe in Denmark allowed his student Kepler to formulate a system in which the planets orbited the sun in ellipses. The sun lay at one focus of each ellipse and during the seventeenth century Kepler's precise mathematical formulation finally found its natural basis in Newton's law of gravitational attraction.

Nature and Nature's Laws lay hid in night:
God said, "Let Newton be!" and all was light
Epitaph by Alexander Pope

With Newton's laws there was no longer a reason for everything to be centred on the sun. There was no point of absolute rest — the universe was not moored at the earth, the sun, or anywhere else. All motion was relative.

Fine … but electromagnetism in the nineteenth century caused a rethink. Electricity moving down a wire creates a magnetic field, and a moving magnetic field creates electricity. A synthesis of electric and magnetic fields emerged,

mathematically formulated by James Clerk Maxwell. His equations involved electromagnetic waves moving at the speed of light, which had to be measured as the same by all observers no matter how fast they were travelling relative to one another.

This universal property of the speed of light, verified by experiment, had profound implications, notably providing the basis for Einstein's Special Theory of Relativity, published in 1905. Here space and time were inextricably linked, and two years later, Einstein's erstwhile tutor Hermann Minkowski formulated a four-dimensional geometry embracing both. In this new geometry — spacetime — everything moves from past to future, and things such as spatial distance and time difference that were measured differently by different observers were jettisoned. Instead Minkowski endowed spacetime with a new 'distance' between any two events, invariant under changes of motion and measured as equal by any two observers, whatever their relative speeds.

Speeds less than that of light were of no consequence, so the previous notions of kinetic energy and momentum — vital in classical three-dimensional physics — had to be abandoned. They were replaced by something called energy-momentum in four dimensions, which for a body apparently at rest led to the famous equation $E = mc^2$, E being energy, m the mass at rest, and c the speed of light. The destruction of even tiny amounts of mass could potentially release huge energy, as the atomic bombs in World War Two made horribly clear.

Ten years after the Special Theory came the General Theory of Relativity, inspired by a famous thought experiment. Imagine yourself in a stationary elevator on earth, separated from the world outside. A force holds you to the floor, just as it would if the same elevator were accelerated upwards outside the earth's gravitational field. Is there any difference? Einstein decided not, and by thinking in terms of the new spacetime this led him to an incredible conclusion.

To get the idea, forget four dimensions and picture just two: one for space, one for time. In this case spacetime looks like a sheet of graph paper with a time-axis and a space-axis. The graph for constant velocity is a straight line, and for accelerated motion it is a curve. So the person in the elevator accelerating in outer space follows a curved path, and the same must be true for a person standing still in a gravitational field. This implied that gravity must turn straight lines into curves, so a gravitational field literally bends spacetime.

To appreciate the idea, think of two ships at the equator sailing due north. They gradually get closer. No force draws them together, just the curvature of the earth. This is what Einstein said was happening with spacetime. The curvature produced by a massive body would cause other things travelling from past to future, including light, to veer towards it. In November 1915 Einstein finally had the mathematics to produce numbers explaining an anomaly in the orbit of Mercury, the planet closest to the sun, and observations during a solar eclipse in 1919 verified that the sun's gravity bent light rays passing close to it, just as the theory predicted.

Yet for one of the greatest intellectual advances ever in physics, Einstein never won a Nobel Prize, and when in 1922 the committee finally gave in and awarded him the 1921 Prize it was a backhanded compliment for other work. Scientists can exhibit a marked preference for more practical work, such as Aristotle's zoology, and be quite sniffy about theoretical physics.

- **Mark Ronan**
  Honorary Professor of Mathematics

First appeared in the November 2015 issue of *Standpoint* magazine.
Website: www.standpointmag.co.uk

## Mentoring Students with Hearing Loss in Science, Technology, Engineering and Mathematics

IIn June 2015, I received a Presidential Award for Excellence in Science, Engineering and Mathematics Mentoring (PAESMEM) from President Obama. This was in recognition of work in recruiting and mentoring an unprecedented number of individuals with hearing loss worldwide into science, technology, engineering, and mathematics (STEM) fields.

When I matriculated at UCL in 1982, an estimated 30 people with profound hearing loss who had been educated at special primary and secondary schools in the UK graduated with degrees from universities. While a few read mathematics, others with partial hearing loss who had attended regular or mainstream schools later became distinguished mathematicians e.g. Charlotte Agnas Scott and Dame Kathleen Ollerenshaw. Nowadays, it is thought that hearing loss of all degrees has an incidence of one in six. But there are three challenges facing the student with hearing loss at university. First is “invisibility”. Those with profound hearing loss need role models who can then help them overcome the other two challenges of “ignorance” and “isolation”.

It helped that some of these role models included alumni from Mary Hare School – the designated national grammar school for children with severe to profound hearing loss – who had dealt with “invisibility” via a “support network”. Thus I learnt to “self-advocate” to address “ignorance” by arranging a meeting with the Admissions Tutor (Peter Williams) ahead of term. We discussed obtaining “accommodations”, a buzzword which came into vogue several years later via the Disability Discrimination Act of 1995 (DDA), to overcome “isolation”. Hitherto, students with hearing loss had relied on notes copied from previous years, textbooks and carbon-copied notes by classmates. But there was a surprise in the form of notes re-written the preceding summer by Katie Naughton to whom I am eternally grateful. Peter also arranged for a FM transmitter and receiver system on loan from the Royal National Institute for the Deaf (now renamed Action on Hearing Loss) which necessitated a demonstration at the beginning of each term. With the receiver coupled to my then analogue hearing aids via electromagnetic induction, it was possible to hear just the lecturer’s speech. Theorems, propositions and lemmas had to be written. Moreover, much of the material was didactic i.e. the same words were used again and again. I recall anticipating the lecturers because the voice was coming through clearly. From a cognitive and educational perspective, this has a profound benefit especially in the era of cochlear implants and digital hearing aids which are now enabling people with hearing loss to comprehend speech at least in quiet. The combination of the kindness of people such as Professor Susan Brown who was my personal tutor and Professor Stewartson’s encouragement to enter his office from the main corridor rather than his secretary’s office – which I did not have to take advantage of – allowed me to focus on my studies.

Stewartson’s untimely death at the end of my first year induced an interest in fluid dynamics which continues to impact on my research in computational anatomy (the study of transformations of coordinate systems in comparisons of brain structures from MRI scans) and cochlear physiology. A few years ago I came across a story about Stewartson’s father who happened to be deaf albeit late in life. I also heard from a contemporary of Stewartson that he had a slight stammer from being forced to be right-handed when he was naturally left-handed. So the environment by the teaching staff in the Mathematics Department at UCL was effectively conducive. It also helped that I had a relationship first as a “guinea pig” with the Department of Speech Sciences which continues to this day.

At Oxford, I was exposed to a wide range of applied mathematics that led to a chance attendance at a mathematical biology seminar on cochlear fluid dynamics. Thus the idea of doing research in the auditory sciences was born. Alas I

**Professor Tilak Ratnanather and President Obama**

did not know who the big players in the UK were until I attended a conference on deaf education in a side trip during a visit to Bell Labs in the United States for my postdoctoral work at City University London (with the late Professor Peter Daniels – a contemporary of Professor Frank Smith – who did his PhD and postdoc research with Professor Brown and Professor Stewartson respectively). A conversation with one of the speakers - Bill Brownell of Johns Hopkins University who had discovered the cellular basis of the active process within the cochlea – resulted in moving to the United States. Also I was inspired by the Strategic Plan of National Institute on Deafness and Other Communication Disorders at the National Institute of Health (the equivalent of UK's Medical Research Council) to leverage my experience as the first person with congenital profound hearing loss in the world to obtain a PhD in mathematics and pursue postdoctoral research in the auditory sciences in becoming a role model.

To begin with, I brought about change by getting the Association for Research in Otolaryngology (ARO) to provide accommodations (assistive listening devices such as FM system and real-time subtitling) for people with hearing loss attending ARO's Annual MidWinter Meeting which is the premier meeting in hearing research. In fact it was the 1992 ARO meeting when I found my calling. I then established the HI-ARO group for undergraduates, graduates, postdoctoral fellows, research scientists and faculty with hearing loss doing research in auditory sciences. Starting with 3 people, there are now about 50 including 7 faculty from United States and Europe on the HI-ARO mailing list with 15-20 people attending the HI-ARO dinner at the ARO meeting. This network enables people to benefit from discussions on navigating the educational system, seeking postdoctoral mentors, obtaining a faculty position, and advocating for support services such as captioning in a positive i.e. non-demanding manner. Senior members network with their colleagues to obtain laboratory

experience for the younger members. There is now a strong UCL connection with 3 people doing research in cochlear implants and cochlear physiology including one fellow alumna from Mary Hare School (and Oxford) who I am privileged to be mentoring from afar while pursuing PhD research.

