De Morgan Association Newsletter

from the Department of Mathematics UCL

Issue - 16 - 2008 **Editor - Michael O'Neill**

De Morgan Association Dinner

Wednesday 4 June 2008

Dr Andrew Murrison speaking at the De Morgan Association Dinner

The venue for the Annual Dinner of the De Morgan Association was again the *Jeremy Bentham Room* at UCL. Over the years it has been known by other names – most of us will remember it as the Upper Hall, one of the refectories. Its relatively new name was particularly fitting since our Guest of Honour was Dr Andew Murrison MP, who spoke on some of the work of Jeremy Bentham as a social reformer. Dr Murrison is currently Shadow Minister of Defence, having previously been Shadow Minister of Health. His political career mirrors his earlier career in the medical branch of the Royal Navy, when research into neurological decompression illness led to the award of an MD and the Gilbert Blane Medal.

This year marked the 10th Anniversary of the death of Sir James Lighthill on 17 July 1998. Sir James was one of Britain's great mathematicians and a former Provost of UCL and, on his retirement, a member of the Department of Mathematics. He died tragically while engaging in one of his hobbies of long distance swimming. In this issue of the Newsletter, Professor Julian Hunt, who was the founding Director of the Lighthill Institute of Mathematical Sciences, assesses Lighthill's legacy to the mathematical sciences some 10 years after his untimely death.

The year also marked the retirement of two distinguished members of the Department – Professor John Jayne and Dr Kalvis Jansons – and the arrival of one new member of the academic staff, Professor Alexey Zaikin.

■ **Michael O'Neill**
Emeritus Professor of Mathematics








Guests at the De Morgan Association Dinner

James Lighthill's Legacy 10 years on

Sir James Lighthill died tragically in July 1998 while swimming around the island of Sark – a repeat of his previous swim in the 1970's. He was 76 and still active in research and the promotion of international science, particularly its contributions to dealing with natural disasters. He was honoured posthumously with the Copley Medal, the Royal Society's highest award. With the founding of the Lighthill Institute of Mathematical Sciences (LIMS) 5 years ago at UCL, we are continually reminded of his great contributions to applied mathematics and how they still influence so much research today. His collected works are available at LIMS and James would have been very pleased, as the founding President of the Institute of Mathematics and its Application (IMA), by its close link with LIMS through our joint evening meetings at De Morgan House in Russell Square. The IMA's London office is next to LIMS on the second floor of De Morgan House, which also houses the London Mathematical Society.

UCL, where he was Provost from 1979-1989, remembers him for visiting every part of the College, for championing interdisciplinary research and for his successes in battling with Whitehall. In this mellower period of his life he did not inflict on UCL a new accounting system, as he had done when he was the youthful Director of the Royal Aircraft Establishment (RAE), Farnborough in his 30's. He helped lay the foundations for UCL's position in the front rank of UK and even world universities. When James retired, he and his wife Nancy shared an office in the UCL Mathematics Department, where he researched and taught.

Lighthill's early papers on the analysis of nonlinear waves and vortex dynamics still provide the frame work for studying these fundamentals of fluid mechanics, and also suggested many applications to engineering and environmental problems. For example: water flow in channels, traffic flow along roads and the behaviour of processes in complex systems generally which tend to change quite suddenly depending on the ratio of the speed of the flow (or other processes) to the speed of waves (or information) through the system. The Lighthill – Benjamin hydraulic theory of 1956 was recently applied by Klettner (a research student at UCL) and others to analyse how the unexpected ways that, on arrival at a beach, some Tsunami waves cause the sea line to retreat before the wave breaks. This occurs when they are in the form of a depression rather than the usually depicted elevated wave, (e.g. by the Japanese artist Hokusai). The Lighthill – Whitham theory of traffic flow has, as we learned at a LIMS evening meeting, now been verified in monitoring the waves (which move at about 25mph) of stop-start traffic on the M25. Modelling traffic flow, like any other random process, usually involves a continual dialogue between macroscopic theories (whether continuum or statistical) and computer simulation of large numbers of individual elements.

Two years before his death Lighthill gave a great lecture in Kyoto on tropical cyclones or hurricanes, in which he described a general theory bringing together the overall vortex dynamics, the energy from the condensing water vapour, and the generation of ocean waves by the movement of the cyclones. He never left an opportunity to remind his audience about the important difference between phase speed and the group velocity of waves – the theme of his IMA Presidential address (which I heard as a research student in 1964).

He always wanted to demonstrate, but in different ways from those of Brooke Benjamin, his *doppel-ganger* in UK Applied Mathematics, the power of classical analysis and physical insight in the solution of complex problems.

From the days when he was Director of RAE around 1960, Lighthill did not foresee or even encourage the extraordinary possibilities of numerical calculation, using electronic computers, in fields as diverse as fluid mechanics, physiology or artificial intelligence. It was as if he saw this new approach as a competitor. By contrast, Benjamin saw numerical computation as a complementary method for studying complex problems; mathematics uniquely provides insight and quantitative analysis into the behaviour of systems that are effectively beyond the digital limitation of computers, just as they may be impossible to measure or simulate experimentally.

