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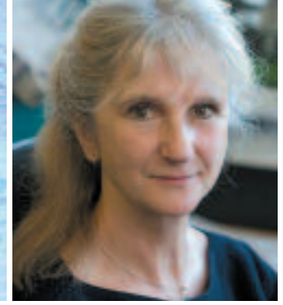
Engineering neurons

Shostakovich 2006

The energy line

New fatherhood



*re:*search editorial

A new age of numbers

Two articles in this issue are about maths. And, when you think about it, almost all the other articles use maths to either obtain or analyse data. Even the music of Shostakovich can be explained using maths – the reason why some note combinations sound pleasing to our ears is due to the generation of frequencies that match up at regular intervals. It is this gradual awareness that maths is assuming a central role in business, science and engineering, and having an ever-increasing impact on our day-to-day living, that led the University to invest £34 million in a new building to house our School of Mathematics. Due to its success in attracting world-class staff and record student numbers over the past four years, the Mathematics Department has outgrown its current capacity.

One of the reasons behind the recent success of maths is the way we gather huge amounts of data, undreamt of only 10 or 15 years ago. In the business world, for example, the massive amounts of data gathered by internet search engines such as Google can be used to predict human behaviour, which in turn informs businesses about our purchasing preferences and potential. These are powerful – and rather scary – tools.

At the same time, completely new areas of study and new disciplines are being created that crucially rely on mathematics for their success. This is bringing a wealth of new opportunities for mathematics and a demand for mathematicians. The world is moving into a new age of numbers. Partnerships between mathematicians and computer scientists are building a whole new domain of business. The mathematical modelling of humanity promises to be one of the great undertakings of the 21st century. It will grow in scope to include much of the physical world as mathematicians get their hands on new flows of data, from atmospheric sensors to the feeds from millions of security cameras.

Located at the heart of the University, the new School of Mathematics will play a central role in the University's ability to achieve its research goals in the coming years. One of the features of the new building will be its public space for intellectual and social exchange, both within the department and with collaborators from other departments. It's a fantastic and unique time to be a mathematician.

Cherry Lewis
Editor

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Articles about research at Bristol University are welcome, please contact the editor.

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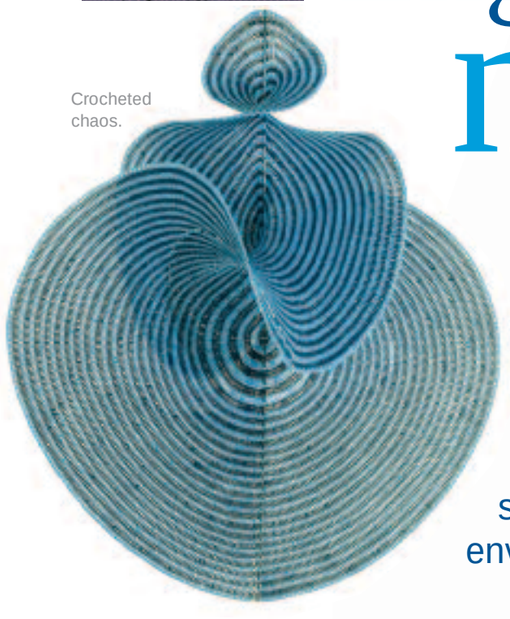
*re:*search No 13, December 2006

PHOTO BY GEORGE SELL, UNIVERSITY OF MINNESOTA

*pre:*view

Dr Hinke Osinga

Engineering neurons



Crocheted chaos.

Dr *Hinke Osinga* is one of only two female Readers in the Faculty of Engineering and the only female member of staff in the Department of Engineering Mathematics. Nevertheless, as she illustrates below, women do have successful careers in the male-dominant environment that engineering still is.

The Department of Engineering Mathematics lies at the heart of many research activities, not only in engineering but also in recently initiated cross-faculty projects with biology and medicine. I have worked in this department for almost six years now and thoroughly enjoy the stimulating research environment that it provides. In August last year I was promoted to Reader (the grade below Professor) and awarded a five-year Advanced Research Fellowship around the same time. The fellowship allows me to concentrate fully on my research, which is a combination of rather pure maths subjects like geometry and topology – the study of qualitative questions about geometrical structures – with a heavy dose of numerical analysis and computer programming thrown in.

How can a neuron be the same as a power plant?

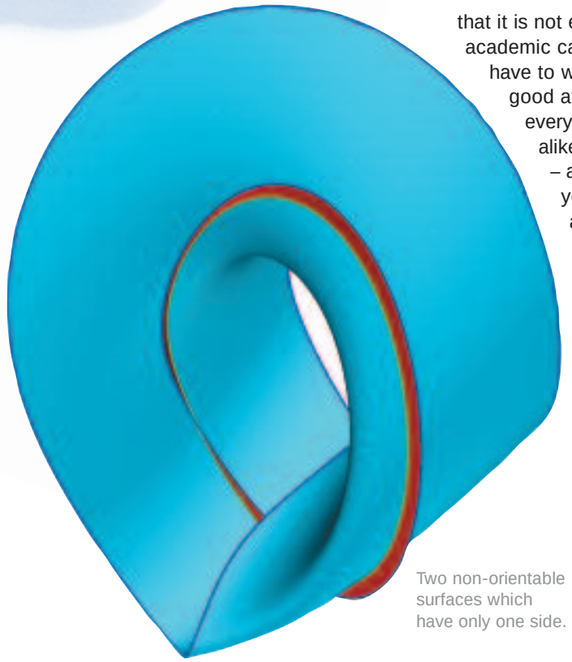
One of the interesting and important aspects of this work is visualising the dynamics of mathematical equations that model processes which vary with time. It can be awe-inspiring to watch a computed surface that was hidden in the equations appear on the computer screen as a beautiful, artistic object. Indeed, many people know me because of images I have created – particularly one which I then went on to crochet as a beautiful three-dimensional structure. This attracted worldwide interest and I now regularly receive emails from other scientists who have learnt about my work and want to use my methods for their applications.

Currently, one of my favourite research projects is a collaborative study with Arthur Sherman at the National Institutes of Health in Bethesda, USA. The project looks at the behaviour of neuron cells in the brain. The membrane that encloses the cell contains tiny channels through which ions like potassium or calcium can enter and exit the cell. The chemical processes that regulate these channels produce electrical currents that generate a varying voltage potential across the cell membrane. This oscillatory electrical activity is the basis for all cell signalling in the brain, which is needed to initiate muscle contraction, tissue growth, insulin secretion, and so on. Our goal is to understand how this process can be influenced so that we may be able to control or even cure diseases like Parkinson's and diabetes.

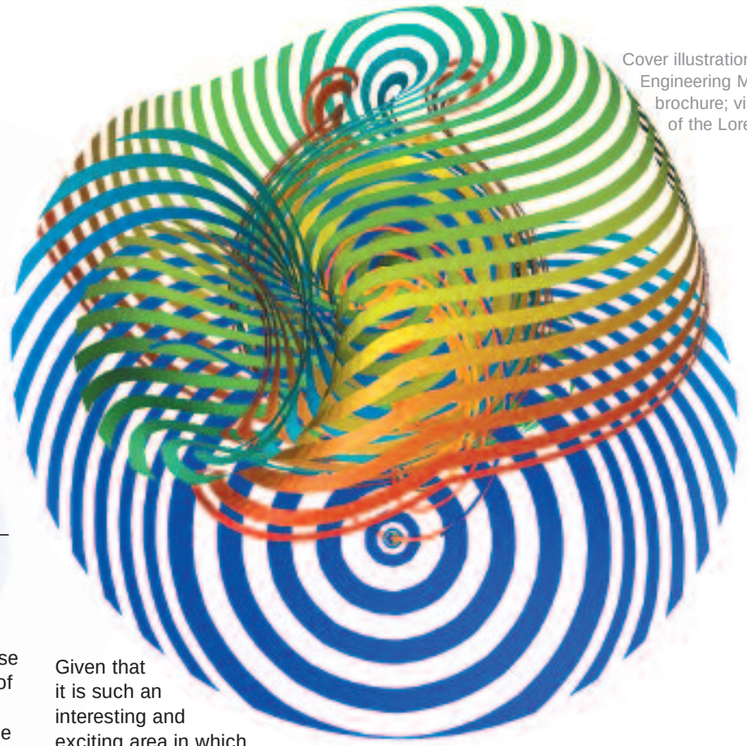
My contribution to the project is to determine the boundaries of particular behaviour. For example, in laboratory experiments extra electrical current is applied to a neuron cell in order to measure its response. The oscillatory electrical activity of the cell membrane is disturbed, which influences the calcium uptake of the cell. With my computational methods, I can find the precise boundary between a net increase in calcium uptake (low voltage) and a net decrease (high voltage), based on the theoretical equations of the process. From the results I can tell the experimentalist how long to apply the added current of a certain strength, in order to get the required effect.