In parallel, since 1994 I worked with the AG Bell Association for the Deaf and Hard of Hearing to provide STEM career information for teens and young adults with hearing loss. Activities include serving on the College Financial Aid Committee since 1996 and as co-chair of the Research Symposium at AGBell's Convention since 2004. The former allows me to recruit students with hearing loss for research in STEM; the latter allows me to tell parents and educators of deaf children that with cochlear implants and digital hearing aids anything is possible including careers in STEM.

It is worth quoting from Ollerenshaw's autobiography "To Talk of Many Things" that mathematics is the one school subject not dependent on hearing. But a few years ago I came up with names of just 21 people with hearing loss known to have obtained PhDs in the past century. These include a postdoctoral fellow with a PhD in Mathematics at John Hopkins and a graduate student in the Department of Applied Mathematics and Statistics at John Hopkins who passed through my lab and now in academia and industry respectively; indeed the former was attracted to work for me having visited my webpage. There are reasons for this small number including "invisibility" and many doing PhDs in other areas, e.g. the "Father of the Internet" - Vint Cerf who happens to have mild hearing loss.

In the United States, about 30-40 people with hearing loss have qualified as physicians. Of these, 8 including 4 JHU students did projects in my lab and now are specializing in anesthesiology, pathology, radiology, pediatrics, emergency medicine and internal medicine. In the future I hope to work with colleagues in Otolaryngology-Head & Neck Surgery to develop opportunities for physicians with hearing loss to specialize in ENT. Hopefully this will be facilitated by the world's first ever undergraduate course in Computational Medicine which we are teaching this academic year.

The new dynamic of students with hearing loss being mentored by role models is facilitating a growing cohort of scientists with hearing loss in auditory sciences and engineering. In turn, this provides a unique perspective on the consequences of hearing loss enabling all scientists and engineers to develop new ways of thinking about their own research.

Much has changed since I graduated from UCL in 1985. But the above mentioned DDA law is not enough because of the three formidable challenges of "invisibility", "ignorance" and "isolation" which can be overcome respectively by finding "role models", being "self-advocates" and getting "accommodations". So subject to optimal conditions, there is no reason why the deaf child with cochlear implants should not be able to succeed in STEM in the 21st century.


- **J Tilak Ratnanather**
  Associate Research Professor, Johns Hopkins University

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## LMS Whitehead Prize

The Whitehead Prize is awarded annually by the London Mathematical Society to several UK-based mathematicians who are at an early stage in their career. The prize is named after the homotopy theorist J.H.C. Whitehead, and it was awarded for the first time in 1979.

My husband David Loeffler (University of Warwick) and I were awarded the prize for our recent work in number theory: the construction of a new Euler system, and its applications to generalisations of the Birch—Swinnerton-Dyer conjecture.

**Sarah Zerbes**

From the LMS newsletter
DR DAVID LOEFFLER of the University of Warwick and DR SARAH ZERBES of University College London are awarded jointly a Whitehead Prize for their work in number theory, in particular for their discovery of a new Euler system, and for their applications of this to generalisations of the Birch–Swinnerton-Dyer conjecture.

# What are the chances of someone winning the National Lottery twice?

Pretty good... but it won't be you!

November 10, 2015

Calculating the odds of someone winning the lottery twice over the next 20 years is a simple exercise in basic mathematical modelling and probability theory. It seemed like a nice topic for a talk I was going to give to a group of A' Level students, I hadn't realised it would also involve appearing on BBC Radio 5 Live's Breakfast Show.

Until the rules were recently changed, to win the UK National Lottery you needed to choose the correct 6 numbers out of 49 possible choices. So the chances of winning with a single ticket in a single draw was

$$p_1 = \frac{49 \times 48 \times 47 \times 46 \times 45 \times 44}{6 \times 5 \times 4 \times 3 \times 2 \times 1} \simeq \frac{1}{14,000,000}.$$

So naively the chances of winning the lottery twice (if you buy a single ticket in each of two draws) is $1/14,000,000 \times 1/14,000,000$ which is roughly 1 in $200,000,000,000,000$. Not great odds.

But that isn't really what we are interested in. We want to know whether *anyone* will win the lottery twice.

To calculate the chances of a two-time lottery win occuring you first need some data. As of 6th Jan 2014, there had been 1882 draws in the UK National Lottery, these had resulted in 4503 jackpot winners (giving an average of 2.4 winners per draw).

Armed with this data we also need to make some assumptions (mainly about the behaviour of players who have already won one jackpot since any two-time lottery winner must first be a one-time winner).

(1) Winners consider themselves lucky and so continue to play, buying one ticket in each draw.

(2) Jackpot winners live for 30 years (from the date of their first win).

(3) The overall number of players doesn't decrease (and so the average number of winners each week remains at least 2.4).

(4) The lottery runs for another 20 years.

(5) Players choose their numbers independently at random (say by using the Lucky Dip option).

The easiest way to do this calculation is to work out the probability that no-one wins for a second time in the next 20 years.

If there are no second jackpot winners then the number of (single) jackpot winners grows on average by 2.4 per draw and so totals around 7000 by 2024. At this point our assumption about life expectancy kicks in (since the first draw was in 1994) and so the number of (single) jackpot winners now remains roughly constant for the next ten years (actually the number would still grow a little due to the fact that originally there was only a single draw each week, but this only increases the chance of a second time jackpot win occuring so we ignore it).

Let $p_1 = 1/14,000,000$ be the probability of winning in a single draw (with one ticket). The probability that none of the 4503 single jackpot winners win for a second time on Wed 8th Jan 2014 is:

$$(1-p_1)^{4503}.$$

Since the number of (single) jackpot winners increases by 2.4 on average per draw (until 2024) the probability that no-one wins a second jackpot before 2024 (during which time $10 \times 52 \times 2 = 1040$ draws take place) is approximately:

$$p_2 = (1-p_1)^{4503\times 1040 + 2.4(1+2+\ldots+1039)}.$$

Using the fact that

$$\sum_{k=1}^{n} k = \frac{n(n+1)}{2}$$

this simplifies to

$$p_2 = (1-p_1)^{1040\times(4503+1247)} = (1-p_1)^{1040\times 5750}.$$

Since the number of single jackpot winners remains around 7000 from 2024 onwards, the probability that no-one wins for a second time between 2024 and 2034 is approximately:

$$p_3 = (1-p_1)^{7000\times 1040}.$$

So overall the probability of no-one winning the jackpot for a second time before 2034 is roughly:

$$p_2 \times p_3 = \left(1 - \frac{1}{14,000,000}\right)^{13,260,000}.$$

Using the fact that

$$\lim_{n\to\infty}\left(1-\frac{1}{n}\right)^n = \frac{1}{e}$$

we can see that this probability will be less than $e^{-13/14}$ which is approximately 0.395. Hence the probability of a second time winner in the next 20 years is better than 60%.

When 18 months later someone duly won a second jackpot (actually Euromillions rather than the National Lottery) the media was full of glorious headlines about a one in a hundred trillion chance event. Luckily a few journalists had read my webpage where I explained the calculation and how this actually wasn't such a big deal.


- **John Talbot**
  Principal Research Fellow

# Football passing networks and Page Rank

Football is arguably the most popular sport in the world, with events such as the football World Cup reaching over 600 million viewers (according to FIFA figures!) worldwide. However, in spite of the widespread passion for football, when it comes to the statistical information reseased during and after games, it has traditionally lagged behind other sports, such as baseball or basketball.

Traditional match reports barely include any figures besides goals, shots, corners, and possession figures. However, the unique nature of football games, with their constant ball flow and comparatively low scores in contrast to other sports, makes such simple statistics insufficient as measures of team and player performance. Fortunately, it seems that the situation is changing. In recent years, starting with the UEFA 2008 Euro Cup, an unprecedented amount of statistical data has been made public after games. The release of significantly larger amounts of data opens up the way for building new and more detailed analyses of football.