As well as the IMA, his other institutional legacy was the Physiological Flow Studies Unit at Imperial College, which he set up with Dr Caro in 1964. The Unit continues as a world class centre for doctors, engineers and mathematicians researching into blood flow viewed as flow processes mainly in the human body. With Imperial College's merger with some of London's leading hospitals, the collaboration between the Unit and medical practice has been greatly strengthened. He would have appreciated the application of their research on flow along the nasal passage coupled to work at UCL and Delft on the dynamics of vortices carrying small droplets. This provided evidence for the successful defence case in the recent murder trial of *R. v Jenkins* in 2005.

Those of us who knew James Lighthill and worked with him were indeed privileged. But everyone can build on the foundations he laid, and continue to benefit from his papers and books. Also, do not forget to view his remarkable film with Shon Ffowcs-Williams on Aerodynamic Sound. Don't forget to laugh as well, when you see it. He would have expected you to do so.

■ **Julian Hunt**
Lord Hunt of Chesterton
Honorary Professor of Mathematics, UCL

Birthday Party

On 12 March 2008, the Department held a party to celebrate the 60th birthday of Professor Frank Smith. Frank first joined the Department in 1971 as a research student of Professor Keith Stewartson. After obtaining his DPhil. degree, he took up appointments at the University of Southampton and Imperial College before returning to UCL in 1984 to succeed Stewartson as Goldsmid Professor of Applied Mathematics, following Stewartson's untimely death. Frank also gave the first Stewartson Memorial Lecture which was established to honour the memory of one of Britain's greatest researchers in applied mathematics. Frank's outstanding career has placed him also in that elite group, with over 250 research publications and election as a Fellow of the Royal Society in 1984. Frank has also been a great teacher, having supervised around 60 research students. We wish him continuing success and good health in the future.

■ **Michael O'Neill**
Emeritus Professor of Mathematics

Kalvis Jansons

Kalvis Jansons retired from the Department in the spring of 2008. Kalvis completed his undergraduate and postgraduate studies at the University of Cambridge and was awarded his PhD in 1983. He held a Junior Research Fellowship at King's College, Cambridge 1983-86, was appointed Lecturer in Mathematics at UCL in 1986 and promoted to Reader in 1991.

During his time at UCL, Kalvis made significant advances in many fields of mathematics and its applications. These include various branches of fluid mechanics (e.g. Stokes' flow, geophysical fluid dynamics), numerical methods, inverse problems, polymer physics, probability theory and applications of mathematics to biomedicine. To be able to contribute to such a broad range of topics, from physics to biology, is a remarkable and rare achievement and reflects Kalvis' enthusiastic and determined efforts to understand the natural world. A characteristic feature of Kalvis' research is his use of modern mathematical techniques in stochastic calculus and probability theory to yield concise but insightful solutions to difficult problems. Kalvis collaborated, and continues to do so, with mathematicians, as well as researchers from other disciplines, based at UCL, Cambridge (where he maintains strong links) and other UK institutions.

An example of Kalvis's use of powerful mathematical techniques is his recent work on Taylor dispersion in oscillatory flows (*Proc. Roy. Soc.,* 2006, vol. 262, 3501-3509). This is a classic problem in fluid mechanics going back to the 1950s and involves quantifying the long-time dispersion of a passive tracer in a channel and has important applications in, for example, biomechanics and environmental flows. The classical treatment of Taylor dispersion proceeds by direct analysis of the governing PDE. In this work, Kalvis uses an alternative approach based on methods of stochastic calculus to derive a simple, but practical, exact formula for the Taylor dispersivity.

Kalvis' broad range of mathematical interests is also reflected in the variety of lecture courses taught while at UCL. These include electromagnetism, analytical mechanics, biomechanics, stochastic and multivariable calculus. As in his research, Kalvis is always interested in seeking a simple, often elegant, argument, typically based on symmetry, to solve a problem, and many of the problems he set students could be answered either this way or the ‘long’ way. For example, a typical example of a Kalvis first year calculus question is to find the integral of x^2 over the surface of the unit sphere [A neat, ‘Kalvis’ solution, avoiding the standard ‘messy’ manipulation of surface integrals, gives the answer of $4\pi/3$ in a line or two].

The unique ability of Kalvis to engage students energetically and with good humour, on virtually any aspect of mathematics was especially welcome during UCAS interviews. With an array of props and ‘toys’ such as magnets and spinning tops, he was able to get even the most nervous candidates to relax and think about a mathematics puzzle rather than their impending interview.

The Department wishes Kalvis all the best during his retirement.

■ **Robb McDonald**
Professor of Mathematics

John Jayne

This year also saw the retirement of Professor John Jayne, who first joined the Department as a Lecturer in 1972. He was promoted to Reader in 1983 and Professor in 1994. John’s research interests in the topology and geometry of Banach Spaces were close to those of the late Professor C Ambrose Rogers, Head of the Department of Mathematics from 1958 to 1986, and the two published many joint works over a period of 25 years. John travelled extensively during his academic career, holding visiting appointments in the USA, USSR, Europe and India. John was also closely involved over a period of 15 years with the organization of the annual International Mathematics Competition for university students. We wish John a very happy retirement.