From the point of view of engineering mathematics, the cell activity is like an electronic circuit and it is no surprise that the model equations are, in fact, rather similar. This can often cause great confusion for the non-specialist: surely, a neuron cell cannot be the same as an electrical power plant? ➜ Indeed it is not, but it is quite a mathematical challenge to explain why they are different. The mechanisms for creating a current and how this influences the voltage potential are rather similar, albeit on completely different scales. Hence, the equations that describe these processes are very similar, and the techniques that one uses to study their dynamics work for both.

I very much like this property of mathematical equations. As soon as the equations are there, one can forget about their physical meaning and study them in their own right. Only at the end must the mathematical results be translated back to what it means for the neuron cell – or the power plant for that matter. The mathematical analysis naturally extracts common features of applications that lead to similar equations, so in a mathematical sense we know precisely what the effects of the similarities are. Engineering mathematics, therefore, is in a unique position to point out where techniques that are commonly used in, say, power electronics may also be beneficial in a seemingly completely different area, such as neuron science. This breadth of mathematics is precisely what is needed for making substantial progress in modern technologies.



Two non-orientable surfaces which have only one side.



Cover illustration of the Engineering Mathematics brochure; visualisation of the Lorenz manifold.

Given that it is such an interesting and exciting area in which to work, I do find it surprising that there are so few women working in this field. Most people would agree that it is not easy to have a successful academic career of any kind – you have to work hard and be very good at what you do. So everybody, men and women alike, has moments of doubt – are you good enough, can you do it, why not just quit and give it all up? Why is it then that women tend to lose their confidence so much quicker? From talking to other academics, I have formed the opinion that there is a big difference in the way others influence this personal battle. Men rarely need to defend their career choices against critical comments from close friends or family, a supervisor, or head of department. Women, on the other hand, often get well-meant, but negative advice from those who should have been giving encouragement and support. I know from personal experience that it is, therefore, extremely important to be inspired by successful role models.

I like this property of mathematical equations

At the moment there is not a single female professor in the Engineering Faculty and only 11 per cent of the Faculty's full-time academic staff are female. This compares with 34 per cent of full-time female academic staff across the University as a whole. For undergraduate students, the number of females in the Engineering Faculty is 14 per cent, compared with 52 per cent of females across the whole University. Hence, it is clear that engineering has a long way to go. More female role models in engineering would be key to changing our (incorrect) opinions that engineering is just for men. ■

Dr Osinga's Fellowship is funded by the Engineering and Physical Sciences Research Council.
www.enm.bris.ac.uk

Dr Pauline Fairclough

Shostakovich 2006

Reflections on the centenary year

Shostakovich became a household name in the West not only because he was a hugely popular and successful artist, but also because he came to be perceived as a Soviet dissident. Dr *Pauline Fairclough* from the Department of Music questions this label and examines the evidence for it.

During Shostakovich's lifetime (1906–1975) the idea of his being a dissident was never really seriously mooted; passing speculation by Western music critics and broadcasters was as close as it ever got. It was only after his death that, at least for the Western media, Shostakovich ceased to be a successful Soviet composer and became instead an embittered dissident. The event that provoked this shift in popular opinion was a book written by a young Soviet émigré musicologist, Solomon Volkov. The book in question was *Testimony*, published in 1979. This was claimed to be Shostakovich's dictated memoirs and proclaimed that every one of his symphonies written after 1936 was a 'tombstone', commemorating the victims of Stalinism and Soviet power.

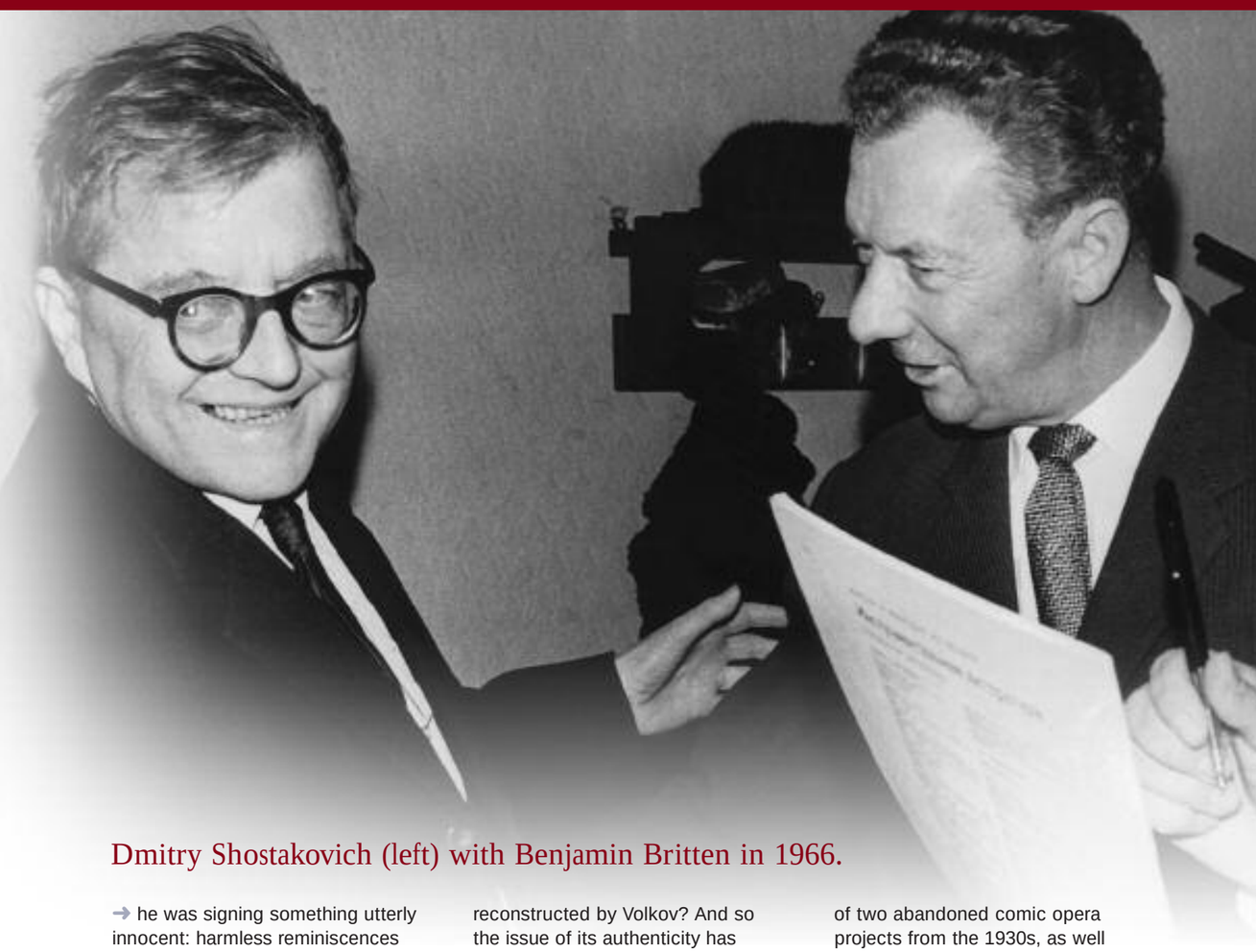
As the collapse of the Soviet Union in 1991 recedes into ever-distant memory, the heat of the controversy over *Testimony* is beginning to cool. For the generations of students and scholars who have no memory of the Soviet Union, it will be increasingly difficult to understand why some writers invested so much in defending *Testimony*'s authenticity.