One of the most overlooked stat when it comes to football games concerns passing. In a typical football game, there are 2 or 3 goals, and about 20 shots, but well over 300 passes. As much as we love to watch nice shots and spectacular goals, most of the time during a football game is spent passing the ball around. Passing figures in the traditional media are often limited to meager passing accuracy percentages, which tell us nothing about how, when or where those passes happen. Hardly a way to understand what is going on during a game!

How can we keep track of passing during a football game, and make sense of that information to describe what happened in a more accurate manner? Can mathematics come to our rescue here? Believe it or not, the mathematics we need to use to solve this problem originated several centuries ago, even before football itself was invented! In 1736, Leonard Euler wrote his famous paper on the *bridges of Könisberg* problem, which is considered to be the first paper in the history of *graph theory*. Graphs (also called *networks*) have been used often to describe and study a variety of problems, ranging from technological and transport issues to social phenomena and biological problems.

In the world of sports, any team sports involving passes between players provides one with interesting examples of networks. One can consider each team's players as the *nodes* of a network, and the passes between players as *(directed) links*. Furthermore, we can *weight* any link between two players by the total number of passes that occured during a game. The resulting network provides a full description of all the ball passing! Additional nodes can also be added to keep track of other interesting events, such as shots (off and on-target). This is insteresting for several different reasons. Firstly, it provides us with a simple visual representation of a team's *style*. All renowned football teams in history have displayed a *recognizable style* that fans and experts talk about, but this style has remained an ellusive quality very hard to put down in numbers.

As an example, let us look at a sample game, the UEFA 2012 Eurocup final between Spain and Italy. To aid visual representation we have fixed the nodes in positions roughly corresponding to the players' formation on the pitch (see Figure 1).

The passing network is by all means an oversimplification of a football game, a s players do not remain in static positions during games. However, it does provides an immediate insight into a teams' tactics. It can be used, for example, to determine areas of the pitch that are favored or neglected, whether the team tends to use or abuse short distance or long distance passes, and whether a player is not intervening enough in a game. The network can also be used by a team to detect under-performing players, fix weak spots, detect potential

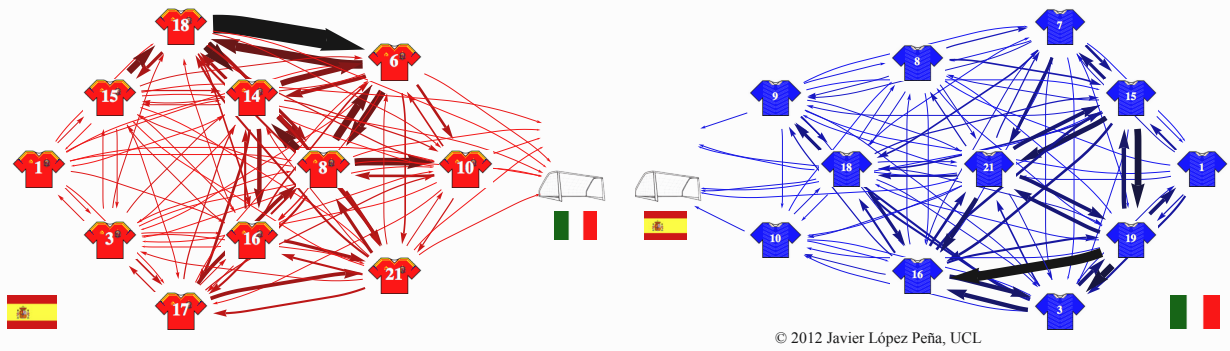



Figure 1: Team networks for the Spain-Italy game, UEFA Eurocup 2012

problems between teammates who are not passing the ball as often as their position dictates, as well as to detect weaknesses in rivals.

But the use of football networks is by no means limited to visualization! There are many network invariants that can be used to describe different properties of the nodes. A particularly nice example of these is Google's PageRank.

The PageRank algorithm was the cornerstone of the web engine classification of websites in order to sort web searches. PageRank gives a measure of the *popularity* of a node in a directed network. In loose terms, the algorithm works as follows: assume that users of the web have a certain (fixed) probability $p$ of clicking on links (Google uses $p = 0.85$), and the dual probability $1 - p$ of stopping their browsing. Assuming also that all links on a website have the same probabilty of being clicked on ($1/n$, where $n$ is the total number of links on the website). If we get a large enough number of users behaving according to these rules for long enough, the proportion of users ending on any specific website will eventually stabilise, and can be thought of as the *popularity* of the website.

The same thing can be done with the football network. Assuming that players have a fixed probability of completing a pass, we can apply the same algorithm in order to determine what is the likelyhood that any given player will have the ball after a high enough number of passes. As any kid who learnt how to play football in the street, the good players are more likely to end up having the ball, so we can use the PageRank value of players as a measure of how important each player is for their team!

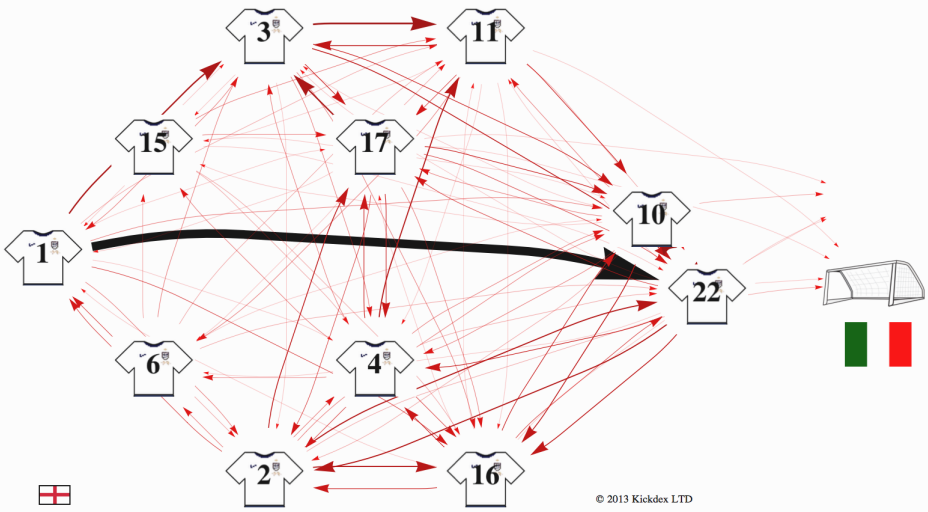
Table 1 shows the different PageRank scores for the players in the Eurocup final. Unsurprisingly, Xavi Hernández and Andrea Pirlo get singled out as the most relevant players for each of their teams posession.

This is just the tip of the iceberg. Network theory is a very rich and well developed theory, and there are many more insights it can give us about football. Just check the references if you are interested!

| Players Spain | PR | Players Italy | PR |
|---|---|---|---|
| Xavi Hernández | 0.143 | Andrea Pirlo | 0.131 |
| Sergio Busquets | 0.124 | Thiago Motta | 0.120 |
| Xabi Alonso | 0.113 | Giorgio Chiellini | 0.117 |
| Sergio Ramos | 0.090 | Daniele De Rossi | 0.098 |
| Cesc Fàbregas | 0.087 | Emanuele Giaccherini | 0.085 |
| Andrés Iniesta | 0.081 | Christian Maggio | 0.082 |
| Jordi Alba | 0.079 | Claudio Marchisio | 0.080 |
| Álvaro Arbeloa | 0.073 | Antonio Cassano | 0.070 |
| Gerard Pique | 0.068 | Leonardo Bonucci | 0.061 |
| David Silva | 0.064 | Mario Balotelli | 0.058 |
| Iker Casillas | 0.024 | Gianluigi Buffon | 0.028 |

Table 1: Players PageRank scores

PS: In case you were wondering, this is how England network looks like:




## References

[1] J. López Peña and H. Touchette, *A network theory analysis of football strategies*, In *Sports Physics*. École Polytechnique Univ. Press, 519–530.