■ **Michael O’Neill**
Emeritus Professor of Mathematics

ECMI 2008 Conference

The 15th European Conference on Mathematics in Industry was held in London from 30 June - 4 July 2008 partly hosted and sponsored by the Department of Mathematics. The conference was organised jointly by an international committee with UCL and Departmental representatives joining in the organisation. A team of undergraduate students, PhD students and postdoctoral researchers mostly from Mathematics UCL did a superb job in helping in the running of the conference itself. Details are on the ECMI website at **http://www.ecmi2008.org/** .

These meetings are organised by the European Consortium for Mathematics in Industry (ECMI) every two years and the last one to be held in the UK was in 1988. The conference was as usual devoted to mathematical modelling, analysis and simulation of problems arising in industry and commerce but in 2008 there was a particular emphasis on new and developing areas of application.

ECMI 2008 took place at UCL and emphasised the role of mathematics as a unique overarching industrial resource. The conference began with appreciations of the impact of Mathematics-in-Industry by leading figures from industry, science and government. Thereafter it took the form of a research conference which promoted the application of innovative mathematics to industry, interpreted in its broadest sense. Emphasis was placed on the industrial sectors that offer the most exciting opportunities for mathematicians of all kinds to provide relevant insight and new ideas. Some of the highlighted themes were as follows.

- Socio-economic interactions, including agent-based modelling, game theory, logistics in the retail sector….
- Medicine and the medical industry, including health systems and planning, surgery, modelling of ageing population, medical devices, patterns in bioinformatics….
- Sport and leisure, including equipment design, strategies, gambling and its regulation, biomechanics….
- Uncertainty and risk, including pension plans, hedge funds, energy options…..
- Optimisation and control, including transport systems, sending and communication devices, distributed intelligence….
- Energy, including sustainability, extreme events, interactions on the global scale…
- Traditional industrial sectors such as glass, metals, textiles, food, electronics, automotive and aerospace…

Synergies between these themes were encouraged. The lists of plenary talks and mini-symposia are on the website. Numerous contributions were made by the Mathematics Department, by the Lighthill Institute and by related members. The proceedings of the conference are to be published next year by Springer in their *Mathematics in Industry* series.

■ **Frank Smith**
Goldsmid Professor of Applied Mathematics

Free Boundary Problems

A typical problem studied in undergraduate mathematics involves finding the steady 2D temperature field $T(x, y)$ inside a *fixed* rectangular box subject to a given distribution of T on the perimeter of the box. In this case, T satisfies Laplace's equation

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}=0, \qquad (1)$$

and progress can often be made using 'separation of variables' i.e. letting $T(x, y) = X(x)Y(y)$ and solving subsequent ordinary differential equations for X and Y subject to the given boundary data. Key to the success of this approach is that the domain in which (1) is being solved – the rectangular box – is fixed.

In many applications, however, it is required to solve a partial differential equation (PDE) in a domain whose geometry is not known *a priori*. That is, the geometry of the domain must be determined as part of the solution. Consider the above example in which the rectangular box is a slab of ice. As the ice melts the geometry changes. The temperature distribution in the ice slab depends on the boundary shape and, in turn, the change in the boundary shape depends on the temperature distribution. This complex interaction is typically nonlinear (even though the governing PDE may be linear) and solving these types of problems is a great challenge for mathematicians.

Such problems are known as free boundary problems (FBPs) and they typically arise in situations in which a distinct boundary separates media with different properties such as the ice-air interface in the above example. FBPs may be steady in which case the boundary is fixed but still unknown (e.g. the steady flow of water over a weir where the fixed surface of the water is the free boundary to be determined) or unsteady as in the melting ice case – this latter class of problems are sometimes referred to as moving boundary problems. In FBPs it is typical that extra conditions must be specified (usually two) at the free boundary in order for a solution to be found.

FBPs arise in a remarkable variety of applications. These include modelling the growth of tumours, flow in porous media, modelling of stock options, naval architecture, oil and gas recovery, industrial coating of substrates, geophysical vortex dynamics and crystal growth. Despite their obvious difficulty, the sheer number of applications has led to some ingenious methods for solving FBPs. Two important classes of FBP are now described.

Water waves

Waves on the surface of water are a familiar phenomenon and predicting their shape is a FBP with many applications. For example, waves radiated by a moving ship constitute a drag on the ship and prediction of their amplitude for a given hull shape is an important consideration for naval architects.

In 2D, with gravity g acting in the $-y$ direction, the water wave problem involves solving Laplace's equation $\nabla^2\phi = 0$ for the velocity potential ϕ in the body of the water subject to

$$\frac{\partial\phi}{\partial t} + \frac{1}{2}|\nabla\phi|^2 + g\eta = 0, \tag{2a}$$

$$\frac{\partial\phi}{\partial y} = \frac{\partial\eta}{\partial t} + \frac{\partial\phi}{\partial x}\frac{\partial\eta}{\partial x}, \tag{2b}$$

on the free boundary (i.e. the water's surface) $y = \eta(x,t)$. The two boundary conditions on the free boundary represent constant pressure (2a) and the fact that a fluid particle on the free boundary remains there (the kinematic condition) (2b). For water of constant (finite) depth these are supplemented by the bottom condition $\partial\phi / \partial y = 0$ on $y = -h$.

