University of BRISTOL

newsletter for maths alumni

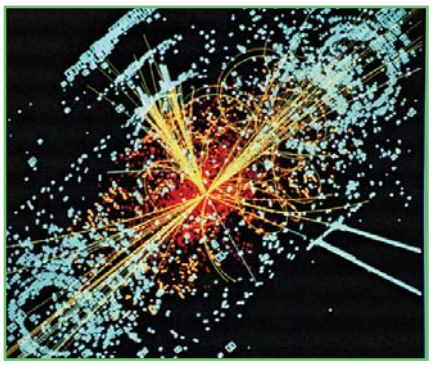
mathsgrad

AUTUMN 2006

Supercomputers to transform science

The installation of three supercomputers is set to turbocharge the University's scientific research, offering new insights into the structure of space and time, climate modelling, the design of novel drugs and many other areas. At peak performance, the multi million-pound high-performance computers (HPCs) will carry out over 13 trillion calculations per second. This is equivalent to the entire population of the world working simultaneously on hand-held computers for around three hours.

Professor Steve Wiggins, Head of Mathematics and a co-instigator of the project, commented that: 'HPC has ascended to a new level of importance. Any university that aspires to be world-class must have this basic research infrastructure. In future HPC will be an indispensable tool in every good researchers' toolbox.'



CERN

The largest of the three HPCs will be one of the fastest university research computers in the UK, and is expected to be one of the top 100 computers of its type in the world.

New centre for complexity sciences

A new centre that will link mathematics, statistics and computer science with engineering, life and molecular sciences will be launched next year. The Bristol Centre for the Complexity Sciences, a joint initiative between the Departments of Mathematics, Engineering Mathematics and Computer Science, will provide an integrated research and training and environment. Between ten and 15 students will be recruited each year for a MRes/PhD graduate training programme. The centre has been funded with a £4 million grant from the Engineering and Physical Sciences Research Council.

As we enter the 21st century, mathematics is assuming a central role in a broad range of subjects in science, engineering and business, and in society in general. The impact of mathematics on people's day-to-day life is expanding at an ever-increasing rate. This was recognised in *BusinessWeek* online, which ran the cover story 'Math will rock your world', stating that 'it's a magnificent time to know math'.

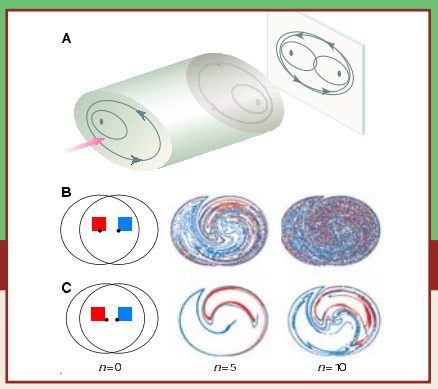
It is a magnificent time to be studying mathematics at Bristol. Our students are a crucial part of our success. Last year was a record year for numbers of undergraduate applications to study mathematics, which topped 2,000 for the first time.

We all benefit by teaching and learning in a research-intensive environment. In these pages you will read how Bristol mathematics is at the forefront of research in pure and applied mathematics and is leading initiatives throughout the University.

Professor Steve Wiggins
Head of Mathematics

Royal Society-Wolfson Award

Professor Peter Green was recently given a Royal Society-Wolfson Research Merit Award – one of the Royal Society's most prestigious awards. Only 25 awards are given each year to 'individuals of proven outstanding ability to undertake independent, original research'.



Statisticians set research agenda

The Bristol Statistics Group has received one of the largest grants ever awarded to a mathematics department in the UK. The £3.5 million Science and Innovation Award, granted by the Engineering and Physical Sciences Research Council, will develop 'SuSTaIn': Statistics underpinning Science, Technology and Industry.

SuSTaIn, led by Professor Peter Green FRS, Professor Guy Nason, Dr Christophe Andrieu and Dr Sean Collins, will support a programme to conduct and disseminate internationally leading research in mathematical statistics.

The award will enable the recruitment of a team to include a new professor of statistics and four lecturers, as well as attracting a number of postdoctoral fellows of outstanding potential into a rolling programme where they will be free to develop the latest ideas in mathematical statistics. Funding will also go towards workshops and research kitchens, visitor support, an international conference and a programme of research training for graduate students.