> 'Looking back, I see nothing but mountains of corpses'

For regardless of our own personal politics, our way of hearing Shostakovich's music, or our respect for some of those who have chosen to support Volkov, *Testimony* is a fake. Did Shostakovich meet with a young Russian musicologist in secret, confide in him anecdotes and opinions that he kept from his family and closest friends, and instruct him, as was claimed, to publish the book 'after my death'? Since there is no record of anything other than a few brief meetings, we shall never know. Did Shostakovich say any of those things to Volkov? He may well have done; but there is no written or taped record of their conversations. The shorthand notes Volkov claimed to have taken have never materialised. What did materialise was a book neatly organised into chapters with the first page of each chapter signed 'Read. D. Shostakovich' in the composer's hand. Volkov emigrated to America, showed his publisher the 'evidence' of his collusion with Shostakovich, and the rest is history. It is now almost impossible for us to imagine a pre-*Testimony* Shostakovich: the allure of his dissidence has proved far greater than the inconvenient facts of Volkov's betrayal of the aging composer.

'Betrayal' is a strong word. But when the American scholar Laurel Fay finally accessed the original Russian manuscript of *Testimony* in 2000, she found that Shostakovich's signature appeared on pages where only previously published anecdotes and reminiscences by the composer appeared. Not a single word on those pages had not already been published openly in the Soviet Union. The shocking line on the first page of *Testimony*'s Chapter One – 'Looking back, I see nothing but mountains of corpses' – was printed on a separate page, slotted in before the signed one, with pagination accordingly altered. What is more, the signed page was counter-sunk to appear like the opening page of a chapter; Shostakovich had clearly believed ➜

IMAGES COURTESY RIA NOVOST: HTTP://EN.RIAN.RU



Dmitry Shostakovich (left) with Benjamin Britten in 1966.

➜ he was signing something utterly innocent: harmless reminiscences about friends and colleagues that he had already published anyway.

Fay suspected something of the sort had occurred when she first read *Testimony* in 1979 and recognised passages from the Soviet journal *Sovetskaya Muzyka*. She challenged Volkov to respond; he never did. It took almost 20 years for Fay to prove that her original suspicion was correct, and now there are comparatively few who would seriously contend that *Testimony* was exactly what Volkov had originally claimed: Shostakovich's dictated memoirs, read, sanctioned and signed by him. But since then the goalposts have been moved. Too much has been invested by too many prominent publishers, Russian émigrés and music journalists to accept that *Testimony* is literally nothing but a fake. Having believed in it for a quarter of a century, how can the West see a Shostakovich that has not been reconstructed by Volkov? And so the issue of its authenticity has been quietly shelved while those who previously insisted upon it now maintain that, regardless of how it came into being, it still presents the 'essential truth' about Shostakovich. Can there ever really be any such thing, though? What was the 'essential truth' about Mozart, about Stravinsky, about Beethoven?

At the Music Department's Shostakovich centenary conference in September 2006, the archivist Leonid Maksimenkov revealed how Shostakovich wrote to several members of the post-war Politburo requesting a new apartment, substantial sums of money and even a trophy German car; hardly the actions of a secret dissident. There were even greater revelations on the musical front: the chief archivist of the Shostakovich Family Archive in Moscow, Olga Digonskaya, described how she had found parts of two abandoned comic opera projects from the 1930s, as well as a wealth of sketch material that sheds new light on familiar works.

There will be many more such discoveries over the next decade as Russian archives continue to be explored, throwing up revelations about both the composer and the man. With so much still to discover, we cannot afford the luxury of imagining we know all about Shostakovich from Volkov's *Testimony* or from his recent book, subtitled 'The Extraordinary Relationship between the Great Composer and the Evil Dictator'. We hardly need fake memoirs to sensationalise Shostakovich's career; the facts are infinitely more exciting than lies and spin; and it will, in the end, be the facts that remain. ■

www.bris.ac.uk/music

The energy line

Cherry Lewis interviewed *Jan Noyes*, Professor of Human Factors Psychology (or Cognitive Ergonomics), after a frustrating drive into work.

It is a Tuesday morning on the M4 and I am sitting in stationary traffic worrying about being late for my meeting with Professor Noyes. To try and find out what the problem is, I phone the RAC traffic line: 'To hear live information about a specific motorway or A road, please say the road name,' requests a polite, almost human, female voice. 'M4,' I say. 'I'm sorry, I didn't recognise that name. 'M4,' I repeat, a bit louder and slower. 'I'm sorry, I didn't recognise that name.' 'EM FOUR.' I enunciate, clearly and distinctly. 'I'm sorry, I didn't recognise that name.' says the repetitive, but ever-patient, voice. 'M4, you idiot,' I shout, turning off the phone as the traffic starts to move.

Jan Noyes works in the Department of Experimental Psychology because she is interested in how people interact with technology – their expectations and perceptions of it – particularly computers and the more advanced technology that might be found on the flight deck of a civil aircraft or control panels of a submarine. Much of her work is with engineers, because if you are going to design something that complex you need a multidisciplinary team. "I design from the perspective of the human users, whereas engineers design inevitably from the point of view of the engineering parameters," she explains. "For example, automatic speech recognition works much better for men than women, possibly because it is designed by male engineers and they tested it on themselves."

Amused, I explain about the little scenario I had experienced on the way in to see her.

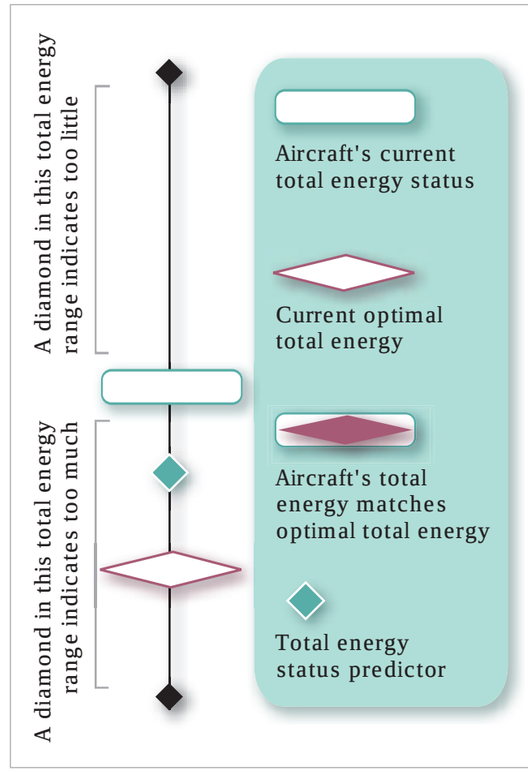
"What you have to do in that situation is look at the way we speak to each other: what happens when I don't understand what you say? You speak louder and slower, you over-pronounce," Noyes explains. "So when we talk to a machine we bring those expectations along with us." Embarrassed, I recall that is precisely what I did. "But if you look at the way speech recognition systems work, they don't operate on those principles at all. The algorithms are not working on the parameters that humans work on – so logically, it could be better not to have any expectations at all and treat the machine as an idiot."