The general water wave problem is extremely difficult to solve, not only because it is a FBP (i.e. $y = \eta(x,t)$ is unknown), but also because the boundary conditions (2a,b) are nonlinear. Typically, problems involving water waves must be solved using sophisticated numerical methods – this being a challenging and important research area in its own right (UCL's Professor Jean-Marc Vanden-Broeck has considerable expertise in this area). A typical profile of a nonlinear periodic water wave in shown in Fig. 1.

Fig 1: Profile of a nonlinear periodic water wave. The dashed line is the undisturbed water surface.

It is worth noting that for waves whose amplitude is small in some sense (e.g. small in comparison to the overall depth or the wavelength), a useful approximation is to linearise the problem[1]. This involves ignoring the 'square terms' in the boundary conditions (2a,b) and, equally importantly, applying them on $y = 0$ i.e. like this dashed line in Fig. 1. With this approximation, the location of the free boundary, $y = 0$, is now 'known' and the problem is no longer a FBP. The solution for progressive waves can now be derived explicitly

$$\eta = a \cos k(x - ct), \tag{2}$$

[1] See the article by Helen Wilson in the De Morgan Association Newsletter, issue 15 2007, for a more general discussion on linearisation and its uses.

where a is the (small) wave amplitude and $c^2 = (g/k)$ tanh kh relates the wave speed c to its wave-number k and water depth h. Despite its apparent crudeness, the small amplitude approximation is a good one in many practical situations. For example, tsunamis in the open ocean have small amplitude and their speed of propagation is approximated very accurately by the expression given here.

Hele-Shaw flows

Hele-Shaw flows are arguably the most important paradigm in the study of free boundary problems owing to the relative simplicity of the governing equations and boundary conditions. They are, however, extremely challenging to solve and their analysis has a long history and they continue to be an active field of research today. Many of the techniques developed to study Hele-Shaw flows have found use in other fields of mathematics – not only in applied mathematics fields such as groundwater flows in porous media but also in more pure mathematics areas such as complex function theory, random matrices and, remarkably, string theory in mathematical physics.

A Hele-Shaw cell is a simple experimental device consisting of two horizontal parallel plates separated by a thin gap into which fluid is either injected or withdrawn through a source or sink of strength Q. The subsequent evolution of the fluid blob within the cell is governed by the following 2D FBP for the air-fluid interface: let $p(x, y)$ be the fluid pressure in the blob $\Omega(t)$, then it can be shown that away from any sources or sinks

$$\nabla^2 p = 0 \quad (x, y) \text{ in } \Omega(t) \tag{3}$$

On the free boundary $\partial\Omega(t)$ the pressure p satisfies

$$p = 0, \quad \frac{\partial p}{\partial n} = -v_n, \tag{4}$$

where v_n is the normal velocity of the free boundary.

The mathematical statement of the problem (3) and (4) appears deceptively simple: it is the unknown free boundary that provides the challenge. Nevertheless, some powerful methods based on complex variables have been developed to find exact solutions to this problem. Consider, for example, the evolution of a blob $\Omega(t)$ of fluid driven by a source or sink located at the origin of the complex plane $z = x + iy$. It can be shown that the time-dependent map

$$z = a(t)\varsigma + b(t)\varsigma^2, \tag{5}$$

from the unit ς-disk to $\Omega(t)$ is an exact solution to (3), (4) provided

$$a^2(t)b(t) = a^2(0)b(0), \tag{6a}$$

$$a^2(t) + 2b^2(t) = a^2(t) + 2b^2 + Qt/\pi. \tag{6b}$$

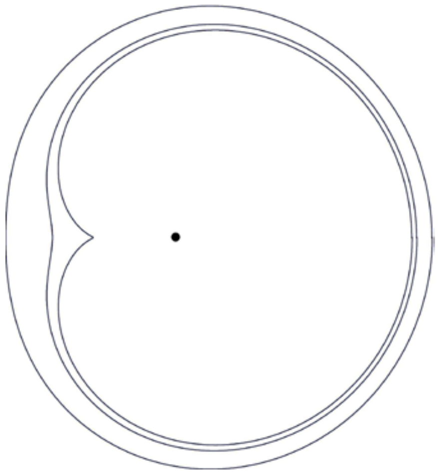

Fig 2: Free boundary shapes as fluid is sucked in toward a sink indicated by the dot.

Fig.2 shows the evolution of a contracting blob in the presence of a sink $Q = -\pi.$ Interestingly, after finite time, a cusp develops on the boundary and beyond this time the solution (5), (6a,b) becomes multi-valued and is no longer physically sensible. In fact, it turns out that such finite-time break-down of sink-driven Hele-Shaw flows is generic in all but a few special cases. Investigation of such singularity development in FBPs is an active field of research. In order to prevent a solution breaking down extra physics such as surface tension must be introduced. In contrast, the injection or source problem is well-behaved for all times with the free boundary eventually approaching a circle.

Further reading

Applied Partial Differential Equations, J.R. Ockendon, S.D. Howison, A.A. Lacey and A.B. Movchan. Oxford Univerisity Press.

Water Waves: Mathematical Theory and Applications, J.J. Stoker. Wiley.

Conformal and Potential Analysis in Hele-Shaw Cells, B. Gustafsson and A.Vasil'ev. Birkhäuser Verlag.

