



De Morgan Association NEWSLETTER

UCL Mathematics Department

The department is proud to recruit excellent undergraduate students who, having typically achieved A*A*A at A-level (with the A*s in Mathematics and Further Mathematics), are among the highest qualified entering UCL. That we do so in large numbers, annually recruiting a first year cohort in excess of 200 students to our undergraduate programmes, is impressive and also makes the department one of the largest at UCL in terms of numbers of undergraduate students.

To sustain such large numbers of well-qualified students it is important that the department teaches well. This means many things of course e.g. presenting mathematics clearly and thoroughly, even inspiringly, in lectures; providing timely and useful feedback; offering a broad range of mathematically interesting modules and projects; and providing effective support for students. Some evidence that we perform these activities well is provided by the National Student Survey (NSS), an annual UK-wide survey of final year students. In the 2016 NSS the department scored an overall satisfaction rating of 93%, ranking us, among Russell Group mathematics departments, equal 3rd in the UK and the top-rated department in London. This was an excellent performance and one that all teaching and administrative staff can be proud of.

Further evidence for the department's commitment to high-quality teaching was recently provided by the 2016 Internal Quality Review (IQR). This is a major, UCL run, exercise

in which a departments' teaching and learning provision are reviewed every 5-7 years. A team of assessors visited the department early 2016 and conducted a thorough review of our teaching-related practices and met with both students and staff. The IQR team reported that "*overall Mathematics operated effectively in delivering high quality undergraduate and postgraduate programmes as demonstrated by the design of its programmes, its responsiveness to industry, and the high levels of satisfaction expressed by staff and students.*"

The IQR highlighted several items of good practice including our commitment to both student transition to higher education and to widening participation. The Undergraduate Colloquium was also singled out for praise. In this activity, undergraduate students, with support from the department, arrange their own colloquium at which they present topics, often very advanced, of mathematical interest to each other.

We continue to review and modify our teaching provision. This academic year the department is introducing two new teaching innovations: the introduction of Python programming for all first year students and post-exam second year group projects.

We are excited about these developments and believe that both these initiatives will further develop the communication, programming and team-working skills of our graduates.

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From the Editor

This year the annual dinner of the De Morgan Association was held on Friday 10th June 2016 in Senate House, University of London. The Guest of Honour was Dr Vicky Neale of the University of Oxford. Dr Neale gave a fascinating insight into the collaboration on the Twin Primes Conjecture facilitated by the open online forum Polymath. Her topic was particularly appropriate as Professor Andrew Granville, one of the world-leading experts on the problem, has recently joined UCL. Professor Granville himself presented his inaugural lecture this year and Dr Yiannis Petridis' article discusses Professor Granville's work on the Pretentious Approach to Analytic Number Theory.

Our Associate Editor Bonita Carboo moved next door to take up a new position in the Department of Physics and Astronomy in 2016. All those who have worked with Bonita in Mathematics were sad to see her move on. Bonita worked indefatigably as Associate Editor on the Newsletter, encouraging articles from staff members and student groups and keeping the production of the Newsletter on schedule, with her feeling for design shining through in the artwork and layout. I am deeply indebted to Bonita for her cheerful collaboration.

Our new Associate Editor is Kate Fraser, who joined the department over the summer. We hope that you enjoy this first edition with Kate at the helm and encourage you to send us articles and photographs for future editions.

Ted Johnson
Professor of Mathematics

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April 2017

Editor Ted Johnson

Associate Editor Kate Fraser

(Continued from page 1)

I am delighted that in the last year the exceptional teaching efforts of department colleagues have been recognised by the receipt of three prestigious teaching awards. Dr Jonny Evans received a Provost's Teaching Award, and Matthew Scroggs (Postgraduate Teaching Assistant) and Dr Luciano Rila won Faculty awards for their outstanding teaching. Additionally, in recognition of the importance of teaching in the department, we have inaugurated our own teaching prize to be awarded annually at the De Morgan Dinner. The prize is open to anyone in the department involved in teaching or its support. I am pleased that first recipient was Professor Helen Wilson, for her teaching excellence, curriculum development of applied mathematics modules and her training of new PhD Teaching Assistants.

And not least, are the annual Student Choice Teaching Awards run by UCLU. In 2015-16 Matthew Scroggs, Dr Mark Roberts, Dr Sergei Timoshin, Dr Jonny Evans and regular nominee, and former winner, Dr Isidoros Strouthos were all nominated in various categories of these awards.

Professor Robb McDonald
Head Of Mathematics Department



**Robb McDonald at the launch of the Henrici Model
(pg 14)**

DE MORGAN ASSOCIATION DINNER

De Morgan Association Dinner 2016

I was very honoured to be invited to speak at the UCL De Morgan Dinner.

I spoke a little about the recent spectacular progress towards proving the famous Twin Primes Conjecture, which seemed particularly appropriate since one of the experts on the problem, Professor Andrew Granville, is at UCL. The conjecture asserts that there are infinitely many pairs of primes that differ by 2 (pairs such as 3 and 5, or 17 and 19, or 101 and 103, for example). A sequence of breakthroughs over the last few years started with Zhang's proof that there are infinitely many pairs of primes that differ by at most 70 million, and has since progressed to showing that there are infinitely many pairs of primes that differ by at most 246. Not only is this a great story about mathematical progress, it also sheds light on some of the ways in which mathematicians make progress, and this was the main focus of my talk.

For example, mathematicians tackle and solve easier but related problems and this can be helpful. Some mathematicians choose to think very hard by themselves, others collaborate. Some of the recent progress towards the Twin Primes Conjecture came from Polymath, an open online collaboration in which a range of people came together to understand the work of Zhang, Maynard and others, to develop the theoretical arguments, and to create computer code for constructing important examples in an efficient way.

Looking back at the blogs and wikis where the Polymath discussions happened gives an illuminating glimpse into how mathematicians do mathematics. It was a privilege to be able to share this story with alumni, students and staff of the UCL Department of Mathematics, thank you very much for inviting me!

Dr Vicky Neale - Oxford University



Dr Vicky Neale speaking at the De Morgan Association Dinner



DE MORGAN ASSOCIATION DINNER



2017 De Morgan Association Dinner

Friday 9 June 2017
Senate House
Sherry at 6.45pm, Dinner at 7.30pm



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 to your address.

Fun with Faraday cages

The ‘Faraday cage effect’ is the physical phenomenon whereby wire meshes can block electric fields and electromagnetic waves. Well-known to physicists and engineers alike, it has countless practical applications. For instance, every time you heat food in a microwave oven, the Faraday cage effect is what keeps the microwaves inside the oven heating your food, and stops them escaping through the wire mesh viewing window and heating you. Of course, experience suggests that the effect is strongly wavelength-dependent: the shielding works for microwaves because their wavelength is much longer (approx 12cm) than the size of the holes making up the mesh (approx 2mm), but visible light has a much shorter wavelength and can pass easily through the mesh, which is useful for spotting when your porridge is boiling over!

The Faraday cage effect is such a classical topic in physics one might imagine that its mathematical analysis — i.e. quantifying the shielding effect as a function of the geometry of the cage, and the thickness, shape and spacing of the wires in the mesh from which it is constructed — had long since been put to bed. Astonishingly this doesn’t seem to be the case. Faraday first studied the effect experimentally back in 1836 [1], and, half a century later, Maxwell (who clearly understood the effect) correctly analysed a special case in his wide-ranging treatise [2]. However, most modern physics or engineering textbooks make only passing reference to the effect; one notable exception is volume two of Feynman’s celebrated lecture notes on physics [3], but it turns out that Feynman’s analysis is inapplicable to practical Faraday cages, because it does not capture the effects of finite wire thickness or the curvature of the cage boundary - see the discussion in [4, 5].

The beauty of discovering such a gap in the literature is that in the 180-odd years since Faraday first documented his experiments, many powerful new mathematical techniques have been developed, which allow the problem to be tackled from a number of different angles. In this article I will survey a few of these techniques, pointing out what they have to say about the Faraday cage effect. For a more detailed exposition see [4, 6].

For simplicity let’s consider a two-dimensional model, as illustrated in Figure 1. Let Ω_- be a bounded simply-connected open subset of the plane with smooth boundary $\Gamma = \partial\Omega_-$ and let $\Omega_+ := \mathbb{R}^2 \setminus \bar{\Omega}_-$ denote the complementary exterior domain. Consider a ‘cage’ of M non-intersecting perfectly conducting circular wires $\{K_j\}_{j=1}^M$ (closed discs) of identical radius r distributed along Γ with constant arc length separation $\varepsilon = |\Gamma|/M$, where $|\Gamma|$ is the total length of Γ , and set $D := \mathbb{R}^2 \setminus \left(\bigcup_{j=1}^M K_j\right)$.

Consider first the problem of electrostatic shielding for a point charge $\phi^i = \log |\mathbf{x} - \mathbf{x}_0|$ located outside the cage at some point $\mathbf{x}_0 \in D \cap \Omega^+$. Here we seek an electric potential ϕ satisfying the Laplace equation $\nabla^2\phi = 0$ in D and the Dirichlet boundary condition $\phi + \phi^i = 0$ on ∂D , with ϕ tending to a constant at infinity (corresponding to the cage

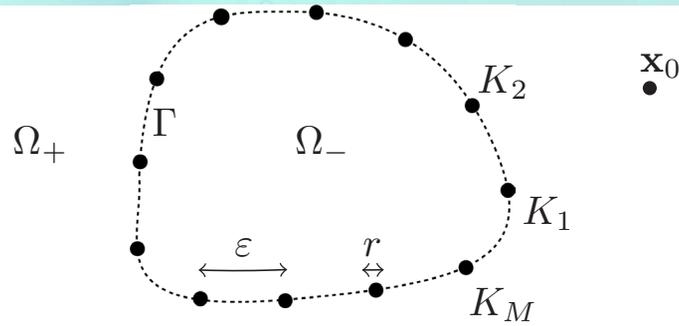


Figure 1: Two-dimensional Faraday cage geometry. The M wires (circular discs of radius r , filled black circles in the figure) are distributed along a hypothetical ‘cage boundary’ Γ (dashed curve) with equal spacing ε . The curve Γ is the interface between the interior Ω_- and exterior Ω_+ of the cage in the homogenized model. The point source at $\mathbf{x}_0 \in \Omega_+$ is also shown. For good shielding we want a small field in Ω_- .

having zero net charge). For good shielding we want $|\nabla(\phi + \phi^i)|$ to be small inside the cage.

With the power of modern computers it is straightforward to solve the above boundary value problem numerically (Figure 2 shows such results for the analogous wave problem). Such computations are a useful reference point, but they don’t provide much mathematical or physical insight into the shielding effect, and furthermore they become expensive when the number of wires M is large (equivalently, the spacing ε is small).

In the limit as $\varepsilon \rightarrow 0$ ($M \rightarrow \infty$) we can use asymptotic analysis (or ‘perturbation theory’) to reduce the problem for ϕ in the complicated domain D to the study of two separate approximations $\phi \sim \phi^\pm$ in Ω_\pm , connected by simple ‘homogenized’ boundary conditions on Γ which ‘smooth out’ the effect of the discrete wires. To achieve this we introduce a thin boundary layer around the interface Γ in which the field varies rapidly but approximately periodically with respect to the tangential direction. Solving the boundary layer problem provides a connection (via the method of matched asymptotic expansions) between the interior and exterior solutions ϕ^- and ϕ^+ .