Professor Peter Green, who is leading the SuSTaIn programme and recently received a Royal Society-Wolfson Research Merit Award

Coffee meets calculus at the Maths Café

the annual fund

The Royal Fort Gatehouse and its garden will be transformed into a dynamic space for mathematics students' interaction and self-directed learning, thanks to a grant from the University's Annual Fund.

Coffee will meet calculus at the Maths Café, which will be a social space for students and staff, as well as a learning centre equipped with Apple Mac computers, wi-fi access and a wide range of relevant textbooks. There will also be staff and graduate students on hand to run a 'Maths Helpdesk' in the venue.

The Annual Fund consists of donations from graduates and friends of the University. Each year in May the Annual Fund panel meets to decide how unrestricted gifts are distributed throughout the University.

In the mix

September saw the publication of *The Mathematical Foundations of Mixing* by Bristol's Dr Rob Sturman and Professor Steve Wiggins, and Professor Julio Ottino of Northwestern University, which explains new ideas in how fluids mix.

Fluid mixing is a common situation in everyday life. The process of mixing often seems straightforward, but mixing tiny amounts of liquid presents a set of new problems. In microfluidics (say in lab-on-a-chip or DNA experiments) a typical quantity of fluid might be only 1 microlitre. Here, a combination of the physical properties of the fluid and the small scale often means that relying on traditional methods such as turbulence or molecular diffusion to mix fluids is not possible. In this instance, mechanical means are frequently used to invoke chaotic motion in the fluid. A powerful set of mathematical techniques can then be applied to characterise and understand the quality of the mixing process.

The book discusses a range of fluid mixing problems setting them into the framework of a class of mathematical models called linked twist maps, which are systems that can guarantee good mixing properties. Using the theory of linked twist maps, Dr Sturman and Professor Wiggins analysed a particular mixing device – the DNA hybridisation microarray – and used knowledge of the mechanism of the linked twist map to propose a new design for such devices which promises to greatly improve mixing properties. This has recently formed the basis of a UK patent application.

if I tell you something, you will know less than before I told you

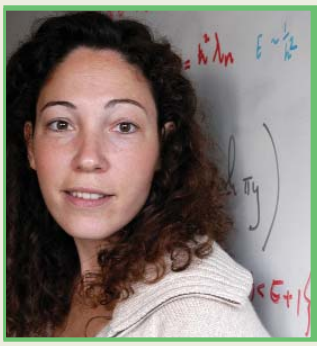
negative **knowledge**

The most ignorant person cannot know less than nothing. After all, negative knowledge makes no sense. But, although this may be true in the everyday world we are accustomed to, it has been discovered that negative knowledge does exist in the quantum world of very small things. The discovery that quantum knowledge can be negative was made by Professor Andreas Winter and his colleagues and was published in *Nature* last year.

But what can negative knowledge possibly mean? 'If I tell you something, you will then know less than before I told you,' explained Professor Winter. Such strange situations can occur because what it means to know something is very different in the quantum world. 'In the quantum world, we can know too much,' added Professor Winter's colleague Jonathan Oppenheim from Cambridge, 'and it is in these situations where one finds negative knowledge.' Negative knowledge (or, more precisely, negative information) turns out to be precisely the right amount to cancel the fact that we know too much.

On the one hand, classical information theory deals with subjects such as classical communication and computation. On the other hand, quantum information replaces classical 'bits' with quantum 'qubits', which are quantum particles like electrons or atoms. While classical bits can only be in the state 0 or 1, qubits can be both in the 0 or 1 state at the same time. By understanding that quantum information can be negative, Bristol researchers hope to gain deeper insights into phenomena such as quantum teleportation and computation, as well as the very structure of the quantum world.

'In the quantum world we can know too much' – Professor Andreas Winter



THE ROYAL SOCIETY

Scientist in the spotlight

Dr Nina Snaith is featured in the Royal Society's 'Spotlight on our Scientists 2006' web page. Dr Snaith looks at the connections between random matrix theory and number theory and their applications in quantum chaos. You can read the full article at www.royalsoc.ac.uk/page.asp?id=2429.

in**brief**

ROYAL COMMISSION RESEARCH FELLOWSHIP

Dr Apala Majumdar has been awarded a 2006 Royal Commission Research Fellowship. The award lasts two years, and was granted by the Royal Commission for the Exhibition of 1851.

MATHS AWARDED TWO RCUK FELLOWSHIPS

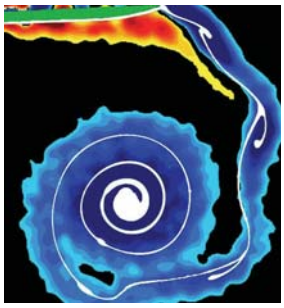
Two of the 14 Academic Fellowships recently awarded to the University in a competition run by Research Councils UK (RCUK) were for mathematics.