■ **Robb McDonald**
Professor of Mathematics

Report on the MSc in Mathematical Modelling at UCL

The MSc in Mathematical Modelling course began in October 2005 with 14 students making up the first year's intake, in October 2006 the intake was 17 students, and in October 2007 the intake was at a similar level. This one-year course aims to teach students the basic concepts that arise in a broad range of technical and scientific problems and illustrates how these may also be applied in a research context to provide powerful solutions. This said, the emphasis is placed on generic skills which are transferable across disciplines so that the course is a suitable foundation for students hoping to advance their scientific modelling skills.

The Mathematics Department at UCL is at the forefront of research and this course allows students to experience the excitement of obtaining solutions to complex physical and other problems. Students initially consolidate their mathematical knowledge and formulate basic concepts of modelling before moving on to case studies in which models have been developed for specific issues motivated by e.g. industrial, biological or environmental considerations.

The high-standard course provides a unique blend of analytical and computational methods with applications at the frontiers of research. Successful students are well placed to satisfy the growing demand for mathematical modelling in commerce and industry. The course alternatively forms a strong foundation for any student who wishes to pursue further research.

Course Aims

The Masters level course in Mathematical Modelling has three main aims:

- To provide an understanding of the processes undertaken to arrive at a suitable mathematical model

- To teach the fundamental analytical techniques and computational methods used to develop insight into system behaviour

- To introduce a range of problems (e.g. industrial, biological and environmental), associated conceptual models and their solutions.

Contact for further information

For further information please contact:

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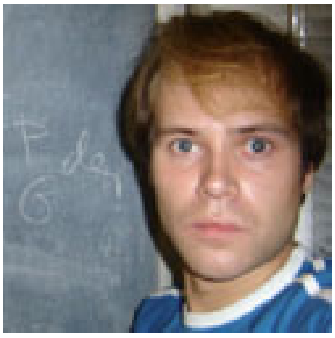
http://www.ucl.ac.uk/Mathematics/graduateadm/
http://www.ucl.ac.uk/Mathematics/graduate/msc/index.htm

■ **Frank Smith**
Goldsmid Professor of Applied Mathematics

Philip Leverhulme Prizes 2006 for outstanding UCL researchers

Three UCL academics were among the winners of the 2006 Philip Leverhulme Prizes, awarded to outstanding young scholars of substantial distinction and promise.



Dr Andrei Yafaev (UCL Mathematics) has been recognised for his study of Shimura varieties, particularly the exceptional insights and new methods he has brought to his work on the proof of the André-Oort conjecture. Many of the deepest connections between algebraic geometry, number theory and representation theory can be translated into problems concerning Shimura varieties.

The prizes each consist of an award of £70,000 disbursed over two years. They were established to commemorate the Third Viscount Leverhulme, who died in 2000. The Leverhulme Trust makes awards to support research and education in all subject areas, with an emphasis on recognising individuals.

Professor Leonid Parnovski awarded Leverhulme Research Fellowship 2007

Professor Leonid Parnovski was awarded the Leverhulme Fellowship during 2007-2008 academic year. The amount of the award was £30,000 to relieve him from teaching duties for one year. The title of the project was `Periodic and limit-periodic problems', and the main objective was to prove Bethe-Sommerfeld conjecture for a wide class of periodic pseudo-differential operators and to study the integrated density of states of periodic Schroedinger operators.

Dr Karen Page awarded Leverhulme Research Fellowship 2008

Dr Page has been awarded a Leverhulme Research Fellowship to study mathematical models of human tumour dormancy.

Karen Page is a Lecturer in the Department of Mathematics at UCL and an active member of CoMPLEX, UCL's centre for research at the life sciences interface. She has a degree in mathematics from Queens' College, Cambridge. Her DPhil at Oxford was supervised by Philip Maini, Nick Monk and Claudio Stern. She spent two years at IAS in Princeton working with Martin Nowak and joined UCL in 2001.

She was recently awarded a Leverhulme Research Fellowship to study mathematical models of human tumour dormancy. Dormant phases occur in many cancers. In breast cancer, following mastectomy, patients can harbour small populations of tumour cells which cause no manifest disease for up to twenty years before relapse occurs. Insights into the mechanisms and dynamics of dormancy should prove important in preventing relapses in breast and other cancers.

Karen works on tumour dormancy with Jonathan Uhr's lab at the University of Texas Southwestern Medical Center in Dallas, Ian Tomlinson's lab at the London Research Institute, Cancer Research UK, Lisa Willis at UCL and Tomas Alarcon at Imperial.

Vernon Harrison Annual Doctoral Prize of the British Society of Rheology

Dr Tim Reis has been awarded the Vernon Harrison Annual Doctoral Prize of the British Society of Rheology for 2007. Tim, who completed his doctoral thesis on "The Lattice Boltzmann Method for Complex Flows" at the University of Cardiff, supervised by Professor Tim Phillips, is now a postdoctoral researcher in the Mathematics Department of UCL, working with Dr Helen Wilson on instability problems in the flow of molten polymers.

The Vernon Harrison Annual Doctoral Prize of the British Society of Rheology is an award for the most distinguished PhD thesis in rheology. The aim of the award is to recognise excellence, creativity and novelty in research and is awarded to the postgraduate member who, in the opinion of the adjudicating committee, has made the most original and significant contribution to any branch of rheological research (experimental, computational or theoretical) leading to the award of a PhD degree in a given academic year.