The nature of the homogenized boundary conditions depends on the thickness of the wires. Most mathematically interesting is the ‘thin wire’ regime where the wire radius $r \ll \varepsilon$ as $\varepsilon \rightarrow 0$. In this case the asymptotic matching implies that ϕ^\pm are continuous (i.e. $\phi^+ = \phi^-$) across Γ , but undergo a normal derivative jump, with

$$\frac{\partial \phi^+}{\partial n} - \frac{\partial \phi^-}{\partial n} = \alpha \phi \quad \text{on } \Gamma, \quad (1)$$

where the constant α is given by

$$\alpha = \frac{|\Gamma|}{\varepsilon \log(\varepsilon/(r|\Gamma|))} = \frac{M}{\log(1/(rM))}.$$

Physically, one can interpret (1) as saying that in the thin wire regime the cage acts like a surface of limited capacitance.

The resulting field strength $|\nabla\phi^-|$ inside the cage is $O(1/\alpha) = O(|\log(rM)|/M)$, i.e. approximately logarithmic in r and inverse-linear in M . These predictions agree closely with the results of numerical simulations, and of theoretical results derived using conformal mappings and other techniques from complex analysis. But they correspond to much weaker shielding than one might expect having read Feynman's treatment of the problem in [3], which suggests that the field should be exponentially small inside the cage. This shouldn't concern users of microwave ovens - the microwave radiation leaking out is not harmful to your health. But it does allow some fun experiments: try placing your mobile phone inside a microwave oven (preferably unplugged) and calling it from another phone. Quite often it will merrily ring!

Approaching the problem from a completely different angle, physical considerations suggest that when the wires are thin they should act like point charges, giving $\phi(\mathbf{x}) \approx \sum_{m=1}^M q_m \log |\mathbf{x} - \mathbf{x}_m|$, with the constants $\{q_m\}_{m=1}^M$ minimising the energy functional

$$E = -\frac{1}{2} \sum_{m=1}^M q_m^2 \log r - \sum_{m=1}^M \sum_{l>m}^M q_m q_l \log |\mathbf{x}_m - \mathbf{x}_l| - \sum_{m=1}^M q_m \log |\mathbf{x}_m - \mathbf{x}_0|,$$

subject to the condition that $\sum_{m=1}^M q_m = 0$ (which comes from the zero total charge assumption). The three terms in E correspond respectively to the self-energy of the discs, interactions between discs, and interactions with the external field. This is a constrained quadratic programming problem which is readily solved numerically by the introduction of a Lagrange multiplier. Interestingly, this approximation can be related to the homogenized problem described above: the energy functional E represents the discretization, using the trapezoidal quadrature rule, of an analogous continuous energy functional, which itself represents a boundary integral equation formulation of the homogenized problem.

To generalise the analysis to electromagnetic shielding, replace Laplace's equation by the Helmholtz equation $\nabla^2\phi + k^2\phi = 0$ (modelling time-harmonic waves), where $k = 2\pi/\lambda > 0$ is the wavenumber (with $\lambda > 0$ the wavelength), replace the point charge by a Helmholtz point source $\phi^i = H_0^{(1)}(k|\mathbf{x} - \mathbf{x}_0|)$ (here $H_0^{(1)}$ is a Hankel function) and the constant condition at infinity by the assumption that ϕ is 'outgoing' at infinity.

Then, assuming that $k = O(1)$ (so that the wavelength is long compared to the wire separation) one can derive homogenized boundary conditions in the limit $\varepsilon \rightarrow 0$ just as in the electrostatic case. In particular, in the 'thin wire' regime, the same homogenized condition (1) holds. But for thicker wires (with $r = O(\varepsilon)$) one observes interesting resonance effects: near certain critical wavelengths the presence of the cage actually amplifies the incident field, rather than shielding from it! (See Figure 2 for a rather striking example.) Here there is an interesting link to spectral theory - the critical wavelengths giving the strongest amplification are perturbations of the square roots of the Dirichlet eigenvalues of the operator $-\nabla^2$ on Ω_- , and the amplified fields are multiples of the corresponding eigenfunctions. (Such resonance effects are often undesirable, but are advantageous in the context of a microwave oven as here one specifically aims to set up standing wave patterns in spite of slight leakage through the viewing window.) Using a

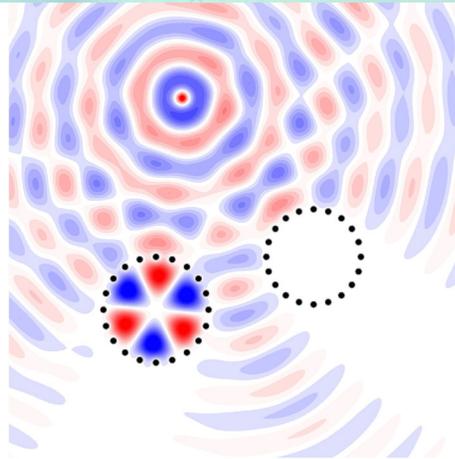


Figure 2: Resonance effects in Faraday cages. Two slightly different sized cages of identical circular (Dirichlet) wires irradiated by the field from an external electromagnetic point source. The smaller cage (right) is shielding its interior while the larger cage (left) is amplifying the wave, through excitation of a Dirichlet Laplace eigenfunction.

modified asymptotic approximation (with $\phi^- = O(1/\varepsilon)$ in Ω_-) one can derive explicit expressions for the critical wavenumbers and the resulting peak amplifications, which provide an excellent match with numerical simulations. Details of these calculations can be found in [6].

David Hewett, Lecturer in Applied Mathematics

References

- [1] M. Faraday, *Experimental Researches in Electricity*, v.1, reprinted from *Philosophical Transactions of 1831–1838*, Richard and John Edward Taylor, London (1839), paragraphs 1173–4; available at www.gutenberg.org/ebooks/14986.
- [2] J. C. Maxwell, *A Treatise on Electricity and Magnetism*, v.1, Clarendon Press (1881), sections 203–205.
- [3] R. Feynman, R. B. Leighton and M. Sands, *The Feynman Lectures on Physics*, v. 2: *Mainly Electromagnetism and Matter*, Addison-Wesley (1964), section 7-5.
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- [6] D. P. Hewett and I. J. Hewitt, Homogenized boundary conditions and resonance effects in Faraday cages, *Proc. Roy. Soc. A* **472** (2016), 2189.

FROM ARCHIMEDES TO MARS BY HELICOPTER - PROFESSOR FRANK SMITH

From Archimedes to Mars by helicopter

Most of us have probably felt or been aware of the increase in pressure as we dive or swim deeper under water. The pressure p measured relative to the atmospheric air pressure p_0 at the waterline increases according to $p - p_0 = \rho_w g D$ where ρ_w is the density of the water, g is the gravitational acceleration and D is the depth. From this you can predict depths and movements of icebergs, ships, apples and other floating or immersed objects as well as rediscover and re-support certain observations of the great Ancient Greek scientist, mathematician, physicist, engineer, inventor, astronomer, Archimedes of Syracuse.

Considering a partly submerged body in equilibrium first, you either work out the force (given by pressure multiplied by elemental area) due to the pressure p acting normally on any area element of the body surface, as in figure 1, then integrate over the wetted surface and take the upward component (other components cancel out); or use the divergence theorem. Assume $p = p_0$ is constant at the waterline, which is flat, and take the pressure as not varying horizontally within the water. Equating the upward force with the weight Mg of the body acting downwards leads to a prediction for the equilibrium depth. Here the mass M of the body is $\rho_B V$ where V is the volume of the whole body, above and below the waterline, and ρ_B is the body density which is assumed constant. The prediction ties in with Archimedes's observation / principle that in effect the mass of water below the waterline balances the mass of the total body, or the upthrust on the body is given by the weight of water that the body displaces; his principle about the upthrust or lift force is different from his famous "Eureka! Eureka!" finding which concerned V only.

Details show a dependence on the ratio ρ_B / ρ_w . For an apple, approximated as a sphere (figure 1), a typical ratio is about 0.9 and you find approximately 90% submergence of the volume; likewise for an orange or an iceberg. A similar argument applies to a completely submerged body. Extending the argument a little to examine vertical oscillations leads to an equation governing the height h above the waterline as a function of time t ,

$$\rho_B V d^2 h / dt^2 = (\pi/3) a^3 \rho_w g \{ (1 + h/a)(2 - h/a)^2 - 4 \rho_B / \rho_w \}, \quad (1)$$

for a sphere of radius a . The depth of the centre of the sphere is $a - h$, strictly $0 < h < 2a$, while V is $(4\pi/3)a^3$, which helps to simplify (1). Equilibrium $h = h_0$ has the expression in curly brackets being zero and corresponds to the prediction of the previous paragraph. Oscillations of $O(1)$ magnitude can be treated effectively in a phase plane. For small disturbances from equilibrium on the other hand you find explicitly an oscillation frequency $(3g\rho_w/4a\rho_B)^{1/2} (2h_0/a - h_0^2/a^2)$ which for a representative apple of radius 3cm gives a value not far from 2 Hertz, i.e. two complete cycles per second; this value largely agrees with what you find for an apple or orange bobbing in water in a kitchen bowl for instance.

The reasoning so far is classical body theory and omits many effects, especially those of fluid dynamics when the water moves appreciably. In such classical body theory the resistance of the surrounding fluid is assumed secondary, as in ballistic motion, or is treated with simplistic representations. At the other extreme, fluid dynamical studies of flow past a body of prescribed shape and position include classical aerodynamics and many other important fluid flow areas. Recent research has been aimed at reconciling the two extremes by allowing for so called fluid-body interactions.

There may well be neater ways to treat the apple or iceberg problem of the sphere subjected to comparatively gentle movements but the above tends to show the role of the pressure more clearly. When the movements are less gentle and perhaps even violent the pressure is a crucial part of the extra influence from the effects of fluid flow. The latter effects involve the Navier-Stokes partial differential equations of momentum, which in vector Cartesian form are

FROM ARCHIMEDES TO MARS BY HELICOPTER - PROFESSOR FRANK SMITH

$$\rho_w \{ \partial \mathbf{u} / \partial t + (\mathbf{u} \cdot \text{grad}) \mathbf{u} \} = - \text{grad } p + \mu_w \text{del}^2 \mathbf{u}, \quad (2)$$

along with conservation of mass in the form $\text{div } \mathbf{u} = 0$. Here \mathbf{u} is the fluid flow velocity and the constant μ_w is the fluid viscosity. The boundary conditions on the body surface make the moving body affect \mathbf{u} and p in (2), but simultaneously p (together with viscous stresses) affects the body movement as in the background for (1), and hence the fluid-body interaction acts both ways.

Many motivations and applications are driving a small group of us on here at UCL, from biomedical and industrial settings to environmental concerns, properties on planets, sports and play. See figures 2, 3. Examples are drug travel through arteries, air effects for cyclists either singly or in groups, swimming interference in lanes, food-sorting problems, ice impacts on helicopters, ship and aircraft safety in storms, swarms of birds, shoals of fish, and dust movement and cleansing. Contacts with companies TotalSim, Buhler-Sortex, AeroTeX, QinetiQ and Dyson have been involved. Intricate work is at PhD level and in papers published in *Mathematika*, journals of the Royal Society and the *Journal of Fluid Mechanics* over the last seven years. This is in addition to contributions to the Prince's Teaching Institute, to a recent Young Researchers in Mathematics conference and to articles on apple-bobbing, pancake-tossing and stone-skimming in the media.