[2] J. López Peña, *A Markovian model for football posession and its outcomes*. `arXiv:1403.7993`

[3] J López Peña and R. Sánchez Navarro, *Who can replace Xavi? A passing motif analysis of football players*. `arXiv:1506.07768`

- **Javier López Peña**
  **Teaching Fellow**

## Faculty Teaching Awards 2015

MAPS Faculty Teaching Awards

Faculty of Mathematical & Physical Sciences Teaching Awards. The Faculty is delighted to announce the winners of this year's Faculty of Mathematical & Physical Sciences Teaching Awards.These annual awards recognise excellence in teaching by staff and teaching assistants at all levels within the faculty.
The winners

- Teaching staff: Dr Helen Grounds (Chemistry)
- Postgraduate Teaching Assistant: Mr Sam Livingstone (Statistical Science)
- Support staff: Mr Bernard Bristoll (Physics & Astronomy)

MSc back in 2008-9
I was teaching first year tutorials (STAT1004 Introduction to Probability and Statistics and STAT1005 Further Probability and Statistics) which were classes of around 20 students each, Math workshop sessions (once per week) for non-Statistics students in STAT2002 Linear models and ANOVA, and workshops for STAT7001 Introduction to Computing for Practical Statistics. I also taught a foundational course on Probability and Statistics for students on the MSc in Risk, Disaster and Resilience (4 hours of lectures). I don't expect you to put all of those things on the announcement though! So feel free to pick and choose as necessary.

There really wasn't anything particularly quirky that I did in my teaching. I just tried my best to focus on what my classes were struggling with and make sure my lessons covered those things as clearly as possible, listened to feedback and tried to update lessons accordingly, and strongly encouraged students to come and ask me questions at any time during the week when they needed some help. I don't really think you need gimmicks to be a good teacher, in my opinion you just have to care, take advice on board, be adaptable and try hard.

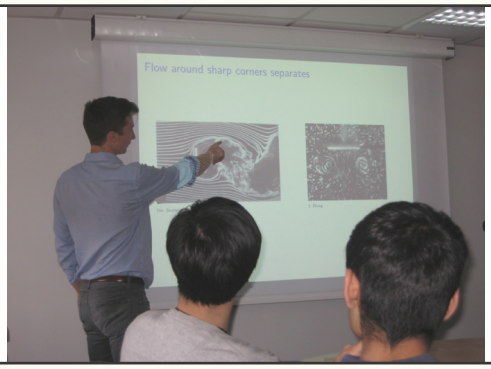
## Student Choice Teaching Awards, UCLU

The Department received three nominations in various categories for the Student Choice Teaching Awards 2015: Dr Riaz Ahmad, Dr Mark Roberts and Dr Isidoros Strouthos. The full list of nominations can be found at:

http://uclu.org/representation/student-choice-teaching-awards/2015-roll-of-honour

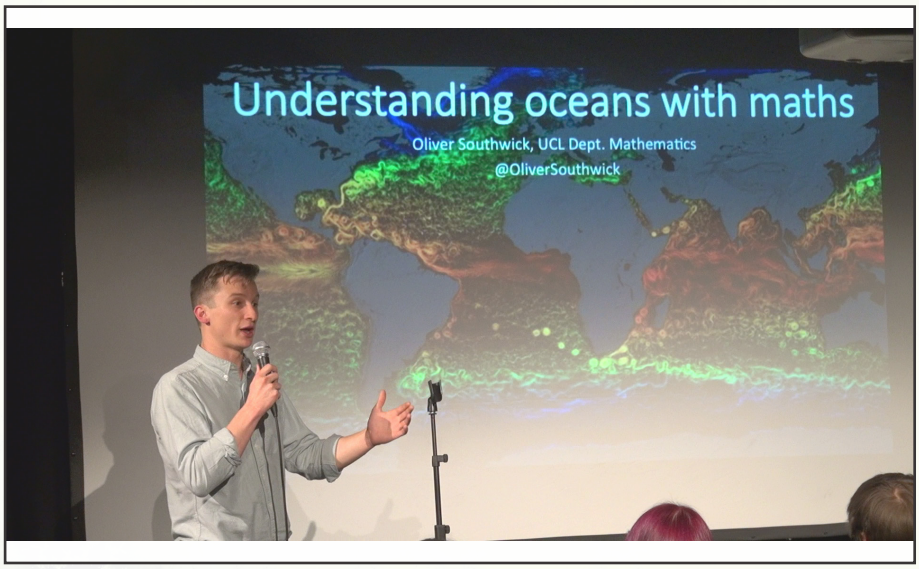
## PhD student Oliver Southwick was awarded a SIAM Student Presentation Prize at the British Applied Mathematics Colloquium

Each year the UK and Republic of Ireland section of SIAM, the Society for Industrial and Applied Mathematics, funds Student Presentation Prizes at a number of academic meetings. These prizes, established in 2000, aim to recognise outstanding scholarship by students in industrial and applied mathematics. Although the presentations may be based on joint work, the prize is assessed purely on the contribution of the presenting author. Typically three or four awards are made at the annual British Applied Mathematics Colloquium (BAMC), a multidisciplinary meeting of applied mathematicians aiming to provide postgraduate students with an encouraging environment to present and discuss their work. The 2015 BAMC was held in April at Cambridge University. UCL Mathematics PhD student Oliver Southwick was awarded one of three SIAM Student Presentation Prizes for his talk “A point vortex model for the formation of ocean eddies by flow separation”. This talk was based on research jointly published by Oliver and his supervisors Professor Ted Johnson and Professor Robb McDonald.




## PhD student Oliver Southwick won second place in the UCL MAPS Faculty Three Minute Thesis competition

In a Three Minute Thesis competition, postgraduate students attempt to explain their work to an intelligent audience with no background in the research area, in just three minutes. The concept originated at the University of Queensland in 2008 and has spread rapidly, with competitions now held in 200 universities globally. By limiting entrants to just three minutes, a single static slide and language appropriate to a non-specialist audience, the competition aims to develop the academic, presentation and research communication skills of postgraduate students. UCL Maths PhD student Oliver Southwick won 2nd place in the UCL Maths and Physical Sciences Faculty;s inaugural Three Minute Thesis competition held in June. His talk “Understanding oceans with maths” gave an overview of the role of mathematical modeling in oceanography and the significance of this to understanding changing climate. This talk was based on his PhD research with supervisors Professor Ted Johnson and Professor Robb McDonald. The competition was won by Earth Sciences PhD student Selina Groh for her talk “Crocodiles through the ages”.




Rod Halburd - It's a long way off until the production of the next De Morgan newsletter, but an interesting article that Rod (copied) might want to contribute might focus on his recent experiences (during reading week) in teaching at Cambodian universities.

CORU –
Work by colleagues Martin Utley, Christina Pagel and Sonya Crowe in CORU published April 2 in the journal 'Open Heart' has led to much media interest e.g. http://www.bbc.co.uk/news/health-32162803
http://www.theguardian.com/society/2015/apr/02/uk-childrens-heart-surgery-deaths-halve-10-years-open-heart

# Inaugural Lecture 2014 - 2015

**Gavin Esler**

Gavin Esler gave his Inaugural Lecture **'The aesthetics of shape'** on Wednesday 5 March 2015.

**Abstract:**
There has been a close relation between aesthetics and geometry since the time of the Ancient Greeks. The golden ratio, the platonic solids and the geometry of perspective are classical examples of the intimate links between the mathematical subject of geometry and the human sense of aesthetics and beauty. At the beginning of the twenty-first century, the mathematics is more abstract, but a sense of beauty still guides us in our research. I shall try to give a sense of the aesthetics of shape from a modern standpoint.

Gavin Esler presenting his Inaugural Lecture

- **Ted Johnson**
  Professor of Mathematics

**Guests at the Inaugural Lecture of Professor Gavin Esler**

# Inaugural Lecture 2015 - 2016

**Andrei Yafaev**

Andrei Yafaev gave his Inaugural Lecture **What makes something special?'** on Wednesday 25 November 2015.

**Abstract:**
In geometry - algebraic geometry in particular, certain objects can naturally be called 'special'. This usually means that they possess extra symmetries that make them stand out from the rest. For example such objects may be acted upon transitively by a certain group. It is desirable (from both theoretical and practical points of view) to be able to characterise these special objects by a property verifiable in practice. They may be characterised by the property of containing many points of a special type. There are other characterisations - they may be characterised by their 'bi-algebraic nature' or in terms of Riemannian geometry (they are totally geodesic manifolds). Proving equivalences between such characterisations is often a difficult (and in some cases unsolved) problem. My research has been mainly concerned with this type of problem. I will present concrete examples, review conjectures and results related to characterisations of 'special objects'. The fascinating aspect of the area is the variety of techniques that can be used, ranging from number theory and geometry to ergodic theory and even mathematical logic.