Dr. Reis presented his work and received his award at this year's Midwinter Meeting of the British Society of Rheology on 11 December 2007 at the Royal School of Mines, Imperial College London.

Global System Dynamics and Policies

Professor Steven Bishop in Mathematics has recently received EC funding for a Co-ordinated Action Project called Global System Dynamics and Policies, which will be exploring system dynamics applications in a range of fields such as environmental, social science, crime and health modelling. The project was launched at UCL on 1-2 July 2008 and the project website is www.globalsystemdynamics.eu.

Other project partners include the European Climate Forum, Centre Nationale de la Recherche Scientifique, Chalmers University of Technology, and the Copernicus Institute for Sustainable Development.

Philip Leverhulme Prize 2008

Professor Marianna Csornyei of the Mathematics Department at UCL has been awarded a Phillip Leverhulme Prize by the Leverhulme Trust.

The prize has a monetary value of £70,000, but, more importantly, is considered one of the most prestigious awards available to young scientists in Britain.

Marianna Csornyei is one of the mathematical world's brightest young stars. At the age of 32 she has already authored or co-authored 35 journal articles, won a Whitehead Prize of the London Mathematical Society and is one of the very few mathematicians to have won a Royal Society Wolfson Research Merit Award. She has given a hundred or more invited lectures in Europe, the US and Japan, including recently, at the Lars Ahlfors Centennial in Helsinki.

Marianna works predominantly in the area of geometric measure theory. This branch of analysis is one of the most technically demanding parts of mathematics. It has a reputation for being highly abstruse, but Marianna's work is so startling and subtle that its importance can be grasped by mathematicians from almost any background. Within this field Marianna is clearly the strongest young mathematician in the world.

- **Keith Ball**

Astor Professor of Mathematics

Inaugural Lectures

2007-2008

Dmitri Vassiliev
Dima Vassiliev gave his Inaugural Lecture '**Spectral theory of differential operators: what it is all about and what is its use?'** on Wednesday, 5 December 2007.

http://www.homepages.ucl.ac.uk/%7Eucahdva/talks/2007/inaugural/inaugural.pdf

2008-2009

Jean-Marc Vanden-Broeck
Jean-Marc Vanden-Broeck gave his Inaugural Lecture **'Searching for new waves'** on Wednesday 8 October 2008.

Abstract: Water waves have been studied for more than 150 years. This is motivated in part by applications such as ship hydrodynamics, the planet's climate and tsunamis. They are also fascinating mathematical problems. In particular their study has contributed to many mathematical theories (free boundary problems, solitons, dispersive waves, etc). The investigation of water waves involve a combination of analytical, asymptotic and numerical techniques. In this talk we will describe recent advances which have led to the discovery of new types of waves. These new waves include solitary waves with oscillatory tails and waves with vorticity.

Robb McDonald
Robb McDonald gave his Inaugural Lecture **'Some applications of vorticity dynamics'** on Wednesday 12 November 2008.

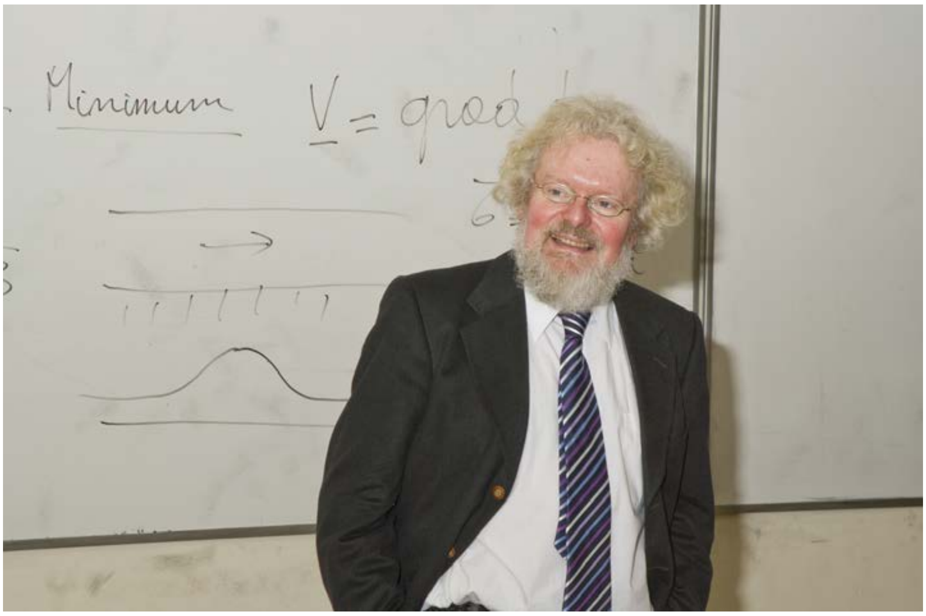
Abstract: Tropical cyclones. Gulf Stream rings and tornados are examples of the remarkable ability of the earth's atmosphere and ocean to form concentrated swirling flows. Such geophysical vortices play a vital role in determining our weather and climate and understanding their behaviour is an important, but challenging task. The mathematical theory of two-dimensional fluid mechanics, which leads naturally to the concept of vorticity, has been an especially powerful tool in the modelling of geophysical vortices. Examples will be presented on the application of vorticity dynamics not only to geophysical vortices, but also on how it has found recent use in modelling processes as diverse as industrial coating of substrates, the abyssal circulation of the ocean and oil and gas recovery.