Several parameters influence the interactive system. These include the Froude number (based on dividing the pressure estimate $\rho_w u^2$ obtainable from (2) by the earlier-mentioned $\rho_w g D$), the Reynolds number $u D \rho_w / \mu_w$ based on (2), the Weber number for any surface tension effects and the Stokes number (yes that George Stokes again!) which in effect concerns the amount of two-way interaction. Most of the applications mentioned earlier have high Froude, Reynolds and Weber numbers but a typical Stokes number of $O(1)$ which spans the range from a body simply following the fluid flow to a body in ballistic motion or acting as in the second paragraph.

To go further with (2) is very difficult mathematically, apart from studying small deviations perhaps, and relatively little progress has been possible in the past. The parameter ranges of the previous paragraph allow inroads to be made, however, showing rational approximations as a complement to direct computational efforts and bulk models. Recent interest has been in various problems of a body on top of the water-air interface as in skimming, skipping, take-off or landing, partly submerged as in flooding problems, or fully immersed. This last concerns sinking as well as problems of fluid-body interaction in channels and pipes and in environmental and aerodynamical situations. These are the subject of much continuing research in the department and elsewhere, yielding findings on instabilities, clashes and rebounds of bodies, criteria for lift-off, stabilisation measures, flow eddies and more.

Is there life on Mars? Well, there is *lift* on Mars. The criteria found above for lift-off fit well with satellite and rover observations (e. g. https://en.wikipedia.org/wiki/Martian_soil) of dust blown by the Martian atmosphere. Getting a firmer grip as it were on the apple or iceberg or cyclists or helicopters, as well as dust, remains quite a challenge.

I owe many thanks to PhD students Kevin (Jia) Liu, Samire Balta and Davide Bella, and to collaborators Andy Ellis, Peter Hicks, Phil Wilson and Ted Johnson.

Frank Smith, January 2017.

The Natural World through the Eyes of a Mathematician: Patterning, Randomness and Evolution

Professor Karen Page



Abstract: This lecture will be about how embryos are patterned and how evolution by natural selection modifies organisms. Most of all, it will be about how mathematics can be used to help to understand these processes. I hope to describe a variety of mathematical approaches including randomly perturbed dynamical systems.

Karen Page obtained a first class in Mathematics at Cambridge in 1995 and a distinction in Part III one year later. From Cambridge she moved to Oxford where she wrote her doctoral thesis with Professors Philip Maini and Claudio Stern, and Dr Nick Monk. She then spent a two-year postdoctoral fellowship at the Institute of Advanced Study in Princeton with evolutionary game specialist Professor Martin Novak. Between 2001 and 2006 she was lecturer in the Department of Computer Science at UCL, and moved to the Mathematics Department in 2006. Karen became a Reader in 2010 and was promoted to Professor in 2015.

Karen's research lies at the life sciences interface. She has been a key figure in UCL's interdisciplinary centre CoMPLEX and has several interdisciplinary collaborations at the new £700m Francis Crick Institute. In 2008 she was awarded a Leverhulme Research Fellowship to study mathematical models of human tumour dormancy.

In her inaugural lecture, Karen gave us a flavour of both her early research in embryo development and evolutionary game theory, and her more recent research in the genetic basis of embryo pattern formation.

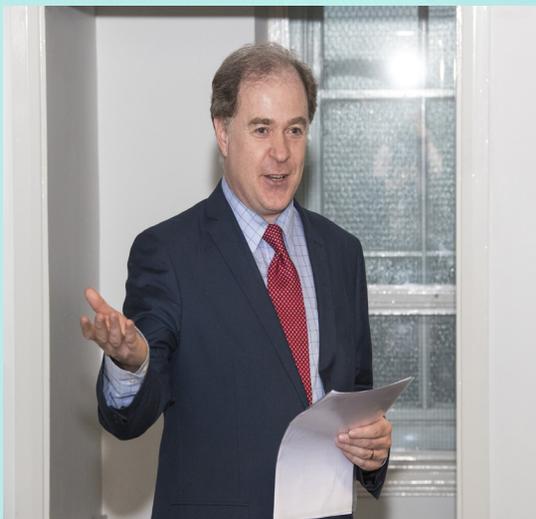
Karen's DPhil had origins in the work of Alan Turing. Known mostly as the man who cracked the enigma code, Turing is also known by Mathematical Biologists for his pioneering work on reaction diffusion equations that he proposed in 1952 as a model to explain how patterns evolve in embryo morphogenesis. As Karen explained, Turing showed that the combination of reacting and diffusing morphogens produced a wide variety of patterns of dots, stripes, spirals and rings that indicate variations in morphogen concentrations.

Until recently, Turing's theory of morphogenesis was just a phenomenological theory. With the advent of modern experimental cell biology his theory can be tested and fleshed out with molecular details. Karen spoke about her joint work with experimental biologists on new gene network models that help us understand how genes turn on and off to regulate the production of Turing's morphogens that help to determine whether a cell ends up as a nerve cell, skin cell, muscle cell, or otherwise.



The 'repressilator' is one such network, as Karen explained, whose behaviour depends on the local concentration of the exotically named 'Sonic Hedgehog' after the Sega video game character Sonic. For low or high levels of Sonic Hedgehog the network behaves like a switch, but for intermediate levels of Sonic Hedgehog it oscillates. Karen and her coauthors identified a simple motif associated with this circuit, calling it the AC/DC circuit after its two modes of operation. When inserted in a reaction-diffusion model the AC/DC motif leads to fixed striped patterns or moving peaks of gene expression.

Unfortunately, in reality these networks work in the noisy environment of a cell, so Karen and colleagues studied the effect of noise on gene regulation in a model that toggles between two states. Using several approaches, including minimum action path analysis, they found that noise profoundly affects the speed at which a pattern is formed and its position in space. Adding noise to a model makes the mathematics considerably more challenging, but it seems here that we can't leave out the noise if we want the truth.



**Dean of MAPS Faculty
Professor Ivan Parkin**

LONDON'S GLOBAL UNIVERSITY
PROFESSORIAL LECTURE **UCL**

Celebrating the Inaugural Lecture of
Professor Karen Page

**The natural world through the eyes
of a mathematician: patterning,
randomness and evolution**

Wednesday 8th February 2017 at 4.00pm

Professor Ivan Parkin will preside
Room 505, 5th floor, Mathematics Department
University College London, Gower Street, London WC1E 6BT
All staff, students and colleagues are welcome to attend

Reception: 5.00pm in Room 502, Mathematics Department
RSVP: Julija Melesko email: j.melesko@ucl.ac.uk
tel: +44 (0)20 7679 2839
map: www.ucl.ac.uk/maps

Karen also spoke briefly about her postdoctoral research at Princeton, where she worked with Martin Nowak on evolutionary game theory, and also some new ideas she is developing with collaborators that combines growth of tissue (the neural tube is the application) with diffusing Sonic Hedgehog. This is a very challenging scenario to model; most diffusion models involve a static domain. It will become a whole level more complicated if the Sonic Hedgehog is made to control gene networks inside the growing tube!



**Colleagues gather after Professor
Page's inaugural lecture**

Report by Dr Y. Petridis

THE PRETENTIOUS APPROACH TO ANALYTIC NUMBER THEORY INAUGURAL LECTURE 2015–2016 BY

PROF. ANDREW GRANVILLE

Andrew Granville gave his Inaugural Lecture on 'The pretentious approach to analytic number theory' on Wednesday 10th February 2016.

ABSTRACT. Andrew Granville, as one of the most eminent analytic number theorists of his generation, joined UCL in 2015. In this Inaugural Lecture he talked about the history of analytic number theory at UCL, and highlighted how the Riemann zeta function can be used to prove the Prime Number Theorem and what the consequences of the Riemann hypothesis are for the distribution of prime numbers. He also explained the foundations of his new theory of pretentiousness and its successes and future potential.

Andrew Granville joined the department in January 2015. Previously he held the Canada Chair in Number Theory at Université de Montréal. He was also the David C. Barrow Chair of Mathematics, University of Georgia, Athens, Georgia from 1995 to 2002. Although he is originally from the UK, he got his PhD at Queen's University in Canada. Among many distinctions, he has been a member of the Institute for Advanced Study at Princeton 1989–1991, 2007, 2009–2010 and the Kloosterman Professor at Leiden. He is a Fellow of the American Mathematical Society and a Fellow of the Royal Society of Canada. He has been awarded the Lester Ford Prize in 2009 and in 2007, the Hasse Prize in 1995 for the article: Zaphod Beeblebrox's Brain and the Fifty-ninth Row of Pascal's Triangle, and the Chauvenet Prize in 2008 for his outstanding expository article: It is Easy to Determine Whether a Given Integer is Prime. He has been awarded the Jeffrey-Williams Prize in 2006 by the Canadian Mathematical Society, and the Ribenboim Prize in 1999 by the Canadian Number Theory Association. In 1994 he was an Invited Speaker at International Congress of Mathematicians in Zürich.

Granville, Alford and Pomerance proved in 1994 that there exist infinitely many Carmichael numbers, that is composite numbers b for which Fermat's little theorem is true, i.e. $b^{n-1} \equiv 1 \pmod{n}$ for b relatively prime to n . Together with Friedlander, Granville disproved a conjecture of Montgomery about the distribution of primes in arithmetic progressions. This was ingenious and shows an unexpected irregularity in the distribution of primes. Granville's main themes of research are: combinatorics, analytic number theory, including the distribution of prime numbers, the anatomy of the integers, the ABC conjecture, and the pretentious approach to number theory.

In his inaugural address Andrew Granville walked through the history of Analytic Number Theory at UCL. The first in line was Theodor Estermann (1926–1969), who supervised three students: Klaus Roth, Heini Halberstam and Robert Vaughan. Roth is famous for the Thue–Siegel–Roth theorem on diophantine approximation of algebraic numbers, for which he was awarded the top prize in Mathematics: the Fields Medal in 1958. Harold Davenport was Astor Professor from 1945 to 1958. Alan Baker started as his student at UCL. He was awarded the Fields Medal in 1970 as well.

Klaus Roth and Tim Gowers, who worked at UCL from 1991 to 1995 and was awarded the Fields medal in 1998, both tried to find ‘order among the chaos (of natural numbers)’. Roth proved that a positive density subset of the integers contains 3-term arithmetic progressions, $a, a+d, a+2d$, while Gowers in a striking way proved that it contains k -term arithmetic progressions, $a, a+d, \dots, a+(k-1)d$, for any k .

Inevitably when talking about analytic number theory the name of Ramanujan comes to the minds of many people, including non-mathematicians. This is partly due to the recent movie *The Man Who Knew Infinity* with Dev Patel in the role of Ramanujan. Ramanujan did not have a connection to UCL, although M. J. Hill (Astor Professor, 1907–1923) was aware of his claims and the lack of mathematical rigour in them. One of the most famous claims is the calculation of the sum

$$1 + 2 + 3 + \dots = -\frac{1}{12}.$$

It is well-known that the series

$$\zeta(s) = 1 + \frac{1}{2^s} + \frac{1}{3^s} + \dots,$$

converges for $\Re(s) > 1$ but fails to converge for $\Re(s) \leq 1$. This is the famous Riemann zeta function. If we could understand $\zeta(-1)$, this could be interpreted as the value of the sum of all natural numbers! Surprisingly there exists a meromorphic function for on \mathbb{C} , denoted also $\zeta(s)$, that equals the sum of the series for $\Re(s) > 1$. The underlying process is called analytic continuation in the theory of complex functions. The Riemann zeta function $\zeta(s)$ satisfies an important symmetry property, called the functional equation, which relates the values on the left of the vertical line $\Re(s) = 1/2$ with the values on the right. One form of it is the asymmetric equation:

$$\zeta(s) = 2^s \pi^{s-1} \sin(\pi s/2) \Gamma(1-s) \zeta(1-s),$$

where $\Gamma(s)$ is the Gamma function. We can easily compute $\zeta(-1) = -1/12$ using the special value $\zeta(2) = \sum n^{-2} = \pi^2/6$. Ramanujan's formula now makes sense!

