SCHOOL OF PHYSICS

THE UNIVERSITY OF SYDNEY

ALUMNI News

AUTUMN 2011

GODLEY'S IN THE DETAIL

CAN A PARTICLE PHYSICIST CURE CANCER? THE ANSWER APPARENTLY IS YES, AND DR ANDREW GODLEY IS THE PROOF.

BY DR PHIL DOOLEY

Andrew Godley completed his PhD in the High Energy Physics group in the School of Physics in 2000, working on the NOMAD neutrino oscillation experiment at CERN. This year he takes up a new position as a medical physicist at The Cleveland Clinic in Ohio, US, where he will be working with cancer patients every day.

"Part of the job is clinical, making sure that the instruments run, and deliver the [radiation] outputs that they are supposed to. Also I work with Physicians and Radiation Therapists developing and delivering treatment plans. It varies a lot from patient to patient, but some tumors, pancreatic for example, or spinal, are very difficult to irradiate safely. You really have to think carefully about how to design the radiation treatment plan because there are very sensitive organs nearby."

Dr Godley's new role, his second as a medical physicist, also includes a research component. "It's an opportunity to do my own projects, I'm very excited - I have lots of ideas!"

He hopes to extend research from his previous position, in Milwaukee, Wisconsin, where he was in a group studying adaptive radiation therapy. In his group's work, patients receiving a course of radiation for a tumor, were imaged every day with a new treatment designed daily rather than being given the same dose twenty times. As tumors (and organs generally) can move several centimeters per day, the new approach allowed for much more precise irradiation of the diseased area, without damaging surrounding tissue.

"We reduced our tumor margin from ten millimeters to three. Seven millimeters doesn't sound like much, but, in the case of a prostate, that's seven millimeters of healthy rectum being damaged," explains Dr Godley.

CONTINUED ON PAGE 4

OPTICAL SCIENCE PRIZE WINNER

Dr. Alexander Argyros a Senior Research Fellow in the Institute of Photonics and Optical Science (IPOS) in the School of Physics has received the 2010 Australian Optical Society (AOS) Geoff Opat Early Career Researchers Prize. The Prize, which was presented at the Australian Institute of Physics Congress dinner in December 2010, recognizes an outstanding early career researcher for her/his contribution to the field of optics.

Alex completed his PhD in 2006, working mainly on microstructured optical fibres. His worked has covered a large scope, from considering a range of materials, dopants and fabrication methods, to theoretical modelling and understanding of the behaviour of the fibres and fibre devices, to considering a range of applications from engineering to astronomy.

Alex joined the School of Physics in 2009 and currently holds an ARF Fellowship on the topic of polymer waveguides for THz radiation. He has also been awarded first place in the Optical Society of America (OSA) Fifth Annual After Image photographic competition. The photo images show micrographs of microstructured polymer optical fibres with a hexagonal array of high-index rings. The resulting resonances and the various sizes of the rings give rise to the different colours.

His winning image was published in the November issue of Optics & Photonics News, and was also used by the OSA on their Christmas cards. The School congratulates Alex on his achievements.

HEADLINE

WELCOME TO THE FIRST ISSUE OF ALUMNI NEWS FOR 2011.

Commencing this year Alumni News will be published in three issues – Autumn, Winter and Spring/Summer.

The School of Physics also produces Alumni Update – a monthly email newsletter that keeps our alumni and friends up to date on the School's latest activities and events. If you would like to receive Alumni Update too, email Alison Muir (alison.muir@sydney.edu.au) to make sure you are included on the e-mailing list.

As I write the School of Physics main building (A28) is currently undergoing refurbishment and updating to incorporate a long overdue disabled lift and other amenities. As well, offices are being moved so some research areas are more logically grouped together. I do know that when the noise and dust subsides the School will have the added benefit of this modernisation while still retaining its heritage features.

As you will be aware the Australian Institute for Nanoscience (AIN) will replace the School Annexe (A29). This building project will take around three years to fully complete but promises to become home to the leaders of groundbreaking Australian nanoscience. You can read an AIN update in this issue.

Sadly, the former University of Sydney Vice Chancellor, Professor Gavin Brown, died suddenly on Christmas Day 2010. A memorial was held in the Great Hall for Professor Brown on 18 February 2011 who made many changes and improvements to the University and the campus during his tenure. Professor Brown was a great supporter of the School of Physics and the Science Foundation for Physics. Our sincerest sympathy is passed onto his widow, Dianè Ranck, and to his family.

Physics also lost three important people from December 2010 to January 2011. Our sincerest sympathies to the families of Emeritus Professor John Bennett, Dr Graham Derrick and Dr Nicolae Nicorovici who were greatly esteemed by the School. They are fondly remembered in this issue. As well, during this time David Cockayne, Emeritus Professor University of Oxford & University of Sydney, died peacefully at his home. Professor Cockayne was known for his work in nanoscience and was a guest lecturer at the ISS2005 – Waves of the Future.

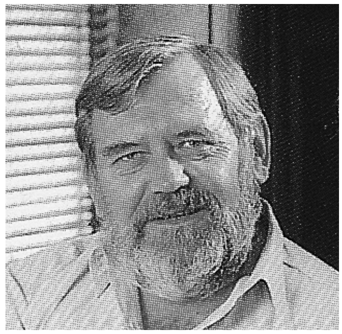
The 36th Professor Harry Messel International Science School (ISS) Light & Matter will take place from 3-16 July 2011. You can read more about the ISS2011 within this issue. We hope that both our Physics and ISS alumni will highlight this outstanding science education program to the Year 11 and 12 science students you might know. Applications for students to attend are available from the Science Foundation for Physics website: **sydney.edu.au/science/physics/foundation/**

I hope you enjoy this issue of Alumni News.