While it is difficult to get a machine to behave intuitively as a human would, Noyes finds that there are lots of little things she can do to improve software by carrying out experimental work ➜ with humans first. A big problem for speech recognition in the car, for example, is background noise – the engine noise, the radio, and noise outside the car all contribute to confuse an automatic system. So you can make the software more intelligent by studying how and in what situations a human actually wants to use it.

Another area Noyes has been particularly involved with is in the management of visual display systems on board civil aircraft. In these times of concern about the contribution aircraft are making towards climate change, there exists a strong rationale for an energy management system that not only helps the crew use the aircraft's energy more efficiently, but also contributes to improved safety. Heavy landings, rushed approaches and runway over-runs could all be reduced through the provision of an energy display which allows the crew's actions to be based on more accurate information. This in turn should lead to more appropriate and timely responses. For example, pilots lower the under-carriage ready for landing much earlier than they often need to, because airlines have to err on the side of caution. However, lowering the wheels causes tremendous drag, which increases both fuel consumption and noise pollution for those under the flight path. Improved information on a plane's energy state during a descent could help the pilot decide on the best time to lower the wheels, without compromising safety.

being able to apply human factors from the outset. In collaboration with Smiths Aerospace, Cranfield and British Airways, three designs were evaluated. It was found that those with a predictive capability produced the most accurate decisions concerning aircraft energy states.

A predictive display is simply one in which the information provided is extrapolated forward in time, enabling the operator to anticipate what is likely to happen in a few minutes' time. Perhaps surprisingly, predictive systems have been little researched in the past with only NASA reporting a sustained interest in the idea. The role of such a predictive display might be seen as being similar to that of the erstwhile flight engineer who, often with the aid of simple calculations, would make predictions about the state of the aircraft which helped the crew make decisions concerning the flight.



The Energy Line display

The idea is that you come in on a 'good' energy line

The primary aim of an energy display would be to provide the pilot with an indication of the energy range in which the aircraft is operating and to ensure that current energy levels lie within an ideal energy range. The idea is that you come in on a 'good' energy line and if you deviate from that you are in what is called a 'dirty' state – a too high or too low energy state – the latter having more serious implications for safety. Thus an important feature of the system is giving the pilot an indication of whether the deviation from 'good' can be corrected in time. So how to incorporate all this information into one system, while not overloading the pilot? Interestingly, experiments showed that while a high workload only adds to the general 'noise' of the flight deck, a low workload display appears to be highly erroneous in terms of decisions made based upon it. Either way, potential for error is high, thus a balance between accuracy of decisions and workload is needed. Of the three systems evaluated, the 'total energy status and predictive display' – or Energy Line – shown above appears so far to be the most effective, but the aircraft industry does not move fast and designs of today may take many years to bear fruit.

I asked Noyes if she thought there would ever come a time when humans became redundant in aircraft. "My understanding is that it is very feasible to have unmanned aircraft – the advantage of crew is when things go very wrong. Humans have an incentive to get home, whereas a computer doesn't," she replied. "The joke is that aircraft of the future will only have a man and dog at the controls. The man is there to feed the dog. So what's the dog there for? To keep the man off the controls!" ■

http://psychology.psy.bris.ac.uk

Dr Jane Memmot (left)
Rachel Gibson (right)

Pollinating rare plants

Left: Catchfly *Silene gallica*.
Below left: Bumblebee *Bombus pascuorum*, courtesy www.entomat.be

Little is known about the pollinators of rare plants, which is cause for concern given that pollination is essential for the long-term survival of most plant species. Dr *Jane Memmott* and *Rachel Gibson* from the School of Biological Sciences spent two years trying to determine the probable pollinators of three species of rare arable weeds.

Forty per cent of the flora in the UK is considered to be at risk of extinction and 66 plant species are listed in the government's Biodiversity Action Plan. Farmland probably holds more rare and endangered plant species than any other habitat in the UK, and species of arable weed, ie plants associated with crop fields, are among those suffering the greatest declines.

Given that 67 per cent of flowering plants rely on animal pollinators for reproduction, it is obvious that increasing pressure from human activities – the introduction of alien plants, habitat fragmentation and agricultural intensification – will seriously compromise this interaction. But little is known about how it works.

All three plants are listed as priority species

The aim of Memmott's work was to determine which pollinators may be critical for the survival of three rare arable weed species: red hemp-nettle, small-flowered catchfly and spreading hedge-parsley. All three are listed as priority species in the Biodiversity Action Plan. Data on the three plant species, at five field sites, were collected over two years in order to construct visitation and pollen transport 'webs'. Most interactions between plants and their pollinators are embedded in a complex web of plant–pollinator interactions which, when analysed by software specifically designed for the task, provides a quantitative approach to understanding the pollinator requirements of these rare plant species.

Researching a site involved the sampling of 16 randomly chosen one-metre-square quadrats. On each sampling occasion the floral units per plant were counted and all insects that visited flowers during a 15-minute period were caught. In the laboratory, each insect was first identified and then examined for the type and amount of pollen it carried. From these data it was possible to determine the importance of a particular insect species in pollinating a particular plant species.

The team found that a wide range of insects visited the three plant species and that pollinators varied considerably across their geographical range, but less from one year to the next. ➜

➜ Nevertheless, the team was able to identify that the red hemp-nettle was primarily pollinated by the bumblebee *Bombus pascuorum* at one site and the hover fly *Sphaerophoria scripta* at another. The latter was also a likely pollinator of the small-flowered catchfly, while the soldier fly, *Chloromyia formosa*, may be of particular importance in the pollination of the spreading hedge-parsley at certain sites because of its apparent specialisation on the flowers of this species. In addition, all three plants were linked to other plants in the community by shared pollinators. In many cases these other plants constituted the primary food sources for the shared pollinators. Gibson therefore recommends that the management of the rare plants should include the protection and management of populations of some of the more common plant species in their respective communities.

It may be possible for rare arable plants to flourish again

Using this approach allowed the team to identify the probable key pollinators of the three rare plants, and to make recommendations for management of the plant–pollinator communities in which they are found. Unfortunately, the management of arable land for conservation can often conflict with the growing of crops. There is hope, however, with the implementation of new schemes that provide subsidies to farmers for employing environmentally beneficial practices such as wide, unsprayed field margins, beetle banks and less intensive hedgerow management. In addition, certain arable plants play an important role in maintaining complexes of beneficial insects, which provide invaluable services to farmers in limiting pest populations. If future agricultural policies are devised with these benefits in mind, it may yet be possible for rare arable plants to flourish in the British countryside once again. ■

www.bio.bris.ac.uk

Evolving a new garden

In 2005 the University relocated its botanical collections and established a new Botanic Garden. This was the fourth time the garden had been moved since it was first established in 1882. Over the coming years, the new Botanic Garden will emerge to provide the University and City of Bristol with a unique botanical and cultural resource for the future. It will focus on four themed plant collections, but of particular interest will be the Plant Evolution Collection, comprising Evolution of Land Plants, Flowering Plant Phylogeny, and Floral Diversity.

The Evolution of Land Plants Collection will consist of a walk through a sunken dell charting the most important stages in the evolution of plants on land, from green algae to flowering plants. This 'evolutionary walk' will take the form of a journey through geological time from the Cambrian to the Cretaceous using appropriately chosen rocks and fossils to reflect the passage of geological time. Living representatives from the various groups of modern land plants will then appear along the walk within the geological times zone when they first evolved – mosses, ferns and clubmosses in the Devonian, conifers in the late Permian and Triassic and flowering plants in the Cretaceous. The walk will reflect the 'crescendo' of plant evolutionary diversification, culminating in the Cretaceous with an 'explosion' of flowering plants centred around a spectacular display of magnolias.