The Riemann zeta function is much more important for Number Theory than Ramanujan's formula. It was Riemann who first considered it in 1859 as a function of a complex variable s and outlined how it can be used to prove the Prime Number Theorem (PNT), earlier conjectured by Gauss. PNT states that the number of primes less than x , denoted $\pi(x)$, grows like the function

$$\text{li}(x) = \int_2^x \frac{1}{\ln t} dt \sim \frac{x}{\ln x}.$$

PNT was first proved by Jacques Hadamard and de la Vallée Poussin in 1896. The relation of $\zeta(s)$ with prime numbers comes from its Euler product, i.e. its expression as a infinite product over all prime numbers:

$$\zeta(s) = \prod_p \left(1 - \frac{1}{p^s}\right)^{-1}.$$

This factorisation is equivalent to the fundamental theorem of arithmetic: every integer can be factored uniquely as a product of prime numbers. It follows easily from the Euler product that

$$-\frac{\zeta'(s)}{\zeta(s)} = \sum_p \sum_{k=1}^{\infty} \frac{\log p}{p^{ks}}.$$

The crux of the proof of PNT is that $\zeta(s)$, while it has a simple pole at $s = 1$, it does not have any zeros of the vertical line $\Re(s) = 1$. This implies that $-\zeta'(s)/\zeta(s)$ has pole with residue 1 at $s = 1$ and no other poles on the line. PNT can be deduced from this using, for instance, the Cauchy's residue theorem. In fact PNT is equivalent with the non-vanishing of $\zeta(s)$ on $\Re(s) = 1$. The relation of $\zeta(s)$ with the distribution of primes is much deeper and manifests itself in the most striking way in the statement of the Riemann Hypothesis (RH), one of the most famous unsolved problems in mathematics, and its relation to the approximation of $\pi(x)$ by $\text{li}(x)$. Riemann conjectured the Riemann explicit formula (proved by von Mangoldt in 1895)

$$\sum_{p^k \leq x} \log p = x - \sum_{\rho} \frac{x^{\rho}}{\rho} - \frac{\zeta'(0)}{\zeta(0)} - \frac{1}{2} \ln(1 - x^{-2}),$$

where ρ denotes the (non-trivial) zeros of the Riemann zeta function. Riemann conjectured (RH) that for all of them $\Re(\rho) = 1/2$. This is equivalent to the best approximation for $\pi(x)$:

$$|\pi(x) - \text{li}(x)| \leq Cx^{1/2} \log x.$$

Surprisingly Atle Selberg and Paul Erdős (1949) found an elementary proof of PNT, i.e. a proof that does not use complex analysis.

Multiplicative number theory is the study of arithmetic functions $f : \mathbb{N} \rightarrow \mathbb{C}$ satisfying $f(mn) = f(m)f(n)$ whenever m and n are relatively prime. Since arithmetic functions behave erratically, we want to study the average behaviour of $f(n)$. If we assume $|f(n)| = 1$, we have easy examples of averages that do not tend to 0, e.g. $f(n) = n^{it}$ for fixed t real. In 1968 Halasz proved the amazing result that the only multiplicative functions of modulus 1 with large mean values are indeed close to n^{it} for some real t . If this happens we say that f is n^{it} pretentious. The notion of being close is measured by a distance function between two arithmetic functions. It is a result of Soundararajan and Granville that this distance satisfies the triangle inequality. This is the beginning of the new theory of pretentiousness. It leads to a new proof of the PNT, by using another arithmetic function, the Liouville function $\lambda(n)$, taking the value ± 1 according to whether n has an even or odd number of prime factors (counted with multiplicity). Pretentiousness explains also the Deuring–Heilbronn phenomenon: the zeros of $\zeta(s)$ and other L -functions repel each other.

The origins of analytic number theory lie in Dirichlet's proof that every arithmetic progression $a, a + d, a + 2d, \dots$ with $(a, d) = 1$ contains infinitely many primes. It is a celebrated theorem of Linnik (1944) that we can find $c, L > 0$ such that the smallest prime in the progression can be bounded by $c \cdot d^L$. His proof was simplified by the use of the large sieve as developed by Davenport, Roth, Bombieri and Vinogradov in the late sixties. More recently (2009) Soundararajan and Granville provided the simplest and shortest proof, introducing pretentious ideas. The notion of pretentious number theory develops since then through the work of D. Koukoulopoulos, A. Harper, Kaisa Matomäki, Maksym Radziwiłł, O. Klurman et al. Granville influenced the new developments at the most fundamental level by mentoring all these young mathematicians.

In another direction, there are tantalising connections between integers and permutations, and between number fields and function fields. They fall under the framework of the 'anatomy of the integers'. For instance, every integer is a product of primes and every permutation is a product of cycles. Distributional results for integers can be transferred to permutations, e.g. the largest prime factor and the longest cycle have the same distribution! Coming back to the Riemann hypothesis, the corresponding statement has been proved for curves over finite fields by Hasse and Weil. Can the analogy help in proving the original Riemann hypothesis? This direction and possible avenue of attack of RH has fascinated number theorists for a long time.

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HENRICI MODEL

Henrici Model

On the 25th October 2016 there was an unveiling of the Henrici Model, previously held at The Science Museum.

Prof June Barrow-Green (The Open University) gave a talk on Olaus Henrici - "Knowledge gained by experience": Olaus Henrici – engineer, geometer, and maker of mathematical models and unveiled the model, now held in the Mathematics Department at UCL.

The (Danish-born) German mathematician Olaus Henrici (1840–1918) studied in Karlsruhe, Heidelberg and Berlin before making his career in London, first at University College and then, from 1884, at the newly formed Central Technical College where he established a Laboratory of Mechanics. Although Henrici's original training was as an engineer, he became known as a promoter of projective geometry and as an advocate for the use of mathematical models.



The Henrici Model



Professor June Barrow-Green

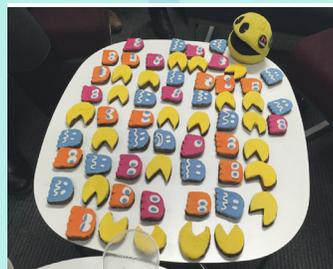


Post Doc News

In 2016, postdocs of the mathematical department have changed a lot. This year Jacqui Espina, Olga Trichtchenko, Olga Cherova Richard Pymar, Panagiotis Gianniotis, Christopher Wray and Yong Wei have left us. We have celebrated their new positions by spending time together, always with some beers around. It was also a great excuse to try the cuisine of their countries (Greek, Indian or Chinese) in different restaurants around London.

Of course, new people started, Adam Townsend, Winston Heap, Ben Lambert, Rodolphe Richard, Matthew Scroggs and Joaquin Rodrigues Jaciato and also joined us in these events and are already part of the postdoc atmosphere in the department.

During 2016, we have kept on celebrating 'The PacMan Awards' (<https://sites.google.com/site/thepacmanawards/>), the math postdocs cinema club that takes place in the department common room, where the best movies are submitted and voted anonymously by present and past postdocs of the department: After a difficult competition due to the high level of the movies suggested, this year we have enjoyed 'The Moon' and 'Jumanji (1995)'. To celebrate the Awards, Ruben and Pilar made special Pacman cookies.



Postgraduate Research Prize

The 2015 Postgraduate Research Prize was awarded to **Niko Laaksonen** for his outstanding achievements in his PhD in Mathematics.

"Niko Laaksonen's doctoral research concerns analytic number theory. He was supervised by Dr Yiannis Petridis. His research has led to 3 submissions to leading journals in pure mathematics, including one submitted for publication in Q J. Math. in which Niko proves the best known estimates for various classes of the hyperbolic lattice point problem, a problem which has engaged pure mathematicians over many years. Further evidence of the outstanding quality of Niko's research was his success in obtaining a grant from the London Mathematical Society enabling him to undertake a research visit to the University of Copenhagen, where he presented the results of research. He has also given research talks at Bristol and Nagoya"

Professor Robb McDonald

MAPS Faculty Teaching Award

Postgraduate Teaching Assistant: Matthew Scroggs

Matthew Scroggs is a PhD student at UCL Mathematics. He also teaches Differential and Integral Calculus to undergraduate students. He has been particularly active in the teaching and teaching-related activity of the department.

He says: "I am thrilled to have won this award; I have been very lucky this year to have such nice students and am grateful for the opportunities that the Department of Maths has bestowed upon me. Also, it's very nice to have won an award without resorting to standing next to chocolate fountains."

AUGUSTUS DE MORGAN MATHEMATICS SOCIETY

Augustus De Morgan Mathematics Society

The Augustus De Morgan Mathematics Society is one of UCL's oldest societies, named after the first maths professor at the university. It proudly boasts to have every mathematics student as member, making the society over 600 strong.

In the first portion of the year the focus of the society has been to hold social events with some specially aimed at the first years to help them to integrate with their fellow classmates as well as the committee and older students. Following the success of the event last year we kicked off in September with a Fresher's icebreaker event and the Fresher's BQQ providing delicious food and drinks, to welcome the new students to UCL.

The ADM society also hosted several events aimed at all years of maths students continuing the tradition of the annual Christmas quiz as the last event of term, inviting students to celebrate the end of the term together with festive refreshments, maths trivia and the excellent quizmaster head of department Professor Robb McDonald.

As we entered the new term we started off leading the society to explore Bloomsbury and Soho on the first of its kind hot chocolate crawl, stopping off at various specialist chocolatiers.



Annual Christmas Quiz

The society also aims to enrich the academic lives of the maths students with our weekly colloquium talks, hosted by students from all years as well as lecturers and PhD students, raising interest in new areas of maths and challenging the minds of students with topics not covered in the scope of the undergraduate degree. A highlight of the Colloquium this term was a talk presented by Prof Helen Wilson and Adam Townsend on "The Fluid Mechanics of Chocolate Fountains" where we finished the evening with a relaxed discussion of the topic and demonstration with a real chocolate fountain.



Hot Chocolate Crawl In Soho



Colloquium Chocolate Fountain

AUGUSTUS DE MORGAN MATHEMATICS SOCIETY

For those students interested in technology we held a workshop introduction to GitHub hosted by Joe Nash, introducing the technology aimed to help review and keep track of changes in code.

We hosted an event in collaboration with Dr Cossette Crisan as part of the UCL Changemakers project to encourage interest in postgraduate study and research in mathematics "Meet Your Researcher", an informal talk where seven postgraduate students currently studying at UCL discussed their projects and helped students gain a better understanding of studying at postgraduate level, which included details of funding options available.