Minhyong Kim
Minhyong Kim will present his Inaugural Lecture **'On numbers and figures'** on Wednesday 21 January 2009, 4.30pm in Room 505, followed by refreshments in Room 502.

Abstract: The study of the mysterious duality that intertwines the algebraic and geometric structures occurring in nature has been a major preoccupation of mathematicians through the ages. The last half-century has seen a robust convergence of numerous strands of this connection into the subject of arithmetic geometry. Persistent recasting of a single object in a complementary fashion using both numbers and figures has led to a unified perspective on a wide-range of mathematical inquiries as well as to the resolution of long-standing conjectures. We give a brief outline of this history and indicate some possible developments of the near future.

Dima Vassiliev, Head of Department of Mathematics, Introducing the Inaugural Lectures .

Professor Richard Catlow, Executive Dean, Mathematical and Physical Sciences Faculty (MAPS), UCL. Chair of Inaugural Lectures



Jean-Marc Vanden-Broeck presenting his Inaugural Lecture

Professor Jean-Marc Vanden-Broeck was appointed Professor of Applied Mathematics at UCL in September 2007. Previously he held professorships at the University of East Anglia (1998-2007) and at the University of Wisconsin (1981-1998). He gave the prestigious Stewartson Memorial Lecture at the British Applied Mathematics Colloquium in 2003. Jean-Marc is a world-leading researcher in free-surface dynamics, including the theory and computation of water waves. In his inaugural lecture entitled ‘Searching for New Waves' given at UCL in October 2008, he presented some of his recent results on water waves These included the discovery of a fascinating new type of solitary waves with an exponentially small oscillatory tail and a family of large-amplitude capillary waves on fluid sheets which, remarkably, have no apparent symmetry.

- **Robb McDonald**

Professor of Mathematics

Robb McDonald presenting his Inaugural Lecture

Robb McDonald attained his BSc from the University of Adelaide in 1986 and his PhD from the University of Western Australia in 1991. He held postdoctoral positions at Oxford (1991-1993) and at Monash University (1993-1994). In 1994 Robb was appointed as Lecturer in the UCL Department of Mathematics. In 2000 Robb was promoted to Reader and in 2007 to Professor.

Robb is a leading specialist in geophysical fluid dynamics. More specifically, he studies rotating stratified flows, rotating hydraulics, geophysical vortices and topographic effects on geophysical flows.

Robb's inaugural lecture "Some applications of vorticity dynamics" was devoted predominantly to the motion of vortices in two spatial dimensions in the presence of obstacles. His talk was an elegant combination of exact solutions, numerical simulations and results of physical experiments. Real life examples of vortices in the atmosphere, the ocean and industrial applications were presented to illustrate the importance of this research.

- **Dima Vassiliev**

Head of Department

Guests at the Inaugural Lecture of Professor Robb McDonald

Robb McDonald and Jean-Marc Vanden-Broeck at the Reception after the Inaugural Lecture

Department News

Appointments

The following have recently joined the Department:
Professor Alexey Zaikin
Dr Luciano Rila, Further Maths Centre Manager
Dr Sergey Morozov, Research Associate
Bonita Carboo, Administration Team

Promotions

We are delighted to announce the following promotions:
Gavin Esler – promoted to Reader in Mathematics
Leonid Parnovski – promoted to Professor of Mathematics

Retirement

David Larman – retired on 15 October 2008.
John Jayne – retired on 30 September 2008.

PhD Awards

Students who have recently obtained PhD's from the Department include:
Jodie Humphreys – *Algebraic Properties of Semi-Simple Lattices and Related Groups*
Shingo Saito – *Knot Points of Typical Continuous Functions and Baire Category in Families of Sets of the First Class*

Prizes awarded July 2008

The following students were awarded prizes:
William Stenner - Bosanquet Prize
Anders Schuller - Kesleman Prize
Amy Brookes-Beighton - Andrew Rosen Second Year Prize
Jean Pierre O'Brien - Andrew Rosen Final Year Prize
Joanna Majkowski - Andrew Rosen Final Year Prize
Shi Woon - Stevenson Prize
Vijal Patel – Ellen Watson Memorial Scholarship in Applied Mathematics
Justyna Petke - Donald Davies Prize
Katharina Scharnetzky - Mathematika Prize
Jade Savage - Mathematika Prize
Lewis Kirkham - Filon Prize
Sandra Hoac - Hill Prize
Henri Roesch - Jeffrey Prize
Pietro Servini - Sessional Prize
Sundeep Chahal - Sessional Prize

The following were awarded Dean's List Commendations:
Vijal Patel, Jean-Pierre O'Brien, Katharina Scharnetzky and Jade Savage.

Maria Botcharova - Monica Hulse Scholarship

Rahul Nilawar – Edwin Power Scholarship

My supervisors are Professor Robb McDonald and Professor Ted Johnson and the title of my thesis is **'The motion of ocean vortices and coastal currents near gaps'.** On my nomination form there was a brief description, written by my supervisors, of my topic which sums it up well:

To a large extent the redistribution of heat by ocean currents largely determines our weather and climate. On the rotating earth, ocean currents frequently take the form of boundary currents which hug the coast or deep-ocean ridges. Many ocean basins are connected to each other by narrow passages and gaps, and the dynamics of boundary currents encountering such regions plays an important role in the overall global ocean circulation.