- **Frank Johnson**
  Professor of Mathematics

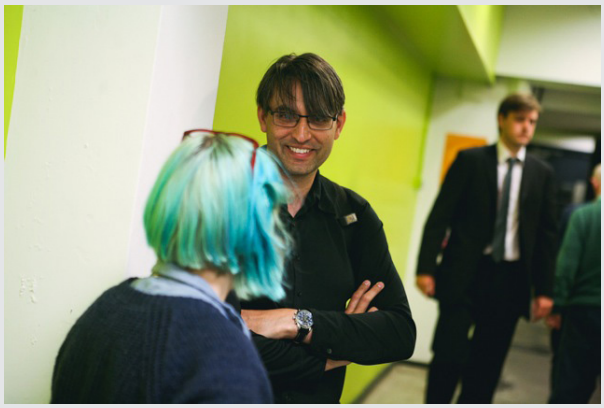
## Take your brain to another dimension

UCL organises many excellent public engagement activities but until recently most of them have been focused on the Bloomsbury area and the events aimed at the general public tend to draw similar audiences. A new venture initiated in part by Bahijja Rahman, a PhD student at UCL, is STEAM:ED Collective, which aims to bring STEM (Science, Technology, Engineering and Mathematics) research to a new audience and through novel means, such as street art.

For one of their first events, STEAM:ED Collective organized a “Science Cabaret” at Goldsmiths in East London. Inspired by UCL’s “Science Showoff” events, they gave scientists 9 minute slots on stage to do whatever they want in order to explain their research (often with hilarious results!), with a comedian acting as compere. This was followed by an informal networking session where the audience had the chance to chat with the performers in a relaxed setting.

I was excited to be invited to take part in the “Science Cabaret”, along with Ashok Jansari (Psychology, Goldsmiths), Cerys Bradley (Security Science, UCL), Galapagos Finch (aka David Urry, Royal Society of Biology) and Steve Fossey (Astronomy, UCL). Whilst the other performers told amusing stories about research or, in the case of Galapagos Finch, sang extremely funny songs about animals whilst in costume, I decided to go for a more standard stand-up comedy routine, with some added dancing! My title was “Take your brain to another dimension”, in reference to a early 90s rave track by The Prodigy called “Out of Space”, which also featured during my act. In between the jokes I tried to explain some of what geometry in higher dimensions means and why it is interesting and important, particularly from the perspective of my own research.

The response to the event was great, and it was clear talking to attendees afterwards that they were not just entertained, but were really engaged with the material and had some probing questions concerning the research they had heard about. I hope that these events continue to happen and that mathematicians take part in them, so that audiences can be inspired by mathematics and learn about the great research we do.



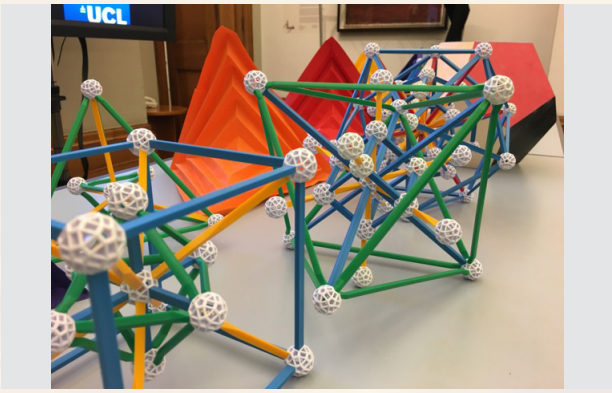


- **Jason Lotay**
  Reader in Mathematics

## Mathematics at the UCL Festival of the Arts

This year I was delighted to be able to bring mathematics for the first time to the Festival of the Arts at UCL. This festival provided an ideal opportunity for a wider audience to take part in the art and mathematics workshop I developed with local artist Lilah Fowler. Around 40 people attended the workshop on 22 May 2015, encompassing a diverse range of interests and occupations, from a National Theatre costume designer to a cognitive behavioural therapist. Feedback from the event was excellent and there were some great pictures of Clifford tori made by attendees after the event, including one made from sinamay, which is usually used to make hats. The festival organizer who attended the workshop was impressed by its success and also enjoyed taking part themselves!

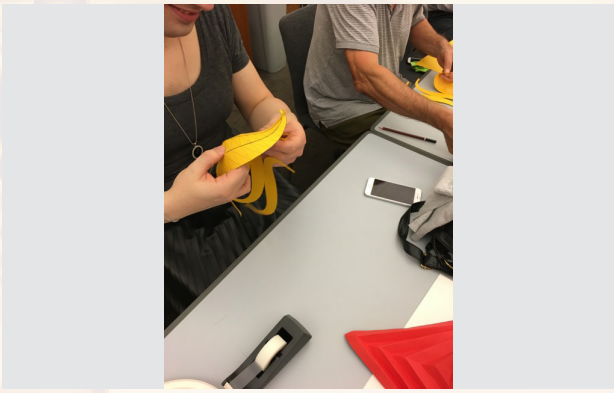
As with previous workshops, the theme was "Seeing in 4D: visualising and making shapes in 4 dimensions". The idea was to give attendees a chance to explore aspects of geometry, particularly 4-dimensional geometry, through art, literature and science, with a focus on explaining the main concepts through pictures and videos. A key aspect of the workshop was the inclusion of practical activities, including drawing, folding and making shapes. Usually Lilah and I demonstrate these activities ourselves, but this time I was happy to have help from three PhD students in geometry, including a student from the London School for Geometry and Number Theory: Raul Galan, Nick Lindsay and Mattia Miglioranza. Their help was invaluable and ensured that the attendees engaged with and enjoyed the workshop, and gave the students some of their first experiences in public engagement.




Building on this success, Lilah and I have already planned two more art and maths workshops, including one with a new theme, so if you are interested in seeing what we do next then watch this space!

## Seeing in 4D


- **Jason Lotay**
  Reader in Mathematics

The British Society of Rheology

## The British Society of Rheology

http://bsr.org.uk

As of March 2015 (and for two years), I am President of the British Society of Rheology. It's a fairly small scholarly society of around 400 members (compare the Institute of Mathematics and its Applications, which has 5,000). It was founded in 1940 as the British Rheologists' Club and still has a bit of the club feel about it – members are very friendly and welcoming and everyone seems to know everyone else (which can be a bit intimidating when you're new).

It's run by a Council of 12 elected members, all volunteers. I've served on its Council before, for 6 years in fact. For four of those I was the Secretary; in the other two years I ran the Society's annual Midwinter Meeting, a two-day conference just before Christmas. As a Society, we work for the promotion of science and dissemination of knowledge on rheology. We do this in a variety of ways: organising conferences; supporting research students to attend other, bigger conferences; and making various awards including one for the best rheology PhD each year, and an Annual Award for rheology research.

But what is rheology? It's not a typo for theology, whatever Microsoft might think. The word was coined almost a century ago and defined as the study of the deformation of matter. In practice, it has become the study of every material that can flow but doesn't conform to Newtonian Fluid Mechanics. So rheology does not mean water, or air, or corn syrup: but it does mean paint, toothpaste, chocolate, oobleck https://youtu.be/f2XQ97XHjVw, foams, emulsions, suspensions, concrete, molten plastic, fibre-reinforced products and most foods.

At the moment my rôle is a combination of overall leadership and strategy, and being the figurehead of the society. I get to notify award winners of the good news; and when the Midwinter Meeting comes round, I will get to present the awards, wearing the splendid chain of office. It might not fit (I am, after all, the first female president, and rather smaller than most of my predecessors) but I will enjoy it nonetheless.

- **Helen Wilson**
  Reader of Mathematics,
  President of The British Society of Rheology

## Postdoctoral Research

Olga and Pilar
The department has a fair number of postdoctoral researchers. We are very international coming from different parts of Europe, North and South America, Asia, and some more locally from the UK. Our fields of research are as diverse as our origins and many of us not only do research, but are involved in teaching in the department. In London, there are many opportunities to connect with researchers at other institutions with frequent seminars, workshops and conferences that we take advantage of. Since postdoc appointments are sadly only temporary, this year we had to say goodbye to some people such Martin Orr, Marcello Seri, Nicolas Salles and Oldrich Spacil. Some of these went on to other positions either locally such as at Imperial or École Nationale Supérieure de Techniques Avancées in France. Fortunately, they still come visit us quite often. That also means we welcomed new postdocs like Alden Waters, Diana Knipl, Chris Wray and Guhan Harikumar among others.