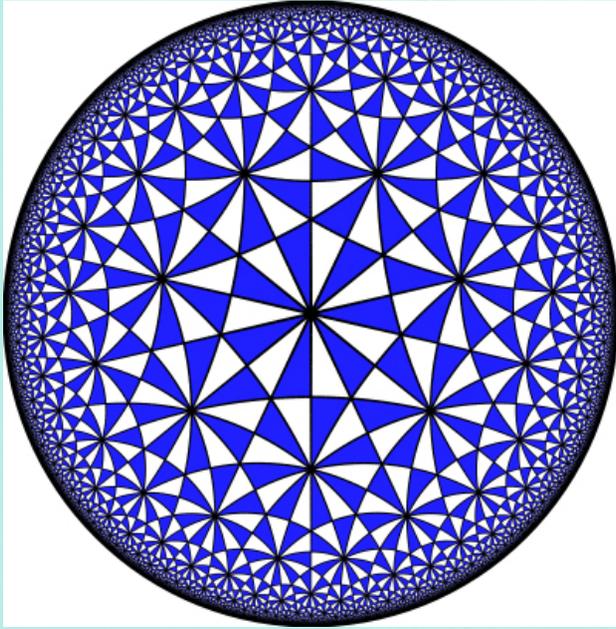
Next term we are very much looking forward to the Spring Ball, a stylish way for all of the students to send off the term and a last chance to socialise and relax before the upcoming exams. The society is hoping to present more career based events for its students and we feel a great way to do this is to host alumni and guest speakers as well as lecturers. If you are interested in sharing work or experiences after leaving UCL please don't hesitate to contact our President - Aryan.ghobadi.14@ucl.ac.uk.



ADM committee
(from left to right, Iona Duncan, Yiannis Simillides, Yassine Elkhadiri, Aryan Ghobadi, Mannix McAlister, Edwina Yeo)



Meet Your Researcher Event



Junior Geometry Seminar

This year we revived the joint UCL/KCL Junior Geometry Seminar, for PhD students in geometry and topology at both institutions (and beyond). Imperial's well-established Junior Geometry Seminar has always been successful, and we were keen to make sure that UCL is an equally happening place to be! With the growing number of geometers in London (thanks to the LSGNT), it has been well-attended, with talks on all manner of topics from the Atiyah flop to Morse homology.

The talks are given by students, on something they've learnt or are researching, and we've also hosted guest speakers from Oxford and Cambridge. The seminar is an opportunity for the junior geometers to come together at UCL, to practise giving talks, and to make links with mathematicians at other universities – indeed several of us have been invited back to speak at their seminars. We meet at UCL on Wednesdays at 5pm, and all are welcome!

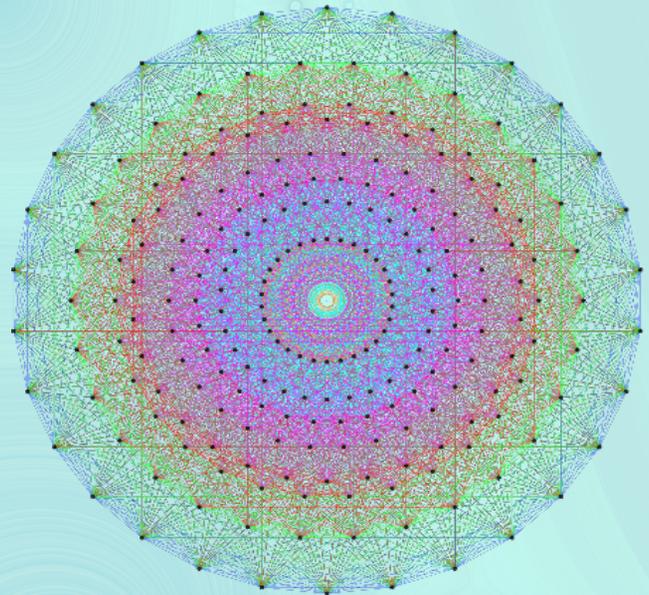
Emily Maw - Post Graduate Student

The London School of Geometry and Number Theory

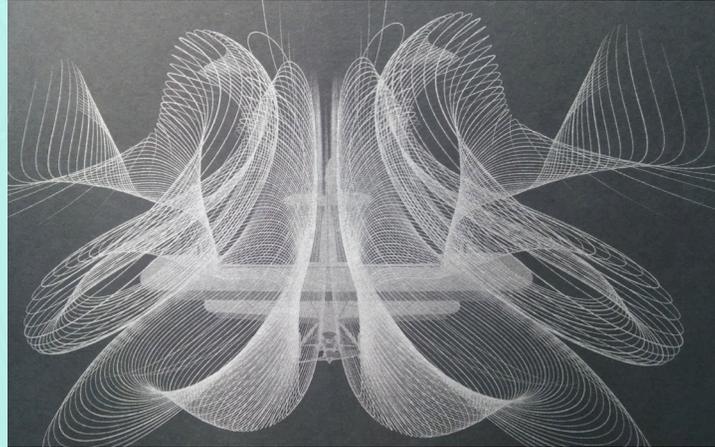
The LSGNT is an EPSRC funded Centre for Doctoral Training in Geometry and Number Theory. This is a partnership run by King's College London, Imperial College and University College London.

Our Centre for Doctoral Training in Geometry and Number Theory is a partnership between Imperial College, King's College London, and University College London.

The Centre currently offers a 4-year PhD programme for students wanting to undertake research in a broad range of topics across geometry and number theory. There is a pool of around 40 potential supervisors across the three institutions who offer a wide range of research projects as well as graduate-level taught courses. We admit 14–15 students per year over a 5-year period.



Mathematics: The Winton Gallery at the Science Museum



David Harding is a financier with a training in Physics, who set out to show that empirical scientific research, rather than marketing, could be the basis of a successful trading strategy. The resultant success of his company Winton has led to him setting up both the Winton Charitable Foundation and, with his wife, the David and Claudia Harding Foundation. In 2016 one of the donations the couple made was a gift of £5 million to the Science Museum to create a permanent gallery on the theme of Mathematics.

Mathematics: The Winton Gallery, was designed by Dame Zaha Hadid, who tragically died during its construction. It opened on December 7th 2016 with what its own blog describes as “a glittering launch event” attended by 700 people including the likes of Sir Tom Stoppard, Kazuo Ishiguro, and Simon Singh... and Dr Luciano Rila and I managed to sneak in there as well.

The gallery is beautiful. The centrepiece is the Handley-Page “Gugnunc” aircraft, which was designed using cutting-edge mathematics of aeronautics in the 1920s to compete in a safety competition. Around it are constructed swooping structures depicting the path lines of air flowing around the aircraft during flight. This amazing piece of mathematical art was also used for the launch evening invitations.

The gallery is accompanied by a book entitled “Mathematics: How it shaped our world”. It consists mostly of chapters on the huge themes of the gallery – War and Peace; Money; Life and Death – but at the end there are four essays

discussing the history and future of mathematics in a slightly broader way. The last of these, I coauthored with Dame Celia Hoyles, of the UCL Institute of Education (hence the invitation to the launch).

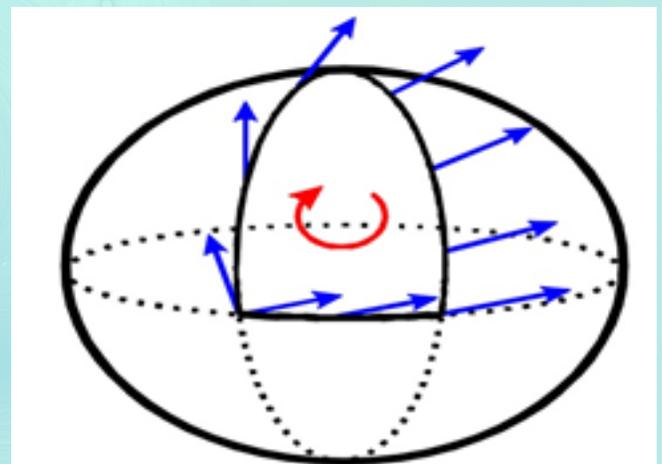
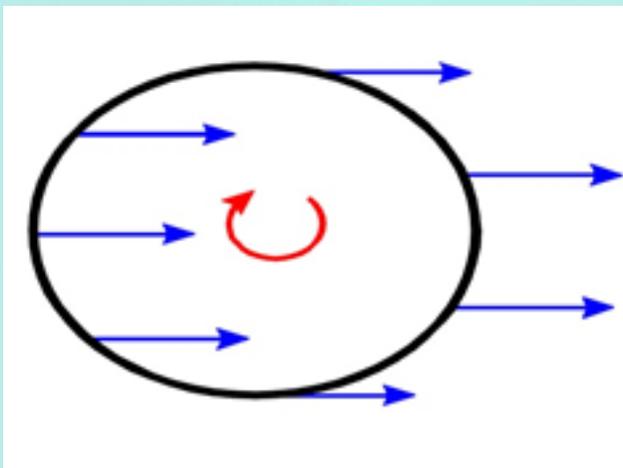
There are many fascinating exhibits in the gallery. You can see the early development of statistics with Florence Nightingale’s original charts, and William Farr’s astonishing English Life Table. You can marvel at the aerodynamics of the Gugnunc and fly past it using a VR headset; and, bizarrely, you can marvel at the marked-up skulls illustrating the deprecated “science” of phrenology (an early victim of systematic statistical testing). Yet I found it slightly unsatisfying: all the examples of mathematics in use skipped past the mathematics itself. This is probably unavoidable; but even at the launch evening I found myself defending the aeroplane exhibit to someone who said “but isn’t that really engineering?”; and most of the places where actual mathematics was visible, it was less mathematics and more statistics. But I shouldn’t criticise too much. It’s rare to see Mathematics brought out in any exhibit designed for the general public – and this gallery should certainly re-ignite the interest of anyone who has known and loved Mathematics at some stage. If you get the chance, do visit!

Professor Helen Wilson

Adventures in the 7th Dimension

I was delighted to be invited to speak about my work on geometry in 7 dimensions at last year's British Science Festival, which took place in Swansea. The festival is an annual celebration of science in Britain and has been running since 1831, making it the longest-standing national event in Europe (according to the organisers). It consisted of over 100 events helping to explain science to the general public, and I was very pleased to take part in the diverse programme.

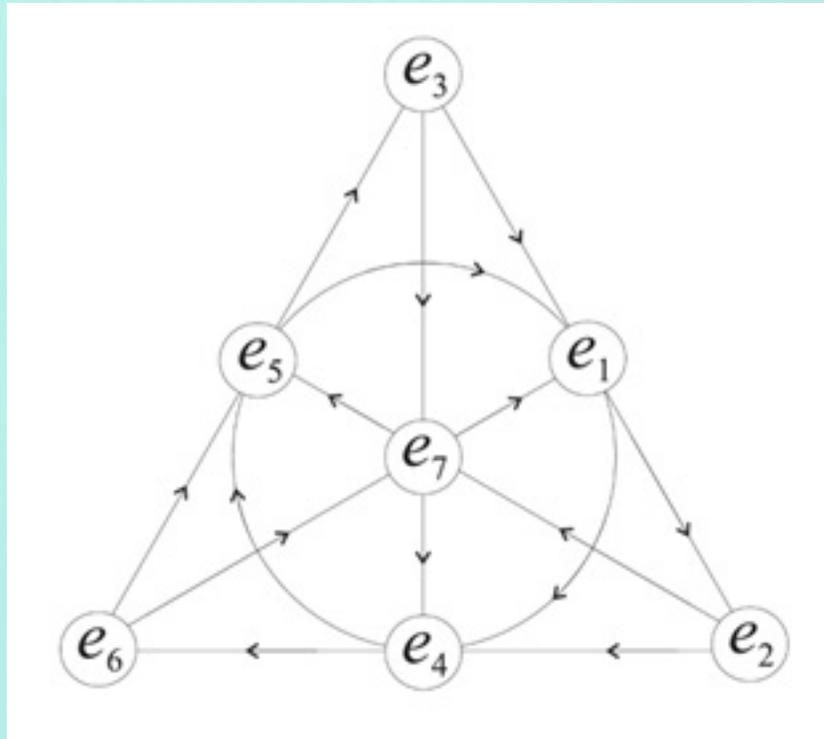
Even before I gave my talk, my title and summary created a lot of interest with the festival organisers, so they arranged for me to feature on the BBC radio programme Science Café, which was broadcast live from the festival. Although it was challenging explaining the 7th dimension on the radio, so without any pictures or props, I was very pleased to be able to reach a wider audience and it was a fun experience. The first aim of my talk was to explain how to think and imagine higher dimensions, using pictures, animations and connections to art and literature. I then wanted to explain why 7 dimensions in particular are important. The key is the notion of holonomy, which can be understood through examples as in the diagram below



When you take an arrow around a loop in the plane then the initial and the end direction of the arrow are the same. If you do the same thing but now on a sphere, you see the arrow rotates and, in fact, the amount the arrow has rotated is related to the amount of area of the sphere enclosed by the loop. By taking different loops you therefore get different rotations and so you get a group of transformations, called the holonomy group.