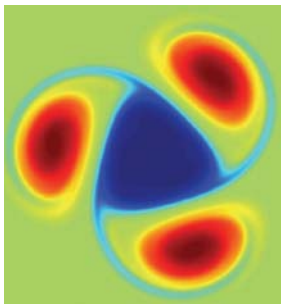
Professor Jens Marklof led the successful bid. The fellowships in number theory are for five years, and at the end of this time the fellowship holders become permanent members of the department.

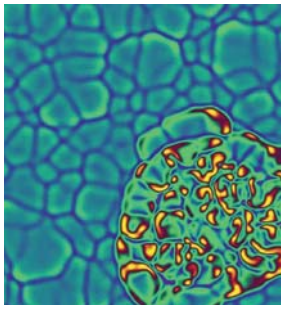
EPSRC ADVANCED RESEARCH FELLOWSHIP AWARD

Professor Andreas Winter was recently awarded an Engineering and Physical Sciences Research Council (EPSRC) Advanced Research Fellowship (ARF). Other members of the department who have been awarded ARFs are Dr Joe Chuang, Dr Nina Snaith and Dr Christophe Andrieu. ARFs are awarded to outstanding researchers with between three and ten years of postdoctoral experience. EPSRC awards approximately 49 ARFs each year.

Department of Mathematics, University of Bristol, University Walk, Clifton, Bristol, BS8 1TW
Tel: +44 (0) 117 928 7978, Fax: +44 (0) 117 928 7999, **www.maths.bris.ac.uk**


ALBERTO VERGA


LORENA BARBA


SERGIO RICA

Scattering knowledge

There are now three ways of doing science. For centuries scientists have made discoveries by means of *experiments* and *analytical thinking*, but in the past few decades science had aquired a new partner: *computer simulation*. Dr Lorena Barba (pictured left), from the Department of Mathematics, is leading a project to train young scientists from developing countries in this new way of working.

SCAT (Scientific Computing Advanced Training) is a ground-breaking research project aimed at improving understanding of how best to use computers in the field of scientific discovery and engineering design. It is a collaborative initiative, bringing together Universities from Europe and Latin America to train scientists in this field.

Funded by EuropeAid, it will provide for 20 research scholarships worth around £11,000 each. A postgraduate mathematics student from Bristol will have the chance to spend eight months in Brazil, Chile or Mexico as part of the project. In addition, 16 students from Latin America will travel to partner institutions in the UK, Spain and France for extended periods of study, including four here at Bristol.

The first two students started their placements in Bristol this September. Felipe Cruz from Chile is working with Dr Barba on the implementation of fast particle methods and Hulmut Wahanik from Brazil is studying objects that appear in fluid flows where a number of eddies form a tight constellation and rotate together.

In addition to the scholarships, SCAT will organise a number of international workshops related to scientific computing and develop online materials for self-learning. SCAT was launched in Barcelona in February and the first workshop took place at the Daresbury Laboratory in Warrington in June.

Dr Barba said: 'For all these aspiring scientists the opportunity to join a research group in Europe, have the mentoring and guidance of established international leaders in their fields, and have the chance to do hands-on computational science in world-class facilities, will be life-changing. They will go back to their countries having developed collaborations that will help their career for years to come.'

NSQI

A Centre for Nanoscience and Quantum Information is being built by the University and mathematicians have a central role to play.

Professor Noah Linden from the Department of Mathematics is leading the project to build the £10.4 million centre, which will be truly interdisciplinary, bringing together biologists, chemists, computer scientists, engineers, mathematicians and physicists, among others.

Mathematicians form part of the Quantum Information Theory Group and the new centre will provide a physical focus for this group, which is one of a handful of elite groups worldwide. The group has helped to found the new field of quantum information science and has made fundamental contributions to the theoretical areas of the subject.

Mathematics also has a vital role in nanoscience. The department is developing a concentrated research programme in the field of 'nano-maths': theory, modelling and simulation in nanoscience. New areas of research in mathematics have sprung up around such topics as nano- and micro-fluidics and quantum devices. Without new, robust tools and models for quantitative description at the nanoscale, the research community will miss important scientific and technological opportunities.

It is also expected that the new Centre for Complexity Sciences will be very closely associated with this building.