Even the most fundamental and simplest question of "does a boundary current leap across or pass through a gap?" is difficult to answer since it depends on many complicating factors such as the earth's rotation, water mass properties and local topography.

This research aims to better understand the transport processes occurring in gap regions using simplified models of inter-basin flows. Despite their apparent simplicity, the models are notoriously difficult to analyse and powerful new mathematical and numerical techniques will be used to provide accurate quantitative answers to fundamental questions. These results will then be compared to more realistic ocean models. Ultimately, better knowledge of transport processes in gap regions will improve global ocean models leading to more accurate weather forecasts and climate prediction.

Jean-Pierre O'Brien - Lighthill Scholarship

My supervisor is Dr Nick Ovenden.

The title of my thesis is **'Modelling Microbubble Ultrasound Contrast Agents'** and here is a summary of my project: Gas microbubbles, stabilized by a surfactant or polymer coating, have become well established over the past 20-30 years as the most effective type of contrast agent available for medical ultrasound imaging. In addition, microbubbles have also shown great promise in therapeutic applications including targeted drug delivery, gene therapy, thrombolysis and focused ultrasound surgery. Their uptake in clinical practice, however, has been significantly hindered by a lack of understanding of the behaviour of microbubble suspensions in vivo, in particular, the effect of multiple scattering of the ultrasound field within a bubble population. The aim of this project is to develop novel analytical and numerical models for the propagation of ultrasound through a suspension of coated resonant microbubbles which will enable more accurate image reconstruction algorithms to be developed.

Luisa Pruessner - Lighthill Scholarship

My supervisor is Professor Frank Smith.

The provisional title of my thesis is **'Special Fluid Dynamical Effects in Sport'**
I am using a combination of analysis and numerical study in applied mathematical modelling of the subject. This is linked closely with experiments and is sponsored in part by industry.

Pouya Kamali - John Hawkes Scholarship 2007-2008

Minette D'Lima - John Hawkes Scholarship 2007-2008

Louise Jottrand - John Hawkes Scholarship 2008-2009

My supervisor is Professor David Larman and my title is '**Shadow boundaries are almost always rectifiable**'.

Take a convex body P in R^d and project it onto X a subspace of R^d. Then, project the relative boundary of the projection back onto P. This produces the shadow boundary of P. It has been shown that the shadow boundary is almost always sharp. Our aim is now to show that the lifting maps back onto the shadow boundary are almost always rectifiable. This uses measure theory which was one of John Hawkes fields of interest.

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.

Donations may be made by cheque, charity voucher or GiftAid. Cheques should be made out to the *UCL Development Fund (J J Sylvester Scholarship)* and sent to the Department Administrator, Helen Higgins, or they can be sent direct to the Sue Berrington, Head of Legacy Giving, UCL Development and Corporate Communications Office. Please remember to add the bracketed words to avoid the monies being put into the general College fund. 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 contact Sue Berrington (020 7679 9727 email: s.berrington@ucl.ac.uk).

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

Navin Dasigi – J J Sylvester Scholarship 2007-2008

Ben Willcocks – J J Sylvester Scholarship 2008-2009

My Supervisor is Dr Gavin Esler and I am currently working on: **'The Turbulent Equilibration of Unstable Baroclinic Jets with Asymmetry and in the presence of Barotropic Shear'** and the following is a brief abstract:

Baroclinic instability has long been acknowledged as playing a major role in weather systems in the mid-latitudes of Earth. The work aims to extend a general theory to predict the equilibrated state of unstable, baroclinic jets and employs the two-layer Phillips model on the beta-plane as a testbed for this theory. Subject to the global constraints of energy and momentum conservation, two hypotheses are advanced to close the problem and predict regions where mixing of potential vorticity (PV) takes place:
(a) the minimization of available potential energy and (b) the maximization of the area in which PV mixing occurs. It is found that for asymmetric jets and in the presence of a linear barotropic shear, hypothesis accurately predicts the shape of the equilibrated jets and successfully accounts for the change in potential energy of the system.

People

Nazim Choudhury (2003)

Two years ago I started my own property investment development business. This year the company of which I have sole ownership – NAZMAN HOLDINGS LTD – has a turnover of over £6m and is expected to be £12m by the year end. For any UCL graduates, particularly mathematicians with an interest in property investment, I would be more than happy to share my experiences. Still yearning to come back to university one day to do a Masters in Mathematics – still my number one passion.

Jodie Humphreys (2006)

Working as FSA approved Quantitative Analyst at Royal Bank of Scotland.

STOP PRESS
For your diary

The Mathematics Department
De Morgan Association Dinner will be held on

Wednesday 10 June 2009
Venue to be confirmed

All those on our database will be sent an invitation to the next De Morgan Association Dinner. Make sure you 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.

We would welcome news and contributions for the next newsletter which should be sent to:
Professor Michael O'Neill, The De Morgan Association, Department of Mathematics, University College London, Gower Street, London WC1E 6BT. E-mail: meo@math.ucl.ac.uk.

Guests at the De Morgan Association Dinner