The holonomy group can tell the difference between the plane and the sphere, and in general it encodes information about the curvature and symmetries of the object, and so is an important tool in geometry. A natural mathematical question which arises once you define a group this way is: which groups can occur as holonomy groups? This is a problem that was solved in 1955 and the answer is a nice ordered list, except for two exceptional cases which can only happen in 7 and 8 dimensions. The exceptional holonomy group in 7 dimensions is called G_2 , and it reveals a special feature of 7-dimensional geometry which has surprising connections. (The group in 8 dimensions is less special from the point of view of algebra, and although the geometry it describes is also very interesting we will have to leave it for another day.)

The group G_2 is closely related to an 8-dimensional number system called the octonions, discovered in 1843. Here, like the complex numbers, one has “imaginary” numbers, but now you have 7 imaginary units e_1, \dots, e_7 which all square to -1 . To understand how they multiply, one can draw a nice diagram, known as the Fano plane



The holonomy group G_2 is also important for the study of Ricci-flat metrics, which correspond to solutions of a generalisation of Einstein’s vacuum equations from general relativity. Ricci-flat metrics form an area of geometry that we still do not really understand, even though the definition goes back to the late 19th century, and which continues to fuel much research in the field.

Moreover, G_2 is intimately related with an area of high-energy theoretical physics called M-theory. M-theory is a theory involving an 11-dimensional space-time created by Edward Witten (winner of both the Nobel Prize and Fields Medal). The point of M-theory is to unite the various 10-dimensional string theories and provide a possible path for solving one of the greatest outstanding problems in physics, namely to obtain a unified theory encompassing both quantum theory and gravity.

I have been working quite extensively in G_2 geometry since my days as a doctoral student, and during my talk I explained some of the ideas behind my recent research in the area and a few of the challenges I and others still face. This is a particularly exciting time for research in G_2 geometry with a recent upsurge in activity and international collaborations developing between both mathematicians and physicists, which will hopefully soon lead to new breakthroughs in the subject.

Following on from my talk at the British Science Festival, I spoke about 7 dimensions as part of the UCL Lunch Hour Lecture series, which will be available online through the YouTube channel for the series, and I have just finished writing a feature article on 7-dimensional geometry for Physics World which will appear in April. I am also excited to have been invited to be one of the two speakers as part of this year’s London Mathematical Society Popular Lecture series, so it seems that there are many more adventures in the 7th dimension still to come!

Dr Jason Lotay

WOMEN IN MATHEMATICS TASTER COURSE

Women In Mathematics

Every summer the department runs a Women in Mathematics day, aimed at encouraging aspiring female mathematicians to study at UCL. This event was originally set up by Dr Bill Stephenson when he was Admissions Tutor for the department, over 25 years ago.

I've been privileged to take part in several of these events over the years. They're always great fun and it's lovely to see an enthusiastic crowd of girls, usually from local schools, who are seriously considering mathematics as their next step.

We run the day in June each year. Our current Admissions Tutor, Dr Robert Bowles, is the MC – and of course runs a session about admissions, which is always very popular. One of the key unspoken messages, though, is that there really are no barriers to girls and women doing well in mathematics – so we unashamedly showcase our female researchers. My research in complex fluids is pretty visual, and lends itself to interesting live experiments (even if this does often end up sticky and sometimes unsuccessful: there's a good reason I'm a theorist in my actual research). Professor Karen Page sometimes talks about her work on the interface between mathematics and biology; and for the purist, Professor Sarah Zerbe gives a very engaging introduction to number theory.

In between the "lecture" sessions (we only have two in a day – more would be pretty heavy going for what is, after all, only a taster course) we have a session of puzzles. Here we recruit current students (mostly PhD student, because the undergraduates have typically left for the summer) to join in with a session of mathematical brain teasers and problem-solving. The highlight is a game of "guess the number of smarties in the box" where students can do pretty much anything short of opening the box and counting them. And of course, at the end, they open the box and fail to count them before eating them!



Professor Helen Wilson's chocolate fountain demonstration

These days are now an established part of the department's routine, and I imagine some of the early participants have gone far. Were you one? Do let us know! - **Professor Helen Wilson.**

The Women in Mathematics taster course this year was held at UCL on 1st July 2016.

Those invited to attend the event are currently studying A level Mathematics or equivalent qualifications and are seriously considering taking a degree in Mathematics or a degree involving Mathematics.

Academic staff from UCL including Dr Robert Bowles (Maths Admissions Tutor), Professor Helen Wilson and Professor Karen Page delivered formal lectures and problem solving sessions covering a variety of mathematical topics.

Advice and guidance was also provided on the admissions process and future career options.

The Women in Mathematics taster days are organised by the Careers Group, University of London and they received very positive feedback for this event

This year, the Women in Mathematics Taster Course is planned for the 3rd July 2017.

Freshers Welcome BBQ

The Fresher's BBQ took place on Friday 7th October 2016. It was an opportunity for our new first year students to meet with each other and also with some other students from the Mathematics Department.

It was eagerly attended by many of our PhD students and post docs who took the opportunity to welcome the first years to the Mathematics Department, and eat a lot of free food!



Chalkdust, the 707 Project

Chalk. A limestone, calcium carbonate, white and soft, the modern remains of skeletal sea creatures that lived millennia ago. A skeleton. A relic. There's a mathematician scribbling at a blackboard. Dust. Fine and dry, the haunting presence of memories. The by-product of history. The waste of time. Irrelevant. A hand raised: "But please, teacher, what's the point?"

We have a terrible reputation, us mathematicians. We have pencils stuck in our hedgerow of hair; our overly round glasses are perched, forgotten, on the tips of our noses; there's more fat on a chip; our blazer is one size too big for us and our trousers, God help us, are wistfully staring at our ankles from where they end, two inches too high. And we're probably male because we're far too awkward to socialise with women. Not that we do 'manly' things, mind you, like—I don't know—go to the gymnasium (at least, not since the word got mixed up with the palaistra), or climb any sort of cliff except those found in the mountains of the mind, and I have no idea what that three dimensional object of constant positive curvature is doing in the corner of my room. At the very best, we might go for a walk. But you won't find us in a pub, unless it's of the country variety and one can sip a beer unobtrusively without much annoying background noise.

Which is all a phenomenal load of old tosh.



Some members of the Chalkdust team after the Issue 4 launch, held in the Print Room Café at UCL.

One gets, in fact, rather frustrated at being pulled around by the hand of our faithful companion: the mathematical stereotype. Rather despondent at answering, to the question "what do you do?", that you do "aerodynamics" rather than "mathematics" because the former is cool and the latter, supposedly, consists of doing complicated things with arithmetic and therefore is not. Rather fed up of being asked to split the bill, which seems to be the only useful, understandable contribution you can make to the advancement of humanity. Rather infuriated at the perception that there are no women in maths, which, while acknowledging that the problem of women under representation in the sciences (especially at the higher levels) has certainly not been solved, certainly helps no one, least of all the very many brilliant women mathematicians I work with and the many more out there who are contemplating a career in the subject.



Professor McDonald shows off his copy of Chalkdust Issue 3.3 in the Print Room Café.

Chalkdust. What's in a name? A light-hearted dig at our friend, The Stereotype; a passing acknowledgement of the shackles we want to break free of. This year, our magazine (for the mathematically curious, which is what we should all really be), has taken our at times irreverent brand of maths writing to conferences across the UK and computer screens around the globe. There's nothing wrong with being irreverent. Or not taking ourselves too seriously, especially when our great isles are tired of experts.

Indeed, perhaps the whole scientific community should take a look at itself too and ask how its contributed to this state of affairs, this public perception, this holding of hands with cliché. How do we view the general public? Do we share our passion or do we keep it locked up? Do we open doors or pull drawbridges up? Do we attempt to bamboozle or do we invite questions?

Is it any wonder if the public doesn't trust us, or dismisses us, or merely can't be bothered, if we fail to make the effort to explain things to them patiently, without recourse to unnecessary technical jargon?

Maybe in a pub. Over a beer. Because you'll find us there too.



Members of the Chalkdust team after the last meeting of 2016, appropriately held in the pub.



Chalky Saturday: the day the finishing touches are made to the magazine before sending it off to the printer.

Chalkdust is a magazine for the mathematically curious, founded here at UCL in January 2015, consisting of mathematics postgraduates and undergraduates, students from other departments and the world outside 'academia'. Unsurprisingly, we've found something of interest to write about every week for the last year, publishing online articles on snowflakes, crime, maps, crochet, spider webs, the Highway Code, tennis, and a very large sphere made of paper cups (amongst much more). We have also, to date, published four issues of Chalkdust, a 60-page magazine, for which we've collaborated with people from across the globe, various walks of life, different levels of qualification and numerous subjects.

Our articles are designed to be as natural as possible, organic as desirable and free range as you like. No harmful chemicals of technical terms were used in their production, but a healthy colouring of humour is always encouraged.

It's a lot of hard work, but we enjoy what we do and believe in it. We hope you do too.

You can find us online at www.chalkdustmagazine.com (where you can sign up to our monthly newsletter), on Twitter (@chalkdustmag) and on Facebook (/Chalkdustmag). If you can support us in any way, please get in touch.

MATHEMATICS CHOIR

Mathematics Choir

After much singing on the bus back from the LSGNT trip to Chicheley Hall in October 2015, it was jokingly suggested that we should form a choir. Shortly afterwards, Professor Michael Singer mentioned that an old friend of his (from their Maths undergraduate days in Edinburgh) was now a professional conductor in London. In January 2016, several meetings and an unimaginative name later, the Michael Singers were formed!

We comprise approximately 15 mathematicians – PhD students and staff mainly of UCL, but also King's and Imperial. We sing a diverse range of music from around the world, from renaissance to contemporary. Our conductor is Sheena Philips, who generously volunteers her time to whip us into shape at our weekly rehearsals! Some of our members are experienced choristers, but others learnt to sing for the first time through their involvement in the choir. Last year we sang at several seminars and open days, before our main performance at the annual De Morgan Dinner.



We prepared a Christmas repertoire, which we performed at the UCL and King's departmental Christmas parties, with audience carols thrown in on request. We have developed a taste for Georgian folk music, which led to an impromptu performance at the 'Little Georgia' restaurant in Angel, where we went for our Christmas meal. We also sang around a piano in St Pancras station, raising £172.33 for the homelessness charity Shelter, and earning a description as a "fantastic choir" on twitter!

We have lost several of our members recently (to other universities, jobs, and thesis-writing), so we are now opening up to undergraduates as well. We also welcome alumni, family, and friends! Please get in touch if you'd like to join us, or have us perform at an event.