We not only work hard, but also enjoy spending time together and exploring other aspects of London life too. We go out for food and drinks (you can find us at the Housman room as shown in the picture) quite regularly. We also explore festivals such as the one in Angel as pictured below. The Sunday of the festival, we started off with brunch on Holloway road and walked to Angel to see the canal festival. We still keep up the tradition of a Cinema Club called Pacman Awards (https://sites.google.com/site/thepacmanawards/) by taking over the staff room after everyone leaves for the day (as shown in the picture). The Pacman Awards consists of everyone suggesting a movie anonymously on a theme and then voting for the one we watch. The winner gets to choose the theme for the next movie night. Oh, and one other well known fact about our corner of the department! We always have interesting snacks and treats to keep us happy during the productive hours and always welcome more contributions!

- **Postdoctoral Research Associates**

**Drinks after a long day at the Housman room (left to right, clockwise) Richard Pymar, Nicolas Salles, Ruben Perez-Carrasco, Pilar Guerrero, Oldrich Spacil, Karsten Fritzsch, Marcello Seri and Olga Trichtchenko.**

**Reliving our childhoods at the Angel Canal Festival (left to right) Alden Waters, Nicolas Salles, Jacqui Espina, Olga Trichtchenko, Pilar Guerrero and Panagiotis Giannioti.**

**One of the famous Pacman Awards nights (left to right, clockwise) Panagiotis Gianniotis, Richard Pymar. Lucio Guerberoff, Pilar Guerrero, Ruben Perez-Carrasco, Olga Trichtchenko, Karsten Fritzsch, Marcello Seri and Nicolas Salles.**

## Postgraduate Research

- **Postgraduate Researchers**

## Chalkdust, the 707 Project

On a cold afternoon on the 27th January 2015, we were gathered on the seventh floor of the UCL Mathematics Department discussing ideas for a new mathematics project. We were not sure whether creating a website with puzzles, or a blog with interesting articles, was a good idea. Would people ever bother to read what we would publish? And if we wanted to print something, then how would we get the money to do so? Indeed, the challenges seemed so many and we weren't convinced it was worth doing anything at all.

Although we were not sure about many things, we did know three things for certain: first, we were convinced that mathematics is beautiful, useful and fun (I mean, it's what we do everyday, so how can it not be fun?). Secondly, we felt that we, mathematicians, have a lot of things to say and that we also enjoy reading about the many ways in which others use this amazing science. And thirdly, that working as a team results in more successful projects than those run by individuals; so gathering a group of people willing to sacrifice a bit of their time was a crucial part, but in that, we had already been successful. That day, there was a group of both undergraduates and postgraduates, trying to start a project.

So, on that wonderful afternoon, in Room 707, Chalkdust was born. The goal was to create a project that could involve every person at UCL who has at least a minor interest in mathematics and so we decided to create a printed magazine that would be free for the readers and also available online. Just a few weeks later we sent the first edition of our magazine to the printers, and then we were ready to launch the project and share it with our colleagues, friends and teachers. Immediately after that we also launched our weekly blog, our monthly newsletter and we started working on our second edition, which we published during the first week of October.

This project is here thanks to the immense support we have received from UCL, from the UCL Department of Mathematics, members of staff and former and current students. It's a project that thrives on the contributions that it receives from others, whether it's a simple puzzle or joke, a blog or an article. We are always happy to receive any mathematics-related content that is worth reading.


**Chalkdust Team**
**From the back left: Sam Brown, Adam Townsend, Matthew Scroggs, Matt Wright, Pietro Servini, Huda Mohd Ramli, Rafael Prieto Curiel and Anna Lambert**

During this first period of Chalkdust we have printed more than 2,000 copies of the magazine, which we have distributed for free, and we have had more than 60,000 clicks on our website, which is something we are delighted about. But we also feel happy to have created a project that belongs to the community of mathematicians. Eventually, all the current members of the Chalkdust team will finish their studies but, hopefully, others will pick it up and carry on this project so that we can continue to enjoy its output.

Finally, if you would like to read the articles that we have published so far, or if you would like to contribute an article or a blog, you can visit our website at www.chalkdustmagazine.com, where you can also subscribe to our newsletter or follow us on our social media channels.

- **Rafael Prieto Curiel**
  Editorial Director, Chalkdust

Rafael will submit a paragraph on the Field Medalist & photo by 20/11


## The London School of Geometry and Number Theory

- **Michael Singer**
  Professor of Mathematics,
  Centre Director, LSGNT

**Eddy Yeo and Silvia Butti**

## Augustus De Morgan (ADM) Mathematics Society

- 
  Secretary of ADM Maths Society

## London Mathematical Society Undergraduate Summer School - 20-31 July 2015

In order to celebrate their 150th anniversary, the London Mathematical Society has started a series of undergraduate summer schools to give students a taste of mathematical research in upcoming fields. The first was held in June earlier this year at Loughborough University for two weeks, accommodating up to 50 students. Undergraduates from around the country not in their final year of study were invited to apply through their university.

The study programme comprised lectures, exercise classes and colloquium talks. The lectures were structured into 8 separate courses, each taught by lecturers invited from top universities across the UK. They cover a wide variety of different subjects: fluid dynamics; mathematical biology; algebra; and geometry. Exercise classes spread throughout each course gave participants the chance to apply and consolidate their newfound knowledge to a set of problems and questions.

In our experience at the LMS Summer School, although the topics appeared to be seemingly unrelated, there turned out to be many common themes that linked the courses together. This was very helpful because the added familiarity gained in an earlier course made it easier to comprehend the later courses. Complex analysis was one such link, arising in the context of the fluid dynamics course by Darren Crowdy (Imperial College) and the material on continued fractions and hyperbolic geometry by Caroline Series (University of Warwick). Another was the platonic solids, which first arose in the lectures by Reidun Twarock (University of York) on groups and virology, and then again in the purely algebraic talk on quivers by Gwyn Bellamy (University of Glasgow). The links helped reinforce the connectedness of mathematics and was one of the many successes of the course.

**Official photo**

Each day concluded with a colloquium talk. The aim of these talks was to provide a general overview without getting into the details. Subjects varied widely, from origami paper folding (geometry) by Tadashi Tokieda (University of Cambridge) to a discussion of 'What is Research in Mathematics' by Sir Timothy Gowers (University of Cambridge).

Accommodation for the fortnight was provided by Loughborough University. The campus is large with great sports facilities, including tennis courts, football pitches and even a gym for those keen mathematicians. The food was excellent – three full meals each day which were very welcome after the demanding lectures!

There was a midweek evening trip to Bradgate Park Trust, where we were given a tour by Alexander Veselov (University of Loughborough), one of the organisers of the Summer School. Over the weekend there were also two excursions. On Saturday we visited Lincoln followed by Woolshorpe Manor, the birthplace of Sir Isaac Newton. On Sunday we visited Chatsworth House in Derbyshire; luckily the house is very large because it rained all day and most people stayed inside!

The London Mathematical Society plans to run the school for two more years as a pilot exercise to assess its success before committing to it as an annual event.

- Mai Bui MSci Mathematics and Statistical Science
- Jeff Leung, Third Year MSci Student
- John Scott, Third Year MSci Student

Exercises

Caroline Series (I)

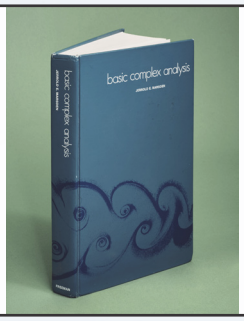
Mark Gross

## Dave Imms

Dave Imms, photographer,
this week, Thursday 12 and Friday 13 Feb 2015.

I had been struggling to know how to approach the idea of Mathematics for quite some time, and I still am during my editing stage. How do you photograph what Mathematics is?

A start, at least, is to show where 'real' Maths all begins. I say 'real' maths since as far as I am concerned, university level is where you separate the men from the boys. Documenting the science of Mathematics with the contemporary demographic of modern day London, in an institution such as UCL is a goldmine for a project. Later this year I'll try and come back and shoot some more and finish the project and photograph some more excellent people.




Rahiil Sachak-Patwa

**Departmental Colloquium (from left): Yanlong Fang, Valery Smyshlyaev, Anna Lambert, Belgin Seymenoglu, Professor John Willis, Adam Townsend and Bernhard Pfirsch**

## Departmental Colloquium

**Professor John Willis, Centre for Mathematical Sciences (CMS), University of Cambridge gave a talk on 3 November 2015 entitled "The constitutive response of metamaterials"**

**Abstract:**
A metamaterial is nothing more than a composite material, designed so as to have properties not usually found in nature but nevertheless allowed by the basic laws of physics – for instance a material with simultaneously negative dielectric constant and magnetic permeability, or with simultaneously negative elastic modulus and mass density within some range of frequencies. I shall describe a general approach towards defining effective properties of composite materials, develop some explicit formulae for the case of elastodynamics and show some simple example calculations for a laminate which demonstrate the possibility of quite complex response.