The Flowering Plant Phylogeny Collection has been designed to reflect modern theories on the evolutionary relationships and classification of the many families of flowering plants inferred from comparisons of their DNA sequences. The paths within this collection will take the form of a branching family tree (phylogeny) of the flowering plants, beginning with the most primitive groups – so-called 'basal angiosperms' – from which the other major lineages of flowering plants diverged. The Floral Diversity Collection will reflect the extraordinary diversity of flower form that has evolved to ensure that flowers are pollinated by insects, birds, mammals, wind or water. Tropical, sub-tropical and some Mediterranean elements of these three sub-collections will be displayed within the glasshouses. ■

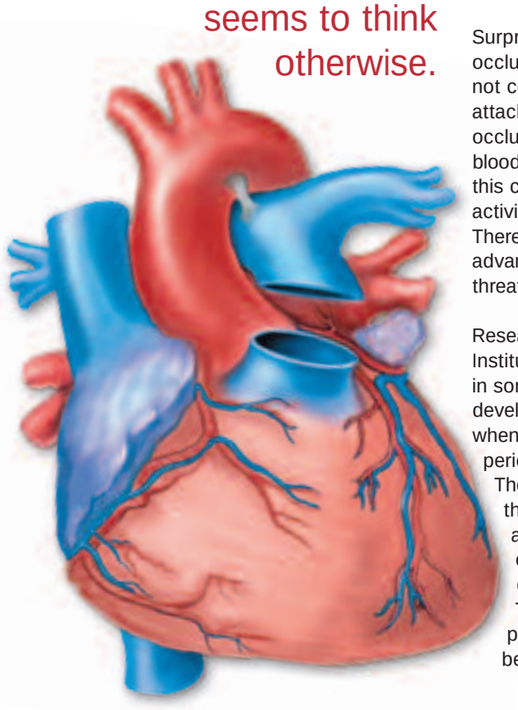
See the website for the Botanic Garden's location and opening times: www.bristol.ac.uk/Depts/BotanicGardens

Below: *Magnolia Watsoni*

Anabelle Chase

Can coronary heart disease ever be a good thing?

With 1.4 million cases of coronary heart disease in the UK, leading to 120,000 deaths per year, coronary heart disease is the last condition one would expect to be of potential benefit to anything. Chris Moore interviewed *Anabelle Chase* at the Bristol Heart Institute who seems to think otherwise.



Coronary heart disease (CHD) is the end result of the accumulation of fatty deposits – plaques – within the walls of the arteries that supply the heart. The symptoms may go unnoticed for some time and over the course of decades these plaques, that at one time were merely streaks on the inside walls of arteries, become obstructions. If a large plaque ruptures, this can attract blood cells called platelets that within minutes form a clot in the artery, or the pieces of the plaque that have been dislodged may adhere elsewhere. Both events can reduce blood flow to areas of the heart muscle, leading to ischaemia – reduced oxygen supply – and it is the most common cause of a heart attack.

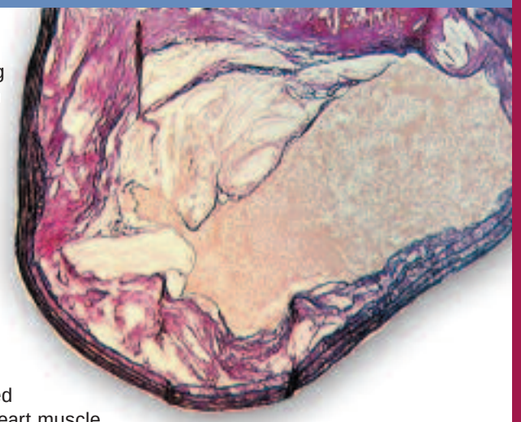
Heart cells have developed a 'coping mechanism'

Surprisingly, less than 70 per cent occlusion of an arterial vessel is not considered high risk for a heart attack. Nevertheless, the greater the occlusion, the more restricted the blood flow becomes to heart cells and this can result in areas of ischaemic activity on a semi-continuous basis. There is, however, a potential advantage to this otherwise life-threatening condition.

Researchers at the Bristol Heart Institute have found evidence that in some cases, heart cells have developed a 'coping mechanism' when the heart is subjected to erratic periods with low levels of oxygen. The cells appear to have developed the ability to shift their metabolic activity towards the anaerobic in order to manage the decreased oxygen level more effectively. This has been termed 'ischaemic pre-conditioning' and Chase believes that this increased hardiness of the cells may be the key to protecting the heart against reperfusion injury during coronary bypass surgery.

During heart surgery the heart is deliberately stopped so that it is not beating while the surgeon operates. The blood, which would ordinarily have passed through the heart, passes instead through an external pump. During this process the heart undergoes a period of oxygen deprivation which can result in damage to the heart muscle. The problem is compounded when circulation is restored, since the sudden influx of oxygen and nutrients can cause inflammation and oxidative damage to the tissue. Rather than restoring normal function, the heart can be weakened even further. It appears, however, that in those patients with CHD, ischaemic pre-conditioning allows heart cells to maintain a level of activity that minimises the chances of being overwhelmed when normal blood flow is restored.

This state of pre-conditioning was discovered by Chase when attempting to develop a suitable model of coronary heart disease. Previous models have all been based on healthy rat models and therefore the effects seen when stopping and restarting these hearts does not accurately reflect those experienced by diseased hearts *in situ*. The question posed by Chase was therefore 'Are diseased hearts different?'. The answer came from another type of rodent, the 'apolipoprotein E knockout' mouse, which has been genetically engineered to be the perfect model for atherosclerosis – the progressive ➜



Cross section of an artery that has become blocked due to plaque rupture.

➜ narrowing and hardening of arteries. Providing it with a high-fat diet causes human-like atherosclerotic lesions and plaques.

Two sets of mice were fed for 24 weeks on either a high-fat or a normal diet. After the 24 weeks had elapsed, the coronary arteries and heart tissue of those on the high fat diet showed evidence of blocked coronary arteries and the heart muscle showed signs of infarction – death/loss of cellular structure. Knowing these mice were suitable models for CHD, Chase excised their hearts and put them through a Langendorff heart preparation – a system designed to study coronary flow during cardiac activity. Both groups were exposed to 35 minutes of ischaemia followed by 45 minutes of reperfusion. The results were fascinating – the diseased hearts showed a 100 per cent recovery, whereas the normal hearts showed about 30 per cent recovery.

The diseased hearts showed a 100 per cent recovery

But why was this the case? What is it about a diseased heart that gives it such strength under such strenuous conditions? Analysis of the diseased and healthy hearts revealed that metabolites such as adenosine triphosphate (ATP) and glycogen were reduced in the diseased heart, and lactate was at a higher level than that of a healthy one, giving rise to the pre-conditioned state that allows a CHD heart to cope better with ischaemic insults. Cellular damage was also noticeably different in diseased versus healthy hearts. When heart cell membranes become damaged, an enzyme called creatine kinase leaks out of the cells themselves. The extent of the damage can be determined by measuring the levels of this enzyme – the more creatine kinase you have, the more damage there is. Unsurprisingly, then, Chase found more creatine kinase in the normal hearts (low recovery) compared with diseased hearts (100 per cent recovery).

Protecting the heart from reperfusion injury is an ongoing field of research and Chase is hoping these new findings can help move the field on. As she explained: "Ischaemic and reperfusion injury occurs in any type of operation that requires a motionless, bloodless heart. So while this includes bypass surgery for coronary heart disease, it also includes valve replacements, arterial defect repair and aneurysm repair. In children too there are tons of congenital heart diseases, so although these diseases don't require bypass surgery as such, they can still suffer from ischaemic or reperfusion injury."

Current cardio-protective techniques are largely based on preserving metabolites – preserving ATP, preserving glycogen and reducing lactate formation. This always seemed like the obvious thing to do. However, what Chase's research shows is that low levels of ATP and glycogen, and high levels of lactate, are actually beneficial and can help to protect the heart. From this point of view, it may be that the cardio-protective solutions we currently use are ineffective or inappropriate and require something of a rethink. ■

This work by Anabelle Chase, a postgraduate student at the Bristol Heart Institute, formed the basis of her PhD. It was funded by the British Heart Foundation. Anabelle won the first prize for best oral presentation at this year's Joint Faculties' Postgraduate Symposium.

www.bris.ac.uk/clinicalsciencesouth

In the news:

Hope for rare heart condition

A team led by Professor *Jules Hancox* and Dr *Harry Witchel* in the Department of Physiology has found a possible way to prevent heart-beat irregularities caused by 'short QT syndrome' – a rare condition that runs in families.

People with SQTS can be prone to dangerous changes in heart rhythm, such as the life-threatening condition 'ventricular fibrillation'. This is due to a defect in regulation of the electrical currents that control heart muscle contraction. The existence of SQTS was only discovered in 1999 thus medical treatments are still very limited.

The team found that when tested on isolated cells, an existing drug called disopyramide appears to be able to correct the molecular defect in one type of SQTS. If the results translate into humans, disopyramide could be a life-saving medicine for sufferers. Professor Jeremy Pearson, Associate Medical Director at the British Heart Foundation, said: "This demonstrates how research into understanding the fundamentals of heart conditions can provide the evidence we need to help more heart patients benefit from existing drugs." ■

www.bris.ac.uk/Depts/Physiology

Dr Esther Dermott

New fatherhood: work in progress?

Being a father has little effect on men's working hours or their preferences over working time. But fathers of today do prioritise family life and want greater flexibility within the workplace in order to play a larger role in their children's lives. Dr *Esther Dermott*, from the Department of Sociology, says that new fatherhood is still 'work in progress'.

There is a tension in our current understanding about fatherhood. The social expectation that men will provide for their family is exemplified in the legal requirement that a father continues to be financially responsible for his children after divorce or separation. Furthermore, recent studies have concluded that breadwinning is still men's main form of commitment to family life and an important component of men's fathering identity. On the other hand, behaviour that is not work-centred seems to be an increasingly important aspect of what fathers do. There has been an increase in men's contributions to domestic work and involvement in childcare activities alongside a spectacular shift in involvement with particular child-related events, most notably attendance at births. Over 90 per cent of married or cohabiting fathers are now present at the birth of their child, compared with a mere 8.5 per cent of fathers in the 1950s. This kind of evidence has led some to argue that the ideology of the breadwinner has been replaced with a nurturing father model, and that it is the quality of the father–child relationship that is increasingly prioritised by men.

> Over 90 per cent of fathers are present at the birth of their child

Exploring the relationship between fatherhood and employment is one way to examine this conundrum. If breadwinning is connected with a fathering role, it is reasonable to expect men with children to work longer hours than their childless colleagues. In contrast, if the advent of 'new' fatherhood is correct, with fathers moving towards more family centred activities, then we should expect to see fathers spending less time in employment than non-fathers. Or could there be a third option? Could it be that fatherhood simply tends to coincide with a time in men's lives that is critical to the development of their careers? In which case, previous research on fatherhood may be overplaying the influence of parenthood in relation to men's experience in the labour market. For example, higher levels of engagement in family care by men may be attributed to alterations in our ideas about fathering, when they are really the result of limited employment opportunities in particular labour market sectors. Thus, argues, Dermott, by assuming at the outset that the categories 'father' and 'non-father' have an intrinsic salience, researchers may produce spurious findings.

Initially, when fathers are compared with non-fathers the results seem to indicate that fathers do work longer hours (and are also more likely than non-fathers to be working extremely long hours). But once other variables are considered this difference disappears. Dermott's analysis shows that men's preferences about working time do not change when men become fathers – around a quarter of men wanted to work fewer hours; less than one per cent wanted to increase their hours; and the remainder wished to maintain the status quo. These findings challenge the orthodoxy of fatherhood as breadwinning – men's engagement with the labour market exists irrespective of their parental status. But it also calls into question assumptions about the arrival of fathers who are adopting a 'female model' of parenting. Although the idea of involved, caring fathers may have become culturally embedded, the suspicion is that stories of fathers working on a part-time basis or men reducing their hours of employment as a consequence of parenthood are exceptional cases rather than substantial movements – despite their frequent media attention. The findings reassert that the relationship between paid work and parenthood is very different for mothers and fathers in the UK since mothers and non-mothers do differ significantly in terms of their hours of work. This ties in with other recent research on gender differences conducted by Dr Sarah Childs, from the Department of Politics. She was the co-ordinator of a study specially commissioned by *Woman's Hour* for the programme's 60th anniversary, which suggested that both men and women are still much more likely to view the stay-at-home mother as a parenting ideal than the stay-at-home father. The survey also found that women are twice as likely as men to feel guilty about placing their pre-school children in childcare, suggesting that the obligations of motherhood and fatherhood have not yet converged.

> Men's working preferences do not change when they become fathers

Men may find other ways of achieving involvement in family life that do not mean a reduction in full-time contracted hours. The period around the first year after a birth is associated with some decrease in working hours so, while fathers may not be taking on the bulk of childcare duties or substantially altering their working hours in a permanent way, there is some short-term adjustment. This may be in line with the idea of good 'new' fatherhood, which promotes men's presence at the birth of a child and a general sense of 'being there' but does not undermine a strong attachment to the labour market. In practice, 'new fatherhood' is not a revolutionary transformation but a moderate accommodation. If family-friendly policies are going to be successful, they will need to take account of how fathers want to adapt their routines to fit in with family life. 'While fathers don't want to work less they may want to work differently,' says Dermott. 'Speaking to fathers it was evident that what they considered most valuable in a job was flexibility over their working hours, so that they could leave early to go to school sports day or make sure they were home in time to read a bedtime story'. ■

> Fathers don't want to work less, they want to work differently

www.bristol.ac.uk/sociology

Dr Nina Snaith

Random matrix reloaded

Dr *Nina Snaith*, in the Department of Mathematics, was one of the Royal Society's Dorothy Hodgkin Fellows, a scheme that provides flexible funding at the early stage of postdoctoral careers when researchers, particularly women, tend to leave science. Today she holds an Advanced Research Fellowship, which means she can spend most of her time doing research. This is an updated version of an interview she gave to the Royal Society.

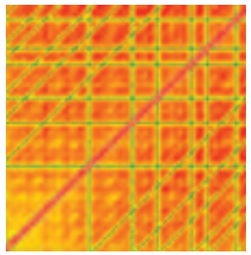
Nina Snaith works at the interface between physics and mathematics, looking at the connections between random matrix theory and number theory and their applications in quantum chaos.

What are the current areas of research you work in?

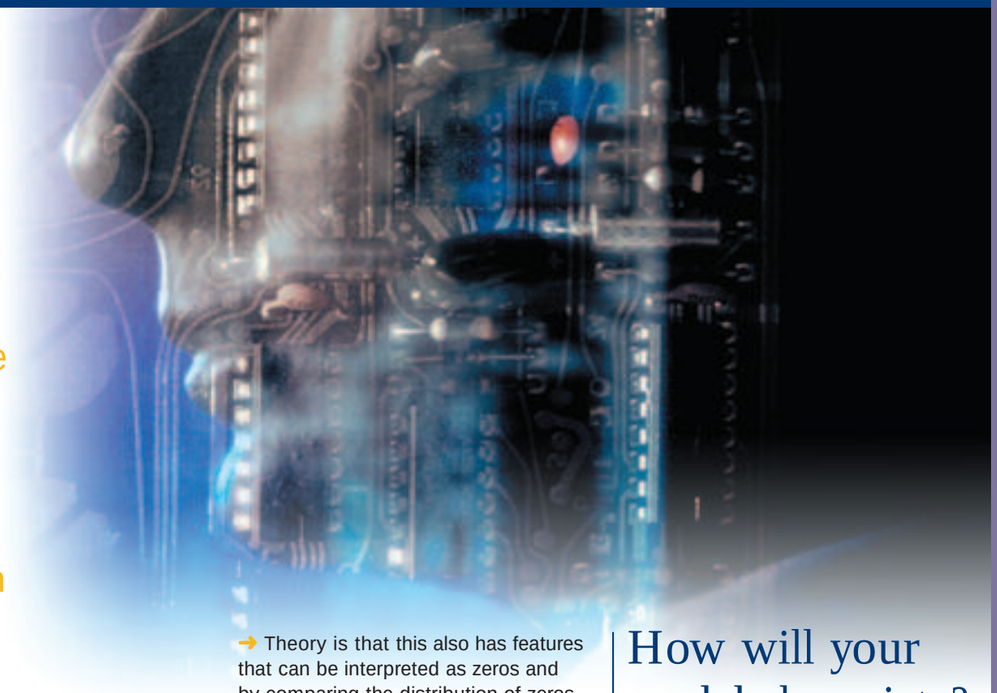
Nina studied theoretical physics as an undergraduate in Canada and was fascinated by quantum mechanics. "Quantum mechanics is a beautiful theory and so different from intuitive classical mechanics," she says. "I was interested in chaotic systems so I chose to come to Bristol to do my PhD as it has an excellent reputation for research in quantum chaos." How large objects, such as balls on a billiard table, interact in a dynamic system can be relatively easily modelled using Newton's classic laws of motion. "In a classical chaotic system, however, it is like modelling balls on a billiard table that no longer has a straight edge but is irregular. This makes prediction of speed or direction of the balls very complicated," explains Nina. "If you imagine the table getting smaller and smaller, reducing to the size of atoms, then the laws of classical mechanics no longer apply and quantum mechanics takes over." At the quantum level Heisenberg's uncertainty principle means that you cannot determine both the position and velocity of a particle, and at this small scale the energy levels of particles, such as electrons, are quantized. This means that only certain discrete energies are allowed. The field of quantum chaos involves understanding how these quantum objects behave in systems with chaotic classical analogues, and determining methods that give information such as the distribution of these quantum energies.

How do you work?

Nina has a traditional approach to mathematics. "I am very much a pencil and paper mathematician," she admits. "My research involves a lot of working with, and thinking about, formulae, but there is also a lot of interaction with other people – exchanging ideas and getting different views." The main part of Nina's work is on Random Matrix Theory – a technique used to model quantum chaos, which is now being applied to fundamental research in number theory. "Usually maths supports physics but this is an example where a technique developed in physics is pushing things forward in maths," Nina explains. She is applying Random Matrix Theory to the Riemann zeta function, an object of fundamental importance in number theory. In fact, solving the Riemann hypothesis is so important it has been designated one of the 'Millennium prize problems'. These are seven mathematical problems that have so far resisted solution, thus a million-dollar prize is attached to solving each one. "Number theory is the theory of arithmetic, literally the theory of whole numbers or integers – understanding how prime numbers arise and other fundamental concepts. The Riemann zeta function, as with other functions, can be thought of as describing a land-scape. I am investigating the contours of this landscape for unusual features: in particular the places where the function is zero. The link with Random Matrix ➜



Triple correlation of the zeros of the Reimann zeta function



➜ Theory is that this also has features that can be interpreted as zeros and by comparing the distribution of zeros in the two systems new insights can be obtained, new questions asked and our understanding of both systems improved."

The connection between number theory and random matrix theory was made during a casual conversation over tea between a physicist and a mathematician in the 1970s and one of the main benefits of Nina's fellowship has been the ability to travel and discuss results and techniques with number theorists. "Bristol is full of experts on quantum chaos but, until the last couple of years, there weren't many number theorists," says Nina. "Now the mathematics department has a very strong number theory group, but at a time when there was less local expertise I was able to spend 15 months in the US at a major mathematics institute working with number theorists, essentially understanding the right questions to ask. It is very much a two-way street for information between number theory and random matrix theory, which makes the interaction even more exciting."

How will your work help society?

Number theory is a vital area for security in IT, ensuring, for example, that internet transactions are secure. Random Matrix Theory is a rapidly growing field in physics and mathematics. It is used in nuclear and solid state physics. "Interestingly, it is now becoming possible, thanks to nanotechnology, to fabricate systems that effectively create quantum billiard tables," says Nina. These nanosystems will be able to test the effects predicted by Random Matrix Theory and should lead to new insights, improved theory and therefore to the design and production of new materials with unusual electronic and other properties.

Do you think studying postgraduate mathematics is becoming more popular?

Nina sees her area of work as being a very cool area of research. "There is certainly no shortage of graduates wanting to study at Bristol," she concludes. "Random Matrix Theory and Number Theory are extremely hot topics, frontier work in fact, and we get some exceptional students inspired to get involved with the work." ■

Dr Nina Snaith's Fellowship is funded by the Engineering and Physical Sciences Research Council.
www.maths.bris.ac.uk

In the news:

Triggering eruptions

A team from the Department of Earth Sciences has shown that magmas heat up as they crystallise, rather than cooling down as previously thought. This ability to self-heat may provide a trigger for eruptions. In addition, the team shows that crystallisation of underground magmas is a short-lived phenomenon – taking years rather than centuries – which is precisely the timescale over which volcanoes can be monitored.

Explosive volcanic eruptions are fuelled by the escape of volcanic gases from magma stored in underground reservoirs and pipes several kilometres below the surface. Predicting such eruptions requires a real-time knowledge of just where the magma is at any one time and what it is doing.

Professor *Jon Blundy* and colleagues analysed tiny droplets of volcanic liquids that become trapped inside crystals as the magma crystallises on its way to the surface. This enabled them to reconstruct the changes in pressure, temperature and crystallinity that occur within a body of magma prior to eruption. The researchers demonstrate that as pressure decreases, crystallinity increases, and the more a magma crystallises the hotter it gets – by up to 100°C.

This surprising result indicates that the driving force behind crystallisation of these magmas was a drop in pressure, rather than a loss of heat to the surrounding rocks, as previously thought. Professor Blundy said: "This work is now being used to gauge the direction of the volcanic activity currently happening at Mount St Helens." ■

This research was published in Nature *443, pp76-80.*
www.gly.bris.ac.uk

Companies wanted for high-level collaborative research

The Great Western Research initiative is a five-year, £14-million investment which aims to catalyse cutting-edge research collaboration between higher education institutions and businesses in the South West. There are five broad research themes intended to support enterprise in the region: Materials, Applied Mathematics, Sustainability, Psychology and the Creative Arts.

As part of this government-funded initiative, GWR will provide matching funds for 130 new PhD-level research programmes to be undertaken in higher education institutions, in partnership with south-west businesses. The projects will be of high added value to both the business partner and the south-west regional economy.

If you want to meet your business and customers' needs through focused, bespoke collaboration with a team of world-class academics, Great Western Research can provide you with the contacts, advice, support and financial backing to achieve this. The initiative will help you focus on developing new products, provide support on a project of strategic importance to your business, and increase your efficiency and profitability. ■

Detailed information on the GWR initiative and the individual research themes can be found on the website: www.greatwesternresearch.ac.uk or contact Jess Warburton on 01392 263456.

University in top rank for supporting early career researchers

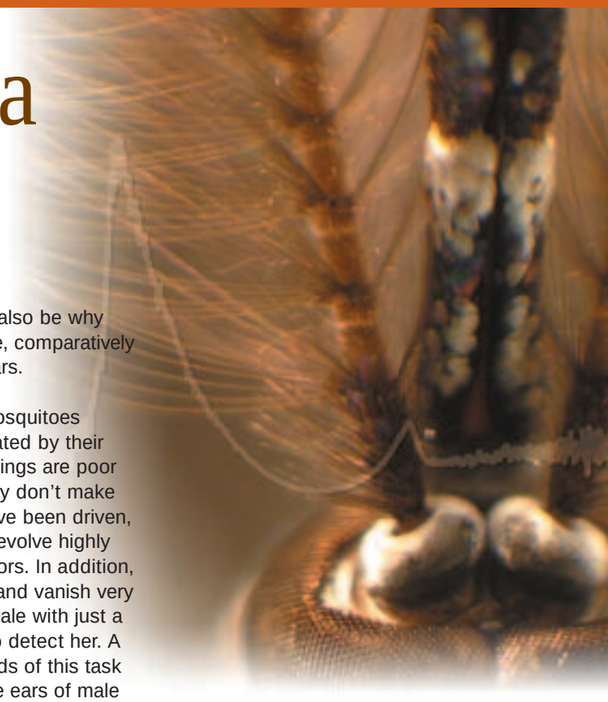
The University has been nominated for a place in the category of 'Outstanding support for early career researchers', in the 2006 *Times Higher* Awards. The award rewards the university that provides the best support in making research an attractive career path, and for helping early career researchers achieve their full potential.

The University, which has an ethos that sees contract researchers as employees rather than students, was nominated because of the world-leading reputation it has earned for handling its 1,100 contract research staff. In 1999 the University established an annual staff survey that has now been rolled out to 43 higher education institutions across the UK. It also has an excellent communication channel with its staff through an annual staff conference.

Dr Iain Cameron, Head of the Research Councils UK Careers and Diversity Unit, congratulated the University on its nomination, saying: "Our sponsorship of this award signals our commitment to helping research organisations improve the attractiveness of research careers, the quality of research training, and the employability of researchers." ■

www.bris.ac.uk/personnel/researchstaff

How to catch a mosquito



The antenna of the male Tanzanian mosquito *Toxorhynchites brevipalpis*. The ring-shaped structures at the base of each antenna (between the eyes) contain the auditory organs. Photo: D. Robert & J.C. Jackson

Male mosquitoes increase their chances of mating with a passing female by enhancing their ability to hear her flying past. Much like the human ear, the mosquito ear is able to amplify the sounds it hears, making a passing female appear closer.

The research was published in the *Proceedings of the National Academy of Sciences*. Professor Daniel Robert, senior author on the paper, said: "To our surprise, we found that the mosquito ear mechanically responds to enlarge its own range of detection. It makes the female appear closer than she actually is, giving the male a split second longer in which to react." This behaviour enhances the male's chance to capture and mate with a passing female. It may also be why such small animals have, comparatively speaking, such large ears.

Males detect female mosquitoes from the sounds generated by their wing-beat. As female wings are poor acoustic radiators – they don't make much noise – males have been driven, by sexual selection, to evolve highly sensitive acoustic sensors. In addition, female sounds appear and vanish very suddenly, leaving the male with just a split second in which to detect her. A reflection of the demands of this task may be the fact that the ears of male mosquitoes contain up to 16,000 sensory cells, a number comparable to that contained in the human ear. ■

www.bio.bris.ac.uk

Optical computer only light years away

One of science's longest-sought devices – an 'optical memory' that stores digital information as light – might soon be a possibility, thanks to funding of over €1 million from the European Commission.

It is already known that light can carry a lot more information than an electric current. In order to develop an optical computer that would outpace today's PCs many times over, a form of memory using light is needed to store information. The problem is – light never stops.

The IOLOS project, led by Dr Siyuan Yu in the Department of Electrical and Electronic Engineering, will develop integrated optical logic and memory devices based on a semiconductor ring laser. The team will work on the principle that light will encircle an SRL, emitting a laser beam in only one of two directions – clockwise or counter-clockwise. When looking at output from one direction you would either see 'light' or 'dark', representing '0' or '1' in a digital system.

Provided energy is supplied to the device the recirculation is endless, much like a toy racing car going around its track for as long as the battery has power. The device can therefore remember its state as long as power supply to the SRL is not interrupted. To set the direction of the recirculation, a beam of light needs to be launched in that direction to begin with, very much like writing a '1' or '0' into a computer memory.

Dr Siyuan Yu, commenting on the project, said: "By making the SRL really small, we aim to develop a practical technology that may one day provide optical memories operating just like electronic memories." ■

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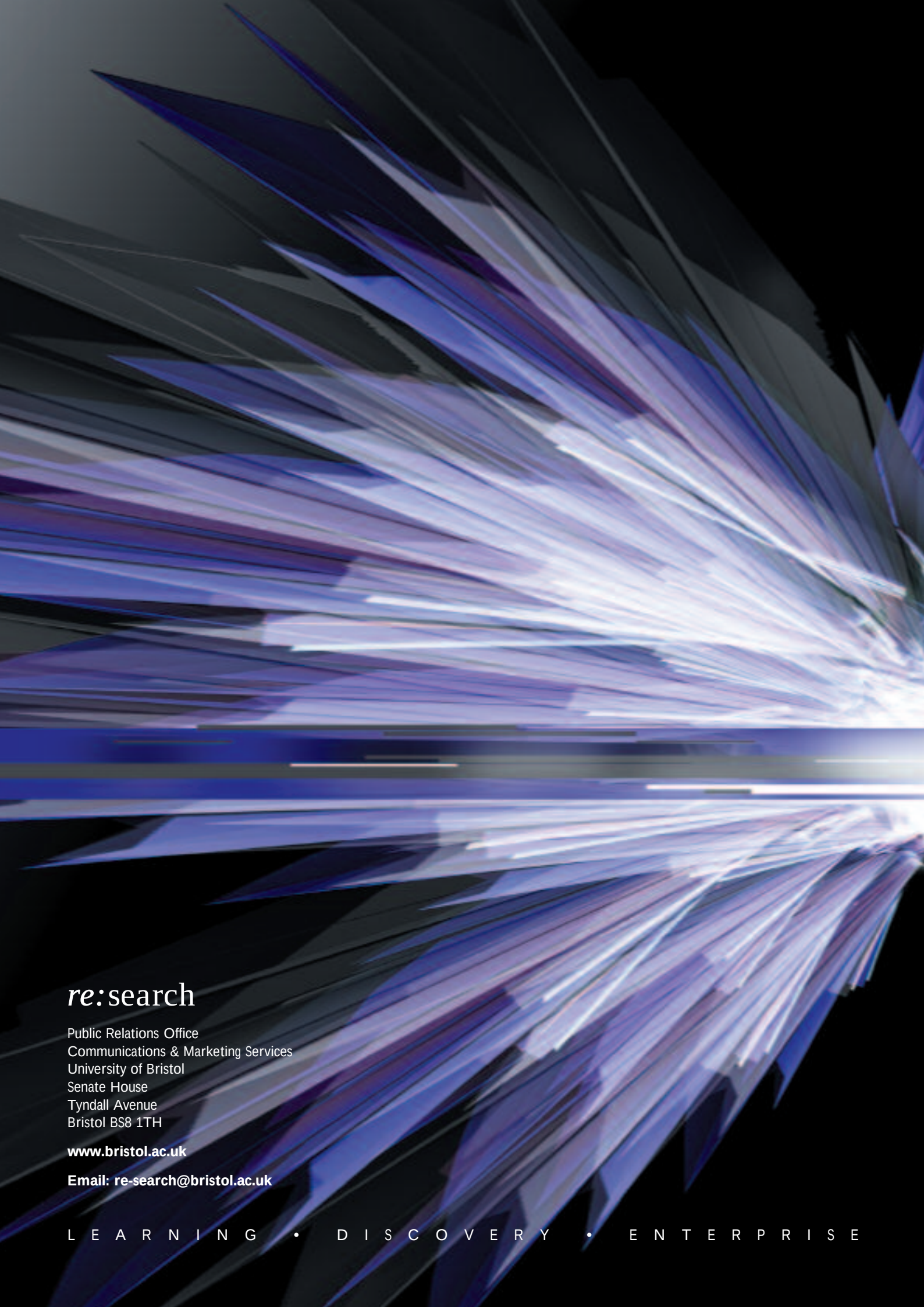

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