Emily Maw – Post Graduate Student



Dr Jonny Evans won a Provost's Teaching Award in February 2016

Dr Jonny Evans joined the department as Lecturer in 2012, his first permanent academic post. Jonny has played a key role in establishing an outstanding group in geometry at UCL with his direct contributions to research and teaching and, importantly, connections between both these activities. This has been clearly evident in his leadership role in the department's Centre for Doctoral Training (the London School of Geometry and Number Theory, shared with King's and Imperial). The CDT admits outstanding students from across the world and Jonny has been responsible for putting together a programme of lectures and 'mini-projects' for 1st year students. The feedback from the 1st year CDT students has been overwhelmingly positive and Jonny can take great credit for this. This is especially impressive when it is realised that Jonny developed all this from scratch and successfully coordinated 3 different departments at 3 different institutions in delivering the programme.

Also related to research-led teaching is Jonny's reinvigoration and modernization of our final year UG course in Lie Groups and Lie Algebras. This is a core topic in modern pure mathematics, but one which was attracting few students prior to Jonny's arrival at UCL. Thanks to Jonny's initiative in carefully constructing a new syllabus and his subsequent teaching of it, the module is now one of the most popular taken by 4th year UG students. Jonny also helped design a completely new course, Geometry and Groups for 2nd year UG students. The course is achieving its aim in garnering the interest of our UGs in modern geometry, an area where the department now has real research strength.

In 2013-14 Jonny won a UCL e-learning development grant to investigate the feasibility and consequences of videoing mathematics lectures; such lectures usually take place on whiteboards and so are incompatible with UCL's Lecturecast system. Jonny conducted a thorough study including the video recording of his year 2 mathematical methods course. His report detailed interesting conclusions including the benefits of the scheme.

Dr Luciano Rila won a Faculty award for outstanding teaching

Luciana Rila is a Mathematics Education Coordinator at UCL Mathematics. He has been particularly involved in developing the breadth of activity and impact of Mathematics on the teaching community.

He says: "UCL has become as a hub for maths teachers where they come to share ideas, learn more maths and explore the wealth of knowledge that we have at our university. We all play different roles in maths education so it is vital to have a platform where we can come together and share our experiences. I'm privileged to have access to so much expertise and, with the enthusiasm and support of the UCL community, it is great to be able to invite maths teachers to UCL not only to learn mathematics but also to explore mathematics in the context of other areas."



Dr Luciano Rila

PROMOTIONS

Promotions (effective 1st October 2016)

Professor Carlo Marinelli - Professor of Mathematics

Carlo's research interests are in infinite-dimensional analysis, partial differential equations, and probability theory.

Professor Helen Wilson - Professor of Applied Mathematics



Helen Wilson studied at the University of Cambridge, completing a BA, Part III and PhD in mathematics. Her PhD thesis, titled "Shear Flow Instabilities in Viscoelastic Fluids", was supervised by John Rallison. On graduation she moved to the University of Colorado at Boulder, where she began research on suspension mechanics with Rob Davis in the Chemical Engineering department. Helen joined UCL in 2004.

Helen is an editor of the Journal of Non-Newtonian Fluid Mechanics and of the Journal of Engineering Mathematics, and a member of the Editorial Advisory Board for Physics of Fluids. She is a Council Member of the Institute of Mathematics and its Applications, and in 2015 she was elected President of the British Society of Rheology.

Professor Sarah Zerbes - Professor of Mathematics



Sarah's research is at the interface between algebraic number theory and arithmetic geometry. She is particularly interested in the Birch-Swinnerton-Dyer conjecture, which is one of the central open conjectures in pure mathematics

Dr Steve Baigent - Reader in Mathematics

Steve's research involves the development and analysis of models of biological and chemical systems. His recent research has included building mathematical models of systems such as the brain and the control of its blood circulation, and also of the liver. Such models often have common mathematical structures that limit their dynamical behaviour, and his most recent research has been in elucidating these structures. The structure of the vector field's derivative, for example, can give global information about the dynamics, such as convergence to a steady state from any initial state, and sometimes uniqueness of the steady state.

Dr Jonny Evans - Senior Lecturer



Jonny's research interests are in geometry and topology, specifically symplectic topology and its links with algebraic geometry.

New Staff (since 1st January 2016)

Dr Cecilia Busuioac - Teaching Fellow

Cecilia's research interests include Algebraic Number Theory, Algebraic K-theory and Arithmetic Geometry

Dr Costante Bellettini - Lecturer

Costante's research interests include Geometric measure theory, Geometric analysis, Calculus of variations and Elliptic PDEs.

Dr Daniel Schwarz - Senior Lecturer



Daniel's research interests are in mathematical finance, the theory of stochastic processes and financial economics. Currently his work focuses on equilibrium based models, the problem of the completion of financial markets with derivative securities and the pricing of assets in commodity markets.

Dr David Hewett - Lecturer



David's main research interest concerns the mathematical study of wave propagation and its applications. His research is at the interfaces between rigorous applied and numerical analysis, asymptotic analysis and mathematical modelling.

Dr Hao Ni - Senior Lecturer

Hao's research interests include stochastic analysis, financial mathematics and machine learning. She is also interested in non-parametric modelling effects of data streams through rough paths theory and statistical models. Rough paths theory is a non-linear extension of classical theory of control differential equations to model highly oscillatory systems, and the core concept in rough paths theory is the signature of a path, which can be used as useful features for learning to summarise sequential data in terms of its effect. She is also interested in its applications, for example, online Chinese handwritten characters and financial data streams.

Colloquium

Imre Leader from Cambridge (previously from UCL) delivered a fascinating Colloquium talk on 7th March 2017. The talk dealt with tilings of the integer lattice \mathbb{Z}^d . Here a tile is defined as a prescribed finite set in \mathbb{Z}^d . It is known that not every tile allows for the whole lattice \mathbb{Z}^d to be tiled (in fact, such tiles are quite rare). However, Chalcraft conjectured that any tile in \mathbb{Z}^d tiles a higher-dimensional lattice \mathbb{Z}^m , where m is some number greater than d . The speaker has recently proved this conjecture. The sketch of the proof was outlined in the talk.



PRIZE AWARDS

Prizes Awarded to Undergraduate Students June 2016

First Year Prizes

Stevenson Prize

Laura Wakelin

Kestelman Prize

Hung Vio & Christian Aniekwena (shared)

Departmental Prizes in Mathematics:

Wenqiang Xu

Chuhui He

Zhe Hong Lim

Daniel bussell

Georgiana Zavoi

Henhong Wei

Vighnna Kundendran

Second Year Prizes

Bosanquet Prize

Mihai Barbu

Kestelman Prize

Bruno Souza Roso

Andrew Rosen

Lingbo Ji

Departmental Prizes in Mathematic

Lewis Marsden

Third Year Prize

The Nazir Ahmad Prize

Ngoc Mai Bui

Wynne-Roberts Prize

Ruoyu Wang

Shor Yeo

Finalists Prizes

Andrew Rosen Prize

Xinyu Hu

Ellen Watson Memorial Scholarship

Luzie Helfmann

Mathematika Prize

Naomi Kraushar

Bartlett Prize

Ze Gao

Castillejo Prize

Wojciech Waniek

Fourth Year Prizes MSci

David G Larman Prize - Pure Mathematics

Udhav Fowdar

Susan N Brown Prize - Applied Mathematics

Eleanor Doman

Project Prize

Patrick Hough

Sessional Prize

Tom Steeples

The Institute of Mathematics and its Applications (IMA) Prizes

1 year membership of the IMA

Third Year Finalist

Ruoya Wang

Fourth Year Finalist

Udhav Fowdar

Students who have recently obtained PhDs from the Department include:

Alessandra Crisafi 'Optimal trading and inventory management in electronic markets' (supervised by Dr Andrea Macrina)

Matthew Wright 'Teleparallel gravity and its modifications' (supervised by Dr Christian Boehmer)

Kevin Liu 'Shallow-water skimming, skipping and rebound problems' (supervised by Professor Frank Smith)

Sam Brown 'Geometric structures on negatively curved groups and their subgroups' (supervised by Dr Henry Wilton)

Ashley Whitfield 'Nonlinear dynamics of wave packets within the framework of the Ostrovsky equation and its generalisations' (supervised by Professor Ted Johnson):

Dimitrios Chatzakos 'Lattice point problems in the hyperbolic plane' (supervised by Dr Yiannis Petridis)

Rosemary Penny 'Developing mathematical models of complex social processes: radicalisation and criminality development' (co-supervised by Dr Robert Bowles with Dr Noemie Bouhana, Dept. Security and Crime Science):

Olly Southwick 'Coastal flows driven by vorticity' (supervised by Professor Ted Johnson and Professor Robb McDonald)

Tao Gao 'Nonlinear flexural-gravity free-surface flows and related gravity-capillary flows' (supervised by Professor Jean-Marc Vanden-Broeck)

Stephen Muirhead 'Intermittency and localisation phenomena in the parabolic Anderson and Bouchaud trap models' (supervised by Dr Nadia Sidorova)

Thomas Luu 'Fast and accurate parallel computation of quantile functions for random number generation' (supervised by Professor William Shaw)

Sergei Siyanko 'Financial modelling with mean reversion through jumps' (supervised by Professor William Shaw)

Alessandra Crisafi 'Optimal trading and inventory management in electronic markets' (supervised by Dr Andrea Macrina)

Matthew Wright 'Teleparallel gravity and its modifications' (supervised by Dr Christian Boehmer)

Kevin Liu 'Shallow-water skimming, skipping and rebound problems' (supervised by Professor Frank Smith)

Yanlong Fang 'Analysis of first order systems on manifolds without boundary: a spectral theoretic approach' (supervised by Professor Dima Vassiliev)

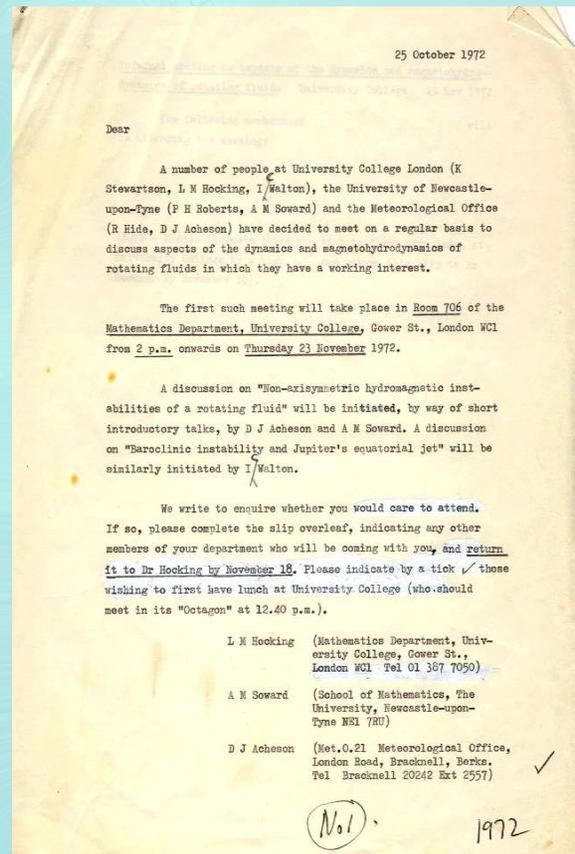
In Memoriam: Raymond Hide



Peter Read (Professor of Physics, Oxford) writes: "Raymond Hide was born on 17 May 1929 into a working class family in an impoverished coal mining village in South Yorkshire. The eldest of three brothers, he had a tough early life. His father committed suicide when he was 12 and his mother left the family shortly afterwards, leaving Raymond and his grandmother to bring up his two younger brothers, earning money cleaning windows and working in a baker's shop. Despite these hardships (or perhaps because of them?) he turned to academic study (at which he excelled), winning scholarships, first to the Percy Jackson Grammar School near Doncaster and later to read Physics at Manchester University, from which he graduated in 1950 with first class honours.