## Karen Page

Promotion to Professor of Mathematical Biology

**Research interests include:**

- Shimura varieties
- Abelian varieties
- Andre-Ooort and Zilber-Pink conjectures
- Applications of Ergodic and Model theories to number theory

## Christina Pagel

Promotion to Reader of Operational Research

**Research interests include:**

Differential geometry and geometric analysis, including

- Special holonomy metrics
- Calibrated geometry
- Lagrangian mean curvature flow
- Gauge theory

## The following staff have recently joined the Department of Mathematics:

Dr Zhirayr Avetisyan, Research Associate
Mr Guhan Harikumar, Research Associate
Mr Harry Donnelly, Administration Team
David Hewett
Dr Diana Knipl, Research Associate
Dr Alden Waters, Research Associate
Mr Chris Wray, Research Associate

# Prizes Awarded to Undergraduate Students July 2015

## First Year Prizes

**Kestelman Prize**
Aryan Ghobadi

**Stevenson Prize**
Bruno Souza Roso

**Filon Prize**
Lingbo Ji

**Hill Prize**
Mihai Barbu

**Jeffrey Prize**
Silvia Butti

**1st year Prize in Mathematics:**
Lyuben Konstantinov
Lewis Marsden
Joshua Smith
Jai Lathia
Hassan Tahir
Pengcheng Chen
Xinyi Xu

## Second Year Prizes

**Bosanquet Prize**
Yi Sun and Ruoyu Wang (shared)

**Andrew Rosen Prize**
Leo Middleton and Wojciech Waniek (shared)

**Kestelman Prize**
Devante Suchit

## Third Year Prize

**The Nazir Ahmad Prize**
Udhav Fowdar

## Finalists Prizes

**Andrew Rosen Prize**
**Imogen Dell**

**Barlett Prize (joint Mathematics/Statistical Science degree)**
Yuxing Chen

**Ellen Watson Memorial Scholarship**
Atheeta Ching

**Mathematika Prize**
Xinze Zhu

**Wynne-Roberts Prize**
Megha Patel

## Fourth Year Prizes MSci

**David G Larman Prize - Pure Mathematics**
Jason Vittis

**Susan N Brown Prize - Applied Mathematics**
Alex Doak

## The Institute of Mathematics and its Applications (IMA) Prizes

**1 year membership of the IMA**
**Third Year Finalist**
Megha Patel

**Fourth Year**
Jason VIttis

## MAPS Faculty Prizes

**Dean's List Commendations:**
Jonathan Lee, MSci Mathematics;
Huiyi Ma, BSc Mathematics with Economics
Megha Patel, BSc Mathematics
Ben Smith, MSci Mathematics
Jason Vittis, MSci Mathematics
Xinze Zhu, BSc Mathematics with Management

**Jackson Lewis Scholarship**
Lingbo Ji, BSc Mathematics and Physics, First Year to Second Year

## Students who have recently obtained PhDs from the Department include:

**Peter Baudains**
Research Title: Spatio-temporal modelling of civil violence: Four frameworks for obtaining policy-relevant insights

**Thomas Evans**
Research Title: Perspectives on the relationship between local interactions and global outcomes in spatially explicit models of systems of interacting individuals

**Yoshinori Hashimoto**
Research Title: Some results on stability and canonical metrics in Kähler geometry

**Thomas Kecker**
Research Title: On the singularity structure of differential equations in the complex plane

**Ali Khalid**
Research Title: Free boundary problems in a Hele-Shaw cell

**Ahmad Nadim**
Research Title: A periodic monogenic resolution

**James Oldfield**
Research Title: A two-term Szego theorem for generalised anti-Wick operators

**Marcus Schofield**
Research Title: Price feedback and hybrid diffusions in finance

## Prizes awarded to MSc and PhD Students – November 2015

**Antoine Pasquier**
**Frank T Smith Prize**
Awarded in the MSc Mathematical Modelling programme for the best overall performance.

**MSc Financial Mathematics Award**

**Pietro Servini**
**Andrew Rosen Prize**

**Rafael Prieto Curiel**
**Andrew Rosen Prize; JJ Sylvester Scholarship**

**Hugo Casillo Sanchez**
**JJ Sylvester Scholarship**

**Sebastian Bahamonde Beltran**
**JJ Sylvester Scholarship**

**Luca Scarpa**
**Lighthill Fund**

**Kavinda Jayawardana**
**Wren Fund; Edwin Power Fund;**

**Jianzhi Cheng**
**Archibald Richardson**

**Celso Dos Santos Viana**
**Corte Studentship**

**Samire Balta**
**Sir George Jessel Studentship**

**Momchil Konstantinov**
**Mayer de Rothschild; Davenport Prize**

**Ashley Whitfield**
**David Warren Fund**

**Tao Gao**
**Monica Hulse**

**Augustin Moreno**
**John Hawkes Scholarship**

;

## J J Sylvester Scholarship Fund

The J J Sylvester Scholarship Fund was set up in 1997, on the centenary of the death of J J Sylvester, one of the most gifted scholars of his generation. The Fund aims to award a scholarship to help support a gifted graduate mathematician.

You can make your gift to UCL online, by telephone or by post. Donations may be made by cheque, charity voucher or GiftAid. Cheques should be made out to the UCL Development Fund and sent to the Departmental Manager, Helen Higgins. Any donation, large or small will be gratefully acknowledged by the College. If you are interested in knowing more about the Fund or other tax-efficient ways of supporting the Fund please do not hesitate to contact Hamish Stewart at makeyourmark@ucl.ac.uk or on +44 (0)20 3108 3834.

Giving Online:
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Giving By Post: To make a gift by credit or debit card, or set up a direct debit (if you have a UK bank account) by post, please download our UK/ overseas gift form:
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Sylvester was one of the greatest mathematicians to be associated with UCL and it is hoped that, through contributions made to the Scholarship Fund, we shall be able to assist in progressing the education of other mathematicians so as to realise their full potential for the benefit of us all.

## In Memoriam: Leslie Hocking

## 1927 - 2015

Good afternoon. My name is Paul Hocking and I am Leslie's eldest nephew. In this short tribute on behalf of Leslie's family, we commemorate Leslie the man, Leslie the academic and Leslie the Christian.

Who was Leslie the man? Leslie was born in 1927 in Finsbury Park, north London, a second son for his parents Leonard and Dora Hocking. My father, Charles, was 2 years older and Elizabeth followed three and a half years later. In 1934 the family moved to a new house in Enfield, Middlesex which was then on the edge of the countryside, providing the clean air that Charles required and exposing him to the farming life that was subsequently to be his occupation.

Tragically, in 1940, Leslie's father Leonard died as a consequence of heart damage caused by rheumatic fever and the following decade was a difficult time for the family. Leslie attended Enfield Grammar School where his mathematical ability was recognised and where a gifted teacher encouraged him to try for Cambridge University. Leslie was successful and from 1945 to 1948 he read mathematics at Gonville and Caius College Cambridge where he was awarded an unclassified degree. This occurred because he missed his final examinations: if this sounds rather unlike the ordered and reliable Leslie we all know, you are correct – the examinations were missed because he was on his sick bed with a very bad attack of whooping cough.

From 1948-1950 Leslie taught at Hertford Grammar school – mathematics teachers being exempt from National Service – and subsequently as a lecturer at Woolwich Polytechnic (now Greenwich University). He developed his expertise in fluid mechanics during this period and gained a PhD through University College London in 1958. Part of his research on fluid dynamics was related to droplet formation, and he was frequently in contact with the met office.

However, Leslie was far more practical than the popular caricature of an ivory tower academic would have it. For example, in the 1960s he constructed a robot that was used for children's talks and he also volunteered for several years in his 20s to help with summer camps for boys. Furthermore, as an applied mathematician Leslie was interested in solving practical problems: on one occasion at his brother's farm in the early 1970s, Leslie was observed watching the flow of milk in a clear pipeline linking the milking parlour to the bulk milk tank; and of course, predicting the weather, and particularly rainfall, was critically important for farmers.