Clive Baldock
Head, School of Physics
Director, Science Foundation for Physics
The University of Sydney

NICOLAE NICOROVICI 1944-2010

BY PROFESSOR ROSS MCPHEDRAN



Dr Nicolae Alexandru Nicorovici was born in Bucharest Romania in the last year of World War II. He completed his education at the University of Bucharest with a PhD in Atomic Physics, dealing with the relation between interaction cross-sections and unitary symmetries. He then worked for the Romanian Atomic Energy Commission, specialising in computation and theoretical physics.

He came to Australia in 1991, having succeeded in obtaining a research associate at the University of Sydney, supported by the Australian Research Council (ARC). This involved him learning a new topic, the multipole method for the theoretical study of photonic crystals, which he took up with enthusiasm and soon became a master of all its technical details. The work went well, and he was the lead author on the first two Australian articles on photonic crystals (Phys. Rev. Lett. 75, 1507-1510, 1995; Phys. Rev. E, 52, 1135-1145,1995).

Simultaneously with this research into photonic crystals, he participated in research into what was termed the partial resonance effects associated with coated cylinders (Phys. Rev. B, 49, 8479-8482, 1994). These partial resonances could make a system of coated cylinders behave like a system of solid cylinders of much larger radius, as far as electrostatic measurements were concerned.

When Sir John Pendry published his first papers on cloaking of objects from electromagnetic radiation, Nicolae and Professor Graeme Milton of the University of Utah were quick to realise that there was a strong connection of this work with partial resonance phenomena (Proc. Roy. Soc. A 462, 3027-3059, 2006). Nicolae was very enthusiastic about the study of cloaking effects and other topics connected with the emerging field of metamaterials, and became well known internationally in this new field. Nicolae delighted in the mathematical details of the research he carried out into photonic crystals, composite materials, cloaking, metamaterials and other topics. In 2000, he was part of a team, which investigated the photonic crystal that occurred naturally in an ooze-dwelling creature called the sea mouse, Aphrodita aculeata (Nature, 409, 36-37, 2001). The work on this was written up in a paper that attracted wide international media coverage.

I was looking at Nicolae's Curriculum Vitae a year or two later, and noticed the paper was missing from his list of publications. I asked him where it was, and he replied that it was listed under "Other Communications". I remonstrated that it was a Nature paper, which normally was a highpoint in a scientific career. He replied: "But Ross, it has no equations."

In honour of this event, we introduced a new unit in our group for papers; the Nicolae. A paper was 1 Nicolae if it had 100 equations: if there were fewer than that, it was hardly to be taken seriously!

Nicolae was known internationally for the quality and thoroughness of his scientific research. He was an indispensable element of the groups at the University of Sydney and the University of Technology Sydney, where he was referred to as the "Romanian Oracle". He was a friendly and committed scientist and a warm and life-loving man, whose passing will be deeply regretted by many, including his partner Stephanie Peschek and step-son Florian Remus.

Vale Nicolae Nicorovici.

DR GRAHAM DERRICK 1934-2010

BY PROFESSOR ROSS MCPHEDRAN

Graham Derrick did his undergraduate degree at the University of Queensland, and moved from there to the University of Sydney in 1955 to do his MSc. (Qualifying) course, the equivalent of an Honours degree. (At that time, graduates not from the University of Sydney could not do Honours there.) It is recorded that Graham topped the class that year, and would have been given the University Medal if he had been a Sydney undergraduate. He then went on to do a PhD under the supervision of Professor John Blatt, the topic being "The Ground State of H3". One of the examiners, the famous Professor Herman Feshbach of MIT judged the thesis to be "a definitive work of great merit and importance".

Graham then went on to study for a year at the Institute for Advanced Study,

Princeton University, before spending a year at the University of Manitoba as an Assistant Professor in Mathematical Physics. Graham returned to Australia in 1961 to take up a lectureship in the Applied Mathematics Department at the University of New South Wales. Graham was there until 1965, during which time he married his wife Diana. They raised four children (James, Sarah, Linda and Chris.)

From 1965 to 1972, Graham was at the University of St. Andrews, first as Lecturer, then Reader in Theoretical Physics. He was able to take a year's study leave at the Australian Atomic Energy Commission, Lucas Heights (1970-1971), before becoming Principal Lecturer in Theoretical Physics at the NSW Institute of Technology (now UTS). In 1974, Graham joined the University of Sydney, where he was promoted to Reader in 1976. He took early retirement from the University in July 1990.

Graham was a physicist with a deep and wide knowledge of his subject, who was able to contribute to the advancement of a wide range of fields: field theory, general relativity, elementary particles, statistical mechanics, nuclear physics and solid state physics. One of the things for which he is best known is the Derrick-Hobart Theorem (J. Math. Phys., 5, 1252-1254, 1964), which proves the instability of solutions of a wide class of nonlinear field equations. (This was discovered independently and simultaneously by Dr. R. Hobart.)

Graham was interested both in the most fundamental questions of physics, like rendering the geometry of quantum mechanics compatible with the Minkowski light-cone of special relativity, and the most practical of applications, like the design of the optical security device for the 1988 Bicentennial bank note. (This featured a diffraction grating-based optically variable device, and did not last very long in circulation after it was announced that the OVD was practically indestructible, but even if it was destroyed the note remained legal tender.) Graham attended in succession in 1985 a Symposium on the Foundations of Modern Physics in Joensu Finland, and the International Solar Energy Congress in Montreal Canada.

I doubt there was any other individual attending both these conferences!

Dr Graham Derrick in his late 20's. (Image courtesy of Dr. James Derrick.)

Graham's work on solar energy commenced when he moved to the University of Sydney. He worked with Dr. Ian Bassett on the very new area of non-imaging optics, as Ian comments: Graham welcomed me when I was a shaky newcomer in the theoretical physics department. Later we collaborated on some work in "non-imaging optics" much of which eventually found its way into an article (whose authors included Walter Welford and Roland Winston) in Emil Wolf's Progress in Optics.

Graham also worked with me on the design of textured surfaces to diminish reflection losses for solar absorbers. The textures had to work well independent of polarization, which meant they had to be doubly periodic rather than singly periodic. This launched us into uncharted waters, so we profited from the opportunity that Graham had to take a sabbatical leave in Marseille, joining up with Daniel Maystre, Patrick Vincent and Michel Neviere to attack a problem which clearly was going to strain the computers of the late 70s.

Graham had the brilliant idea to use a coordinate change in the style of general relativity to flatten the surface by "curving the space" above it. This idea is now at the heart of an emerging field called transformation optics. In an amazing coincidence, when we arrived in Marseille, we found Daniel had a PhD student, Jean Chandezon, who had had precisely the same idea.

Jean developed his form of the transformation method with Daniel for singly periodic gratings. Graham, Daniel, Michel and I developed the method for crossed gratings, with certain differences caused by the need to fit our larger calculations on computers available at the time. The result was a series of papers which were probably twenty years ahead of their time: similar calculations are being carried out today, mainly advanced photovoltaic cells rather than for the photothermal systems we studied.

Graham and his family impressed the researchers in Marseille with their ability to surmount the many difficulties in transplanting a group of six people (two with significant health problems) from an English speaking country to a far-away part of France. I will end this obituary by quoting Daniel Maystre (with Michel Neviere having expressed very similar sentiments), "Above all, I remember the long stay of Graham and his family in Marseille. They gave us a lesson of courage and showed us that human life is stronger than difficulties. If only for this reason, I will never forget."

VALE

EMERITUS PROFESSOR JOHN BENNETT AO 1921-2010

BY ALISON MUIR

John Bennett came to the School of Physics from London in February 1956. He had barely set foot in the School when he found out he had a looming deadline of the University's Open Day being held in March that year, in which SILLIAC was to be displayed to the world.

It was then announced SILLIAC would be fully operational by 4 July and officially launched on 12 September 1956. With a PhD in Computer Science from Cambridge University and degrees in mechanical and electrical engineering from the University of Queensland - along with four years of WWII radar experience - he rose to the challenge.

Barry de Ferranti worked with John on SILLIAC and recalled the time Professor Messel asked whether or not he had heard of Dr Bennett.

"Harry Messel came to me one day late 1955 (I was probably up a ladder testing the Williams tube store on SILLIAC) and said: "Do you know a fellow called John Bennett? He's applied for the senior analyst job and says he worked at Ferranti Limited".

Did I! John had given the final session of a course I was on at Imperial College London, supported by a young enthusiast, Dr Chris Wilson, just a few months earlier, when I was preparing to return to the engineering job Harry had offered. His lecture was to paint a picture of the future of computers in commerce and industry, as seen by him and Ferranti.

I had discovered then he was an 'Oz', had been one of the 'Bailey Boys' (taught by that remarkable University of Sydney Physics lecturer, V.A.Bailey, for Radar at the end of WWII), and had great vision of where computers could lead. What is more, his wife, the talented Mary, had been economist advising a senior director of the company.

I was delighted when they arrived and the rest as they say is history. Years later when I had left IBM Australia to set up Ferranti Computers in Melbourne, I was in London, when a young hopeful, one Peter Jones, came in looking for a job. When he saw me there, he exclaimed: "John Bennett gave me a list of possible employers in London, so I came to Ferranti."

In no time at all I had him meet the management, including Chris Wilson, and he was soon one of the team. John's network in UK was indeed formidable and we all knew he had made a great name for himself everywhere. It was only later that John told me that originally, before SILLIAC, he was considering joining IBM!

We must all have fond memories of John and many tales (some unpublishable) to tell of his exploits. I join those who knew John not only in mourning his passing but also in enjoying those memories."

John's first course taught at the School of Physics was the Industrial Use of Electronic Computers and was an outstanding success.

His broad view of research recommended that the Adolph Basser Research Laboratory (eventually evolving into the University's School of Information Technology) should 'extend beyond the mere provision of a tool for nuclear research,' adding, 'In fact we consider that we have a prime duty to help members of the community who are likely to be affected by these new techniques.'

John Bennett went on to build KDF9, the next computer in Physics after SILLIAC, and enjoy a long and illustrious career in Physics and computer and information engineering.

John Bennett died peacefully on Thursday 9 December 2010. He was well respected and much loved by those who knew him.

GODLEY'S IN THE DETAIL CONTINUED

The technique relies on computer automatically outlining the organs near the tumor, rather than facing the long wait to get a physician to eyeball the image. "Kidneys are easy." says Dr Godley, "Intestines or lymph nodes are really hard, but I think it can be done. This area of research is changing rapidly", he says.

Dr Godley is also trying more precisely to irradiate tumors in the lungs, which of course move as you breathe, making it difficult to not damage healthy tissue around the tumor.

This kind of direct outcome from his work is what prompted Dr Godley to make the switch from high-energy physics, after completing post-doctoral studies in South Carolina in the US. "I wanted my work to have a more immediate effect on the community; day-to-day I'm working with patients, and my research will help the community in the near future."

There are other benefits too: "I'm not just hanging out with physicists any more!" he laughs. "But the physics is not as precise - it's infected with biology."

To make the switch he re-trained in the Medical College of Wisconsin, but found a PhD in physics ample preparation for the course. "I was in with the radiation therapists, and I felt a bit bad when I got 100% on the first anatomy test. I thought, 'I'd better tone down the studying'."

Originally from Perth, Dr Godley has found the move to the US a great experience. "I feel I've done more than my friends who stayed on at UWA. You meet people face to face at national meetings and make great contacts for future collaborations."

And was it hard to get a job in the US? "Australian PhD students are perfectly trained to do a postbox in the US," he says. "They kept asking me, 'Are there any more Aussies coming?'".

A DAY IN THE 人生 (LIFE)

BY JOHN KIPRITIDIS, PHD GRADUATE, APPLIED & PLASMA PHYSICS (2006-2009)

Looking at one of the gridded spherical cathodes used for IEC.

On the surface, my postdoc position at Kyoto University, Japan was aimed at the study of small-scale nuclear fusion plasmas. But with Kyoto being the origin for so much Japanese tradition, it became also the study of wonderful contrasts and similarities.

By June of 2010, I had been in Japan for 12 months. Each morning the sun would creep over the ancient Uji river and onto the walls of my sonically-transparent flat, a short walk from the Institute of Advanced Energy and about 10 km from the city center. From here the 1.5 million strong city of Kyoto seemed to whir like a thoughtfully crafted timepiece encrusted by steep, forest-lined hills. Distinct, but not altogether different to the sprawling bustle of Sydney, where I had completed my PhD in research in the School of Physics, University of Sydney.

In summer, a day in the lab would begin early so as to outpace the arc of the hot sun. There was some humour in this; the goal of fusion research is to produce nuclear reactions similar to those occurring in the sun itself, releasing energy and other radiation products like protons and neutrons.

The mainstream method of achieving controlled fusion on Earth is to use magnetic fields to confine ions of a deuterium plasma (essentially an ionized, electrically conductive gas). Its appeal is in the potential for being the ultimate, environmentally-sustainable means of producing electric power; its challenge is in producing ion densities large enough to do so. Walking past family-run electronics shops, talking vending machines and air-conditioned convenience stores, I had no doubt that magnetic plasma confinement would one day be of practical use to such a technologically orientated nation, which already employs over 50 nuclear fission reactors to contribute to its ubiquitous electric hum.

Waiting at lowered railway boom-gates amidst rushing motorscooters, salarymen and schoolchildren, I watched as commuter trains sped past each other and thought to my research here. In fact my work at both Sydney and Kyoto had focused on a lesser-known fusion method called Inertial Electrostatic Confinement (IEC). This aims to accelerate and collide positively-charged plasma ion beams between concentric, spherical gridded electrodes, with the central one placed at a large negative voltage (around -100 kilovolts), at low gas pressure (1 Pascal or about 10 millionths of an atmosphere).

Being able to speak and read only a little conversational Japanese, I could begin to see how ideas can sometimes go relatively unsaid. The appeal of IEC is its simplicity and portability; its electrodes are typically less than 30 centimeters in radius making the concept well suited to security imaging and medical isotope production. Yet in the language of energy production (that all-important ratio, energy-out to energy-in) IEC cannot yet really compete.

In Kyoto the IEC program is nevertheless very well funded, and in a way it was fitting to study it in a place where Gucci and neon coexist alongside kimono and temples. The technology had improved, with high voltage power supplies and turbo vacuum pumps becoming more automated and compact, but some elements of experimental method - counting neutrons using gas-filled detectors - were mostly unchanged since the original 1960s experiments of Robert Hirsch and Philo Farnsworth (the latter also being the inventor of television).

Image of the IEC chamber exterior

Having worked with A/Professor Joe Khachan at The University of Sydney I had come to appreciate the innovative technique of Doppler spectroscopy (analyzing the spectral line-shapes of emitted light) in understanding dynamics of the plasma. A different language one might say, but with the same meaning; the Sydney IEC group has contributed greatly to the understanding that the gas itself tends to neutralize energetic ions. This is considered an energy loss as it reduces the confinement of particles by the electric field. A crucial challenge for IEC devices is to maximize the beam density while minimizing the gas pressure.

In Japan, Professors Masuda and Nagasaki had overseen the development of a new type of IEC device which adds a ring-shaped array of small cylindrical magnets to produce the plasma at much lower gas pressures (about 5-10% of the usual). And so my job in Kyoto, ultimately, was to count neutrons and confirm whether this new device was an improvement.

The Uji campus itself was a strikingly quiet place of conscientious energy management and dutiful sorting of recyclables, a pleasant town of beveled cement extrusions, distant radio towers and neat gardens. At the glass doors to my lab, were posted three of the few kanji I could actually read **高電圧** ("high-voltage!")

Inside the doors I felt the whoosh of industrial-strength air-conditioning, removed my Fuji-worn hiking shoes and stepped into the comfortable lab slippers. It was a surreal thing, to glide past Geiger counters and massive concrete slabs, encasing below them experiments far more radioactive than mine. Arriving finally at my lab, I would notice reflections of rice fields bouncing off the cylindrical outline of a metre-tall stainless steel vacuum chamber, and felt as if I had stumbled upon yet another world.

As any researcher knows, so much of what one finds in research is a surprise. The IEC device designed by Masuda sensei does indeed improve the efficiency of neutron production (up to a factor of ten under certain conditions). Yet at these low pressures, computer simulations suggest significant ion beam losses to the cathode grid itself - opening up entirely new challenges and opportunities for design.

Returning the lab keys to the office I shared with the students of Nagasaki lab, I would be continually impressed how the members of this group were so adept at English. Working in Japan was an unforgettable experience - and thinking back on it, perhaps the most surprising part of the research was in making so many friends. Teachers of customs and cooking, language and life (**生命**).

Experiencing the traditional Gion summer festival with student members of the Nagasaki lab.

AIN PROGRESS

BY DR CHRIS WALSH

School Annexe building (A29)

Our alumni and friends would be aware from previous issues of *Alumni News* that the University was awarded $40M towards the construction of a new building for research in the physical sciences, focussing on nanoscience, in the third round of the Education Infrastructure Fund. In essence, the funds will support a major expansion in the teaching and research capabilities of the School of Physics. With funds from the University that more than match the EIF grant now approved, the new building will replace the 1960s-era School Annexe building (A29) and be integrated with the existing heritage building on Physics Road to create a nationally-leading facility for teaching and research in physics.

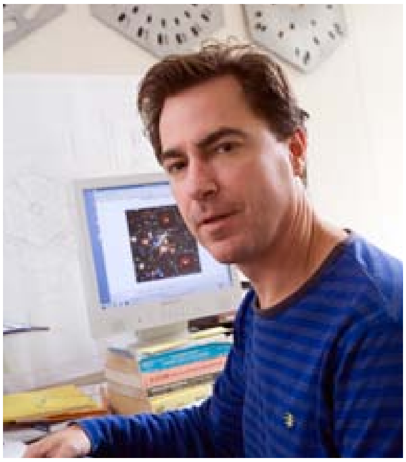
What facilities and capabilities will this new building provide, and how will it benefit the School? The School of Physics has been successful in attracting a stream of international research leaders over the past decade as Federation, Laureate and Future Fellows. Since 2003 we have hosted the headquarters of one of the ARC Centres of Excellence and from 2011 onwards the School will be the headquarters for two Centres and host major nodes of another three. At the same time as these spectacular achievements in research were leading to an explosion in numbers of research-only academic staff, the numbers of undergraduate and postgraduate research and coursework students were also increasing. The School faced the prospect of being a victim of its own success by being unable to provide the infrastructure to support its greatly expanded teaching and research programs. Furthermore, despite renovations in recent years, the existing research facilities were inadequate for the leading-edge research challenges that our high profile researchers were keen to address.

Our new building will solve these problems. Operating under the banner of the Australian Institute of Nanoscience, it will be purpose-built to provide laboratories in which advanced structures and devices with nanoscale features can be made using optical lithography. Other laboratories will provide tightly controlled environments in which experiments of exquisite precision can be conducted using these devices.

The building will be designed with state of the art teaching facilities at both undergraduate and graduate level. These will include a lecture theatre designed to enhance student collaboration and other teaching spaces that enable a mix of lecture, tutorial, and laboratory experiences. The students' learning experience will also be enhanced by the close coupling to advanced laboratories for teaching and research.

Research across a broad spectrum of the School's activities will benefit. As examples, the photonics program (including CUDOS, the ARC Centre of Excellence) will have access to tools to fabricate metamaterials and other advanced optical materials while our quantum information scientists will both fabricate and test electronic transistors and other electron-based systems where the dimensions are so small that the quantised nature of the electron spin can be measured and controlled. Our instrumental scientists in astronomy, high energy and space science will have access to advanced assembly and test facilities while programs in advanced biomedical science (biomaterials, imaging and drug delivery) will receive a major boost.

The Australian Institute of Nanoscience will also provide a facility of national importance to researchers across the country. This facility will be based largely on the research infrastructure operated by the Bandwidth Foundry, a University-owned company that provides nanofabrication services to Australian research together with the $3M optical lithography stepper to be purchased with funds provided by the Australian National Fabrication Facility. The combined physics buildings will provide facilities to attract and retain students in all phases of their physics career. The integration of a national access facility with the leading teaching and research program in Australian physics will cement the School's position as an international leader in the physical sciences.



FOUR FUTURE FELLOWS IN SYDNEY PHYSICS

THE ANNOUNCEMENT OF FOUR FUTURE FELLOWS TO BE BASED IN THE SCHOOL OF PHYSICS HAS ADDED TO WHAT HAS BEEN ALREADY A HIGHLY SUCCESSFUL 2010 FOR THE SCHOOL.

Three Future Fellows, A/Professor Peter Tuthill, Professor Geraint Lewis and Dr Scott Croom, are astronomers based in the School's Sydney Institute for Astronomy (SIfA). The fourth Fellow is Professor Kostya Ostrikov, based at CSIRO, for his research into nanoscale control of energy and matter for future energy-efficient technologies.

Professor Tuthill, who is the Director of SIfA, said it was an encouraging sign that so many astronomers based at the University of Sydney were acknowledged for their high-level research especially as the three Fellows now make a total of six Future Fellows in Astronomy alone.

"As Director of the Sydney Institute for Astronomy (SIfA), I am really delighted with this result. Three successful fellowships here from a total of only nine astronomy fellows nationwide is an outstanding result. Coming on the heels of our recent success with the CAASTRO Centre of Excellence (led from here by Laureate Fellow Professor Bryan Gaensler), SIfA is certainly one of the most exciting places to be in the astronomy community worldwide."

Future Fellowships promote research in areas of critical national importance by giving outstanding researchers incentives to conduct their research in Australia, the aim being to attract and retain the best and brightest mid-career researchers and to significantly boost Australia's research and innovation capacity in areas of national importance.

A WARM CHILE RECEPTION

Dr Richard Lane had been in the workforce for seven years when he decided to pursue a degree in Astronomy and Astrophysics at Macquarie University. He then completed a PhD in Astrophysics in the School of Physics. Richard now has a postdoctoral research position at the astronomy department at the University of Concepción, Chile. *Alumni News* contacted Richard to see how his life in astronomy is going in Chile.

Alumni News: So you're still in the Southern Hemisphere but there must be some significant differences between, Chile and Sydney, Australia can you tell us your first impressions? How's your Spanish these days?

Richard Lane: My first impressions of Concepción itself were that there was still some damage visible from the earthquake last February (magnitude 8.8). The Chemistry building here at the University, for example, suffered major damage from a series of large explosions during the earthquake and it is still a burned out shell. But also that it is a lovely little city.

It is a smaller city than I am used to (the population is about 300 000 in Concepción itself with the larger metro area being about 1.3 million), but the smallness is really nice in a lot of respects. Another thing that is quite different is the public transport. Although I live five minutes walk from the University there is often a need to go further afield using buses, taxis and colectivos. Colectivos are basically communal taxis with set routes (amazingly handy as long as you don't mind being in a car with three strangers for a while), and the bus drivers are insane!

My Spanish is slowly getting better. My partner and I are having a couple of lessons a week, which obviously helps a lot, but it is still slow going. Everyone speaks English at work but outside the department very few people speak any English at all, so it can be interesting trying to have a couch delivered from a department store, for example.

AN: Your past research has examined dark matter, globular clusters and remnant cores. What are you hoping to explore next? Why?

RL: My new boss (Tom Richtler) has been investigating dark matter in large elliptical galaxies for several years, so I am now involved in that too. If dark matter exists, large ellipticals are one place where there should be lots of it – because dark matter is thought to be solely gravitationally interacting, it stands to reason that where there is lots of visible matter there should also be lots of dark matter. This seems not to be the case in several ellipticals, which is strange, and one line of reasoning goes that we, therefore, do not understand gravity correctly. Very interesting research.

I am still involved with the remnant cores of dwarf galaxies and their associated tidal streams (material stripped from the dwarfs through interactions with their host galaxy). I am in the process of trying to identify the remnant core of a dwarf associated with a particular tidal stream at the moment.

With other collaborators in Germany I am also looking into the formation mechanisms of Cartwheel-type galaxies, galaxies which seem to form through very specific interactions between a large spiral and another, smaller, galaxy.

What do I hope to explore next? Whatever interesting thing comes my way! That's how research often works; reading the scientific literature may provide surprise results which are worth following up, sometimes observations of a specific object turn up something unexpected in the background, it can go anywhere, and often does.

AN: What do you hope will be the impact of your findings?

RL: I think this would be the same for most people involved in scientific research. I hope that my work will lead to a new understanding of the Universe in some small way. Whether that be how Cartwheel galaxies form, how gravity behaves, or something else entirely.

AN: You used to be a guide at the Sydney Observatory, and the School of Physics does astronomy outreach for secondary school students and the general public. Is this kind of outreach also done at the University of Concepción?

RL: I am definitely not involved in any outreach, and until my Spanish improves immensely I will not be able to be! Outreach is definitely done here though; quoting from our Astronomy Department's website, which explains it better than I could:

"The Department of Astronomy at the University of Concepción conducts numerous continuous educational initiatives and popularization of science. This includes offering a series of activities aimed at teachers and students from various educational establishments in the Region of Biobío. Among these activities, emphasis is placed on training workshops for teachers, Astronomy exhibitions, mounted next to our portable planetarium (that is available on request to educational establishments); and public visits to the Department Observatory, located on the Campus of the University of Concepción."

AN: Finally any words of advice for potential mature age students who might be thinking about trading in the 9 to 5 routine?

RL: Do it. You won't regret it.

AN EXPLOSION OF LIGHT & MATTER — ISS2011

WHAT HAPPENS WHEN YOU BRING TOGETHER 150 OF THE WORLD'S TOP YOUNG SCIENTISTS, A DOZEN LEADING RESEARCHERS ACROSS A WIDE RANGE OF FIELDS, AND A VERY EXCITABLE BUNCH OF VOLUNTEER STAFF, FOR TWO PACKED WEEKS AT THE UNIVERSITY OF SYDNEY?

You get an explosion of light and matter — ISS2011: Light & Matter, to be precise.

This July the School of Physics is hosting the 36th Professor Harry Messel International Science School for high-school students. Talented young minds from across Australia will meet peers from China, Japan, Malaysia, Singapore, New Zealand, Thailand, the UK and the USA for a fortnight of science talks, experiments, activities and excitement.

The main feature of the ISS is always the series of talks by leading scientists, and, this year, the students will meet Sir John Pendry of Imperial College, London, renowned for his work on invisibility cloaks. This isn't some mere Harry Potter-esque magic show - Sir Pendry works with metamaterials, so carefully engineered that they have bizarre properties — including invisibility!

Then students will get a glimpse of the very earliest moments of the universe after the big bang with Prof. Allan Clark from the University of Geneva. Prof. Clark works on the ATLAS detector Large Hadron Collider in Switzerland, the world's largest particle accelerator, where particles collide at energies higher than we have ever seen on earth to explore the very smallest scales of matter.

Dr Christine Charles, head of Australian National University's Plasma Research Laboratory, will introduce the students to the most abundant form of material in the universe, the stuff of stars and the beautiful northern and southern lights: plasmas. She will show the vast range of plasma applications, from fluoro lights to microchips, hydrogen fuel cells and even plasma space engines.

The talk series will also feature home grown researchers from the University of Sydney. Prof. Ben Eggleton will talk about his team at the Centre for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS), who are creating fibre optics and light-based computers for the future of communications and IT. Geoscientist Dr Jo Whittaker will show how her work on plate tectonics can reconstruct the shape of our world in the distant past. And in this, the International Year of Chemistry, Dr Deanna D'Alessandro will speak on doing her bit for the planet through research into 3D chemical structures that capture greenhouse gasses.

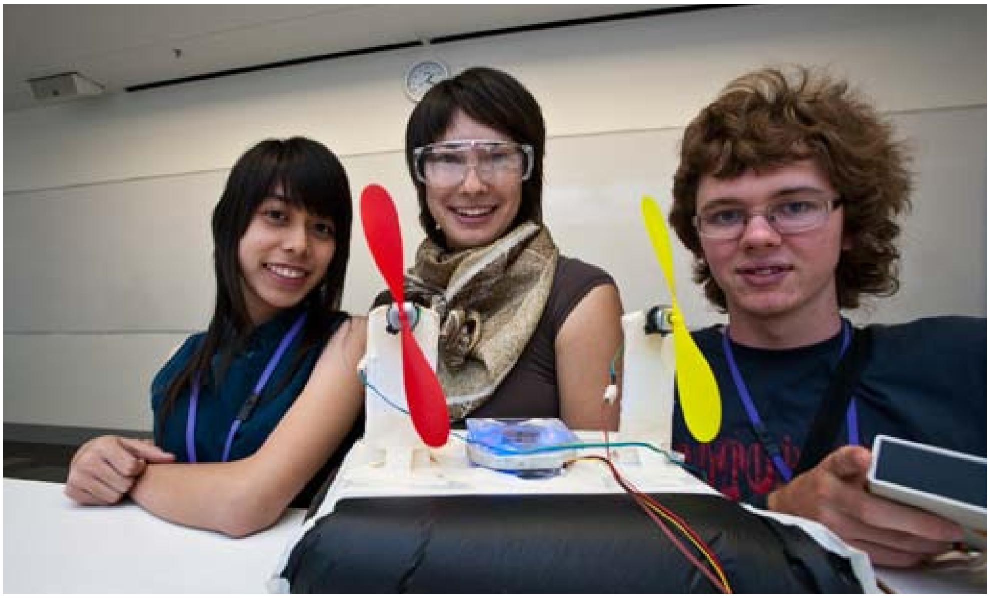
This is just a sample of the amazing research and inspiring scientists our ISS students will encounter at ISS2011. When they're not absorbing science in the lecture theatre, the students will be running around campus with GPS units on a Geosciences treasure hunt, or taking eye-popping images with the Electron Microscope Unit, or designing airships, breaking codes and modelling power grids with the Science and Engineering Challenge.

And when they are done with science for the day, each evening they can take part in a wide range of social activities, from movie and games nights to the famous ISS Sydney Harbour Cruise.

Applications for the International Science School are open from February and close Friday 1 April 2011 — the application form and information kit are available from **sydney.edu.au/science/physics/foundation/iss/iss.shtml**

Please note that our overseas ISS students are selected through application processes in their country of origin, and do not use the same application form as Australian students.

For more information contact
Dr Chris Stewart, +61 2 9351 3722 or
email: christopher.stewart@sydney.edu.au or visit
sydney.edu.au/science/physics/foundation



ISS2009

Rebekah Raymond, a young Indigenous Northern Territory student and an ISS2009 alumna is now attending the University of Sydney. In 2010, Rebekah graduated from Taminmin College, a rural school 40km out of Darwin. With an ATAR of 80.95 and an A for her Modern History class, Rebekah is now relocating from Darwin to Sydney to study a combined degree of Bachelor of Science and Bachelor of Arts.

Studying at the University of Sydney is a dream for Rebekah, who hoped to attend the University after staying on-campus in 2009 for Harry Messel's International Science School. "After going to the University of Sydney in 2009 as part of ISS, I was inspired to return when I graduated Year 12. Throughout Year 12 it was my motivating force to get to Sydney, and I am so excited that my perseverance paid off and I am now studying at the University." Rebekah begins her first year of study this year.

A DECADE ON

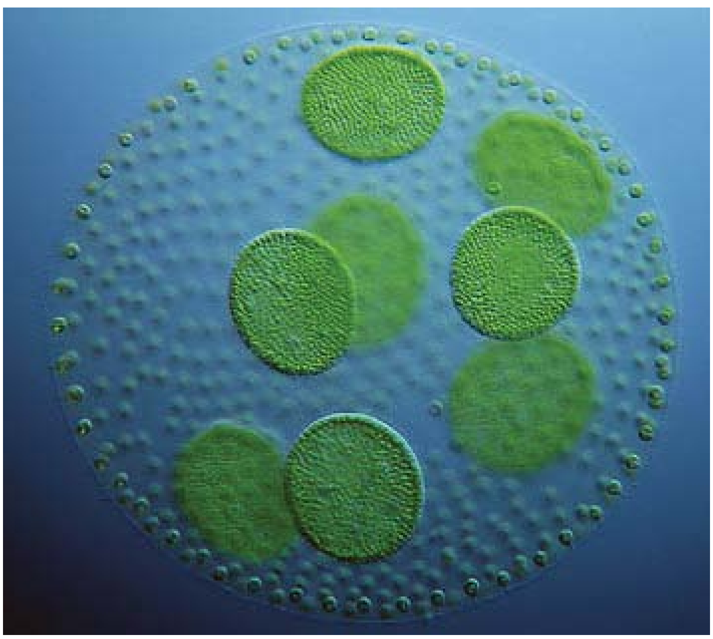
FROM 'WATER BABY' TO A 'LANDLUBBER' ENVIRONMENT SCIENTIST, MELANIE KEETCH (ISS2001), TELLS *ALUMNI NEWS* WHAT'S BEEN HAPPENING IN HER LIFE OVER THE PAST TEN YEARS

It was July 2001 alone and feeling a little apprehensive at being a last minute inclusion into the Professor Harry Messel International Science School (ISS) for 2001, I was greeted by the grandeur of the University of Sydney. I had made it to ISS2001! My apprehension and uncertainty disappeared and I felt right at home. I spent the next fortnight attending lectures, testing out my practical capabilities in the labs, and sightseeing Sydney and making friends. And of course, had a ball doing it!

The ISS2001 gave me a newfound respect for physics, but I knew a biologist at heart and no amount of lectures with a spritely, comically attired Dr. Karl would change my direction. I fell in love with biological science and Mother Nature in my early teens as I sat with my grandfather watching a documentary about African animals. I knew there and then, as I watched the wilderbeest and impala gallop across the screen, I was to spend my life working on animals and the environment, African, if I had a preference. Big cats were a particular favourite.

I wanted to educate people about the planet they call home. I embarked on becoming a Zoologist and my love for the African continent never waned. But I discovered the wider world of biological sciences and was intrigued with freshwater science. I attribute my fondness for aquatic science to my Year 12 Chemistry teacher, Mrs. Spizzo, who introduced us to the notion of eutrophication. I became fascinated with nutrients and water quality. Perhaps I foresaw the dire circumstances Australia would face in years to come with endless drought and water restrictions. I've always had an affinity to water and it felt right that I'd pursue aquatic science as a career path. For the moment, my African dream was on hold.

Following Year 12 I enrolled in a Bachelor of Science at the University of Adelaide. In 2005 I majored in Environmental Biology and Zoology. I tackled with the prospect of going on to do Honours. I wasn't sure if I was made for it to be honest. But with some encouragement from



Green algae

my older brother (he must've had a hidden agenda), I enrolled to undertake an Honours degree with Assoc. Professor Sean Connell. I entered head first into the world of Marine Biology. My Honours project centred around benchmarking a method used by marine scientists to simulate nutrient enrichment in marine environments, as well as the comparison of eastern Australian coastal environments with southern Australian coastal environments.

After completing my Honours degree, I began the arduous task of gaining employment in my field of study – certainly no easy feat in small town Adelaide. Apparently, Environmental Biologists, particularly newly graduated ones, aren't a highly sort after commodity. In late 2006 I managed to secure part-time work at the Aquatic division of the South Australian Research and Development Institute (SARDI). It was a foot in the door but in mid 2007 the lab work at SARDI dries up.

Then I landed a more long-term, full-time work at the Australian Water Quality Centre (AWQC). I joined the Algal Operations team within the Biology Unit. For the following two years I learnt all there is about algae. Cyanobacteria, diatoms, green algae. You name it - I knew it! I enjoyed the job, which gave me with a great opportunity to gain a new skill set but alas emunerating algae was not my passion and I wanted to seek new opportunities, and explore other areas of environmental science.

After a period of being between jobs a South Australian engineering firm, FMG Engineering, offered me a job as an Environmental Scientist. Private industry was certainly a different world to the public sector. I adapted and made the most of the opportunity the kind folk at FMG Engineering had given to an aquatic scientist. Sixteen months later I haven't regretted my decision to expand my horizons and challenge myself.

I have gained an enormous amount from my time at the firm and still find myself learning each day I go to work. I am growing fond of hydrogeology and hope to expand my knowledge in this area (there's that affinity to water!). I have the luxury of combining an office job with fieldwork, so I don't always feel confined by the four walls.

The division is constantly evolving and looking to expand its repertoire. It's a hard business and the competitive nature can sometimes get you down. You have to develop a thick skin to survive. But despite the challenges, I feel I'm still making a difference - I am correcting the wrongs of the past and educating those willing to listen.

So, while it's not the Serengeti I'm fortunate enough to have a job that makes a difference. My role highlights the fact that it's not just the wider environment we should be concerned for but the environment we deal with everyday. Eventually I will make it the African continent. Whatever pans out for me, I will always dream the African dream.

A SPACE DETECTIVE AGENCY AT THE SCHOOL OF PHYSICS?

WHAT WOULD HAPPEN IF A BILLION DOLLAR SATELLITE TRAVELLING AT TEN KILOMETRES PER SECOND COLLIDED WITH A TOOTHBRUSH?

BY DR PHIL DOOLEY

If Professor Anne Green has her way, we'll never know. Her plans to set up a space debris tracking system using the School of Physics' Molonglo Observatory Synthesis Telescope (MOST), 30 km south east of Canberra, address this bizarre-sounding, yet very real danger.

"In low-earth orbit there are tens of thousands of pieces of debris larger than 10 cm in size, and hundreds of thousands between 1 cm and 10 cm. And these things are really moving" she says. Lost equipment, such as tools or cameras, garbage bags from space missions, jettisoned rocket stages or dead satellites are just a few of the items making up the mess. At such high speed, these items could cause billions of dollars worth of damage to the over 6000 satellites humankind has launched.

In February 2009 the worst collision of this kind occurred when an Iridium Communications satellite collided with a defunct Russian communications satellite at about 11 km per second (about 40,000km per hour), destroying both craft. The collision also created clouds of debris, which are now a danger to other craft – there are predictions of a cascade effect known as the Kessler Syndrome, where new collisions will create more debris, increasing the likelihood of further collisions and so on, until low-earth orbits are rendered unusable.

Already NASA is tracking around 19,000 pieces of debris, but the MOST telescope could provide additional vital data for the southern hemisphere. The inspiration for Professor Green's plan came from a visit to the Medicina Observatory near Bologna in Italy, which is a similar facility to the Molonglo Observatory. "They detect a radar signal sent by a radiotelescope in the Ukraine, using a technique called bistatic radar."

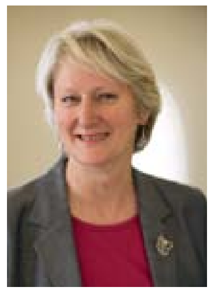
Professor Green realised that a possible partner telescope for MOST could be DSS46, a 26 m dish at the Tidbinbilla tracking station, 30 km away to the southwest of Canberra.

"DSS46 was the dish at Honeysuckle Creek that received the first signals from the 1969 Man on the Moon mission, before Parkes came into view" says Professor Green. "It was moved to Tidbinbilla, and is currently no longer being used. Because of its heritage significance this excellent dish should be preserved and we have a proposal that would give it a new lease on life. However, there is still much to be done to secure permission to use this dish. If it is not possible, an alternative telescope must be found."

The plan would be to transmit a narrow, low frequency signal skywards, and use the MOST to detect the radio waves scattered back from the debris as it passes over. Although the transmitter would be quite powerful – possibly up to 10 kW – the returning signal, from a piece of debris the size of a toothbrush 700 km overhead, is, not surprisingly, very faint: Professor Green calculates MOST will be chasing signals of about 10-17 W: over a billion billion times fainter.

However MOST is up to the task. The paraboloid (trough-shaped) dish is the largest telescope in the southern hemisphere, at 12 m wide by a mile long (made up of two 778m arms), and Professor Green estimates it will just be able to see the returning radar signals.

The goal is to get several radar blips on a piece of debris and to use that to track the orbit.



That is just the start of the story, however. "We don't even know what the data are going to look like" says Professor Green. In addition to the complex electronics required to sort out signals coming from either end of a mile long telescope, picking out the extremely weak transient signal of a passing piece of space-junk will be a challenge.

"We plan to collaborate with scientists working at NASA's Jet Propulsion Labs in California on techniques for imaging transients and radar ranging." says Professor Green. "A new