It was during his time at Manchester that he encountered the Nobel Prizewinning physicist, P. M. S. (later Lord) Blackett which, together with his background from the coal mining industry, fired his lifelong interest in geophysics. At this time in the late 1940s, Blackett was exploring a new theory for the generation of the Earth's magnetic field and Raymond became involved in some of Blackett's measurements while at Manchester. Blackett's theory was in competition with the dynamo hypothesis, being promoted at the time by Sir Edward ("Teddy") Bullard, then at Cambridge University. Raymond subsequently went to Cambridge to work for his PhD, initially to investigate a laboratory analogue of fluid motion in the Earth's core in the form of a differentially heated, rotating, cylindrical fluid

annulus. Although this experiment was a long way from being able to capture the Earth's geodynamo, its possible link to the dynamics of the atmosphere was only made (according to Raymond's own account) following a chance encounter with Sir Harold Jeffreys, who happened to pass by Raymond's experiment when it was running, peered over his shoulder and remarked "Hmm – looks like the atmosphere!". This opened up a wholly new perspective on these rotating annulus experiments and Raymond's seminal observations of baroclinic waves, quasi-periodic "vacillations", intransitive multiple flow states and hysteretic transitions towards irregular states we now interpret as "deterministic chaos" or "geostrophic turbulence". It is difficult now to overestimate the significance of these discoveries, which predated the much more prominent developments in the theory of dynamical systems and chaos in the 1970s and 1980s by others such as Ed Lorenz, David Ruelle and Floris Takens.



The initial letter setting up the first meeting at UCL of the continuing series of meetings on The Dynamics of Rotating Fluids.

After his PhD, Raymond moved briefly to work with S. Chandrasekhar at the University of Chicago in the USA, where he also met fellow experimentalist Dave Fultz (famous for his “dishpan” baroclinic convection experiments) before spending a period of National Service working in plasma physics at Harwell. Raymond met Ann Licence whilst at Harwell, marrying her in 1957 and beginning a long and devoted partnership that lasted until Ann’s death in 2015. He became a Lecturer in Physics at King’s College, University of Durham (now the University of Newcastle upon Tyne) in 1957, but in 1961 he was offered a prestigious faculty position at MIT where he set up a successful laboratory and was promoted to full Professor.

This proved to be a very important development, bringing him into close contact with key people in meteorology at the time, such as Ed Lorenz and Jule Charney, who were then developing a whole new way of thinking about the general circulation of the atmosphere and issues such as its predictability. The influence of Hide’s and Fultz’s experiments on these developments was frequently acknowledged by Lorenz himself. It is now clear that they were crucial in establishing the relevance and physicality of idealised theories of baroclinic instability, such as those of Eric Eady and Jule Charney, to synoptic meteorology. Raymond’s time at MIT also brought him into contact with NASA’s space programme during the opening phases of the unmanned exploration of other planets and their atmospheres. This stimulated his imagination to propose inventive explanations for features such as Jupiter’s Great Red Spot (the first of these based on the concept of a Taylor Column over a large mountain) and cloud bands, which remained an object of his interest throughout his life. For the latter, he noted the significance of the length scale $L = \sqrt{U/\beta}$ some 10 years before its more well known invocation by Peter Rhines (now known as the “Rhines Scale”). For the former, it relied on the presence of a solid obstacle blocking the flow, which became untenable on realising Jupiter has no solid surface. But he later came up with other ideas involving sloping convection that are still being discussed.

In 1967 Raymond made the headlines in the UK when he was persuaded by Sir John Mason to return to England to take up a senior scientist position at the Met Office; against the “brain drain” of European talent toward the USA at the time. Mason’s reasoning was to invigorate the research culture of the Met Office by recruiting a charismatic intellectual role model who could connect Met Office researchers more effectively with the wider scientific world

It was while Raymond was at the Met Office that he and Keith Stewartson FRS (Mathematics, UCL) decided to meet regularly to discuss the magneto-hydro-dynamics of rotating fluids, since there were then few relevant meetings. The initial meeting, held at UCL on 23rd November 1972, got off to an inauspicious start as there was a rail strike and so hardly anybody got there. However subsequent meetings grew and the series prospered under the direction of David Acheson (Oxford) so that over the next 10 years many of the world experts in Geophysical Fluid Dynamics spoke when meetings coincided with their visits to the UK.

The meetings continue as the series “The Dynamics of Rotating Fluids” (<https://www.ucl.ac.uk/maths/events/other-events/dynamics-of-rotating-fluids>) and are held on the Friday before the beginning of term in January each year at UCL and in September at Oxford. With the most recent meeting at UCL attracting around 80 attendees - a big change from the three who braved the rail strike in 1972 and a fitting legacy to Raymond Hide and, in Peter Read’s words, “his energy, creativity, enthusiastic curiosity, wisdom and in particular, his selfless support, advice and encouragement for generations of the younger scientists.

J J SYLVESTER 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. 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.

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<https://www.ucl.ac.uk/makeyourmark/how-to-give/give-accordion/post.pdf>

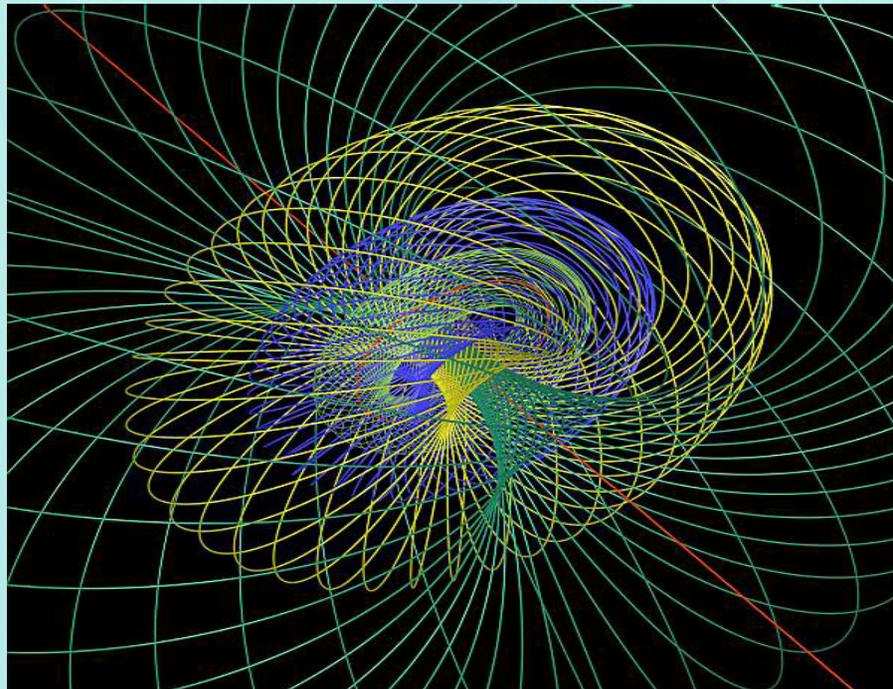
and return it to UCL Development & Alumni Relations Office, University College London, Gower Street, London, WC1E 6BT, UK.

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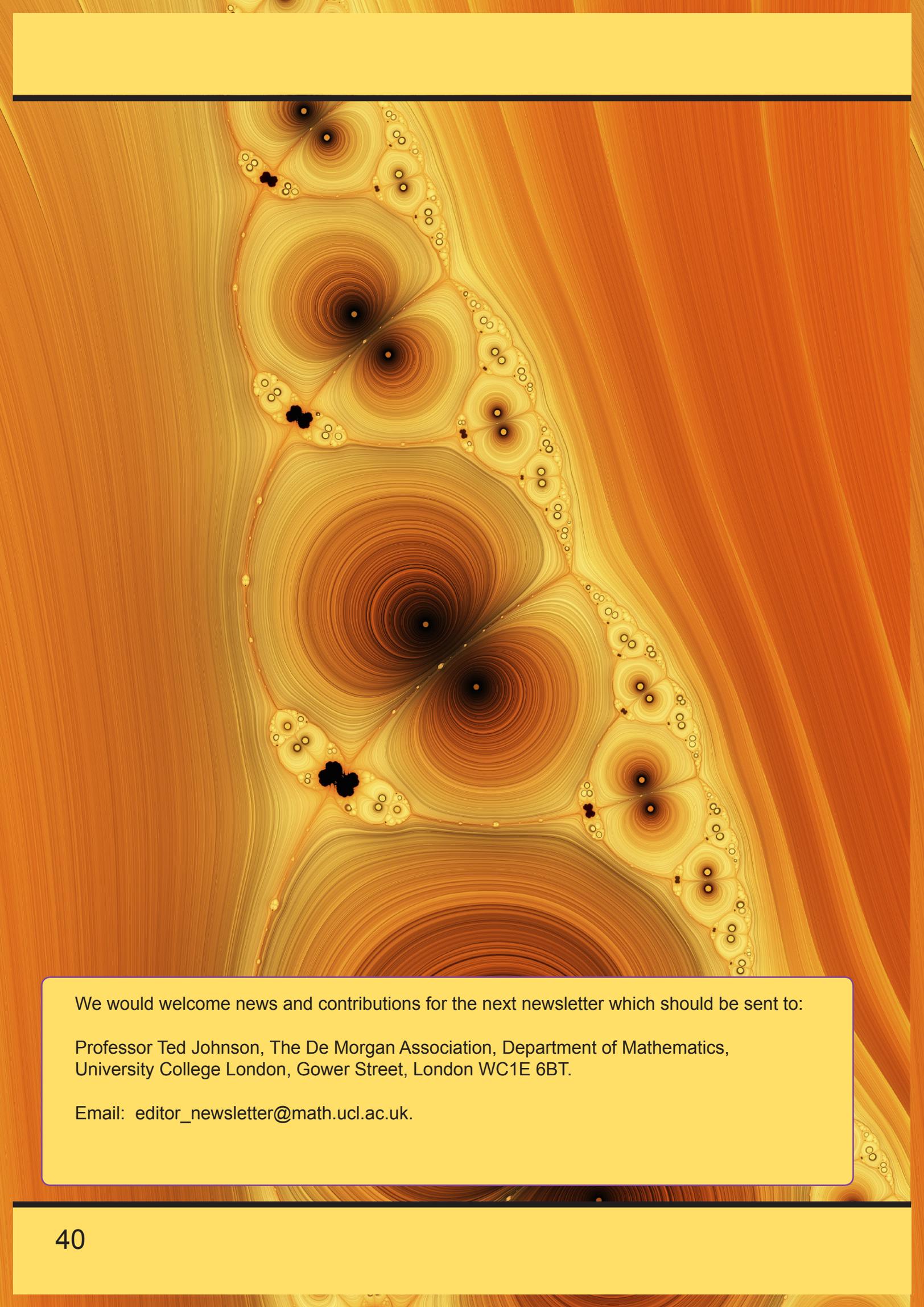
Sylvester was one of the greatest mathematicians to be associated with UCL and it is hoped that, through contributions made to the Scholarship Fund, we shall be able to assist in progressing the education of other mathematicians so as to realise their full potential for the benefit of us all.



Alumni Careers Advice

The department is keen to welcome alumni to its careers events and fairs for our present students. This includes alumni who have gone on to do further study.

If you are interested in this possibility, please contact Robb McDonald n.r.mcdonald@ucl.ac.uk



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: editor_newsletter@math.ucl.ac.uk.