From 1957 to his retirement Leslie was employed at University College London where he was awarded a personal chair in1977. He travelled frequently to lecture and conduct research overseas including a year-long sabbatical at the University of Michigan that led both to a close personal friendship with Walter Debler and many subsequent years of collaborative research. From 1988-1993 he edited the Quarterly Journal of

Mechanics and Applied Mathematics. He also travelled widely for both work and pleasure and kept a detailed record dating from 1955 to 2011.

In 1992 Leslie retired from UCL and took up voluntary work, mainly with the Joint Educational Trust, helping disadvantaged children to obtain boarding school places. He also took up interests from earlier days recognising the need for intellectual challenge (this for someone who would complete the Times crossword over breakfast!). In 2010, he embarked on an Open University course on classical studies with some additional maths, much to the delighted amusement of Elizabeth! Unfortunately his ability to concentrate for long periods deserted him at his final exam last year, aged 86, and to his annoyance was awarded a pass degree instead of the honours degree that he had hoped for.

Leslie's last interest was in writing poetry (inspired by Chris Payne, a member of this church). He enrolled with the Poetry Bureau and after sending his efforts off to be evaluated by a tutor would eagerly await the comments and recommendations on his submission. The wider family have enjoyed his poetic take on every-day and not so every-day events. The last set was returned to him while he was in hospital: he was gratified for his work to be given a B, up from the grade C when he started.

Leslie's family have fond memories of a generous and caring man. His great-nephew Chris recalls: "Leslie always had a grin and his very own unique chuckle", whilst his niece Sue comments "I liked that he was a little eccentric. For instance that he rode a moped at one time and wore a denim jacket. His hair was quite cool too!" (Leslie's hair stuck up on end and there was nothing he could do about it.)

Now what of Leslie the academic and mathematician, what were his achievements?

A colleague at UCL writes that "Leslie was a truly British Applied Mathematician. He analysed the equations that govern fluid motion theoretically but also was one of the earliest adopters of numerical computation by computer. Leslie made significant contributions to the study of the strange effects when a fluid is rapidly rotated, which, perhaps surprisingly, is relevant to the motions of the atmosphere and oceans, dominated as they are, at large scales, by the Earth's rotation. However Leslie's greatest impact was in the theory of fluids spreading on a solid surface. This is an extremely difficult problem as the contact between the edge of the drop and the supporting surface [such as milk in a pipeline] is to this day poorly understood. Leslie resolved many of the problems associated with these motions which had troubled researchers the world over. Two of his papers on this topic have been cited between them almost four hundred times. In all Leslie published 80 papers, the last in 2003, in the highest quality journals and 6 of his papers have been cited over 100 times."

In 1991 Leslie published a text book: Optimal Control: An introduction to the theory and applications. To date it has sold a magnificent 1840 copies and has been reprinted twice. This book is still recommended for advanced maths courses at both Oxford and Cambridge. Furthermore Leslie taught himself the topic in order to teach a course at UCL.

An ex colleague writes: "For me the most important part of Leslie's contribution was his clarity, integrity and friendship. As a young lecturer at UCL I learnt much about academia from him. He freely gave advice, encouragement and support (particularly the latter when I had put my foot in it). He was also a wonderfully clear and concise lecturer." One of his students has written that "Leslie was an excellent supervisor, and indeed colleague. He was approachable and helpful, and I always felt well looked after, both academically and personally".

Lastly, but importantly, what of Leslie the Christian? Leslie's early background was in a branch of the Plymouth Brethren in which his father and particularly his grandfather were active leaders and speakers. It is somewhat ironic that Leslie, and indeed the whole family, including his cousins, should have subsequently joined the Church of England in which Leslie was a lay reader for 50 years, mainly here at St James. Leslie's last sermon, number 563 (yes they are all numbered and recorded in this book) was

on 20th January 2013, on the occasion of his retirement as a Lay Reader. The subject was "water into wine" based on the demonstration of Jesus' divinity in the changing of water into wine at a Middle Eastern marriage: this is the final paragraph:

"I have now reached a milestone in my life, from now on it is downhill all the way, so people say. Actually, it is uphill as age increasingly makes life more difficult. What the future holds is unknown, but in whatever happens, I hope I will be able to say 'you have kept the good wine until now'. So I, and I hope you too, may experience again the transforming power of Christ, changing the water of everyday experience into a draught of new wine".

This may sound unlike the sober, quiet and reserved man of few words known to Leslie's colleagues and (possibly loud and extravert) family. But his Christian faith was of fundamental importance to him and held with firm conviction. In 1989 Leslie gave a sermon on "My Faith" some of which is reproduced on the back of the service booklet (if anyone would like to read the complete sermon please let me know and I will forward it by email). It is an erudite account of why he believed in God – a belief based, appropriately for a mathematician, on the orderly nature of the world. It also deals in wonderful simplicity with the problems that faith encounters – natural disasters, wars, sickness and disappointment. Finally the sermon points to the "good news" of God's gracious acceptance of all who put their trust in the death of Jesus Christ on the cross on his or her behalf. God has now welcomed Leslie into his presence, and will welcome each one of us, on the basis of this all sufficient sacrifice.

Today we remember, and celebrate, Leslie's life with us.

## In Memoriam: Klaus Roth

With deepest regret, I write to tell you that Klaus Roth passed away peacefully in the middle of the night of 9/10 November at the Highview Nursing Home in Inverness, Scotland, a few days after his 90th birthday on 29 October

# In Memoriam: Steve Gallivan

## ? - 25 July 2015

From CORU website:
Prof. Steve Gallivan

We deeply regret to announce the death of Professor Steve Gallivan after a period of illness. Steve joined CORU in 1985 and served as our Director between 1995 and 2007. He made an immense contribution to the life and work of the unit, and to the application of operational research to health care internationally. His contribution to OR was recognised by the Canadian Operational Research Society in 2009 when it awarded Steve the prestigious Harold Larnder Prize. His influence on the work we do remains.

The thoughts of everyone at CORU are with his wife, Mary.

Steve Gallivan

*David Larman writes:* When I returned to UCL in 1968 (after a period of learning the trade at the University of Sussex) I was allocated, for my tutees, Steve Gallivan and Richard Gardner. What an incredible piece of luck to be allocated two of the very best mathematics students seen at UCL in modern times. We spent the tutorials discussing, and trying to solve, some the most tantalising research problems.

Steve subsequently became my PhD student and spend a year at the University of British Columbia, Vancouver where he produced some excellent mathematics and proved to be a very much better ice skater than me.

Steve was spotted by Professor Ray Jackson, then Head of CORU (Clinical Operational Research Unit), based in the Statistics Department of UCL, and subsequently, Steve succeeded Ray as Head of CORU.

Steve was an avid cricket fan and, together with his wife Mary, became members of the Lord's Cricket Ground.

He will be sorely missed.

## Inaugural Lecture 2015-2016

Andrew Granville will present his Inaugural Lecture **'The pretentious approach to analytic number theory"** on Wednesday, 11 February 2016, 4.00pm in Room 505, followed by refreshments in Room 502.

**Abstract:**
Deep ideas that tie together seemingly different fields, are often the catalyst for the most insightful work in mathematics. In 1859 the great geometer, Bernhard Riemann, wrote his only article about prime numbers, a ten page memoir that was to have an enormous influence in the development of the subject, suggesting a brilliant and surprising approach involving complex analysis of functions. This became the main approach to the whole subject of analytic number theory for the next 150 years.

Over those years, various researchers have developed "ad hoc" approaches to specific questions, that did not use Riemann's ideas directly, yet it was only about six years ago that Soundararajan and the speaker suggested that the whole subject might be approached by a combination of these alternative ideas, and then went on to show that this is so.

Since we released a first draft in 2011, many of the finest young minds in analytic number theory have joined in developing this approach, and recently some well-known, challenging problems have been resolved that had been inaccessible to the old methods.

In this inaugural lecture we will give some idea of what is interesting about these recent developments, and explain what is "pretentious" about our approach to the subject.

## Sublime Symmetry - De Morgan Foundation
## The Mathematical Devices Underpinning William De Morgan's Fantastical Ceramic Designs

This sounds like a fantastic opportunity, thank you so much for thinking of the exhibition. At present, we are still negotiating with our funders and so not advertising this exhibition publicly at the moment.
I am hoping this this should be resolved by December however, and therefore we would be able to be featured. I will have the information you require to you by 20th November.
Thank you again,

Sarah

We would welcome news and contributions for the next newsletter which should be sent to:

Professor Ted Johnson, The De Morgan Association, Department of Mathematics, University College London, Gower Street, London WC1E 6BT.

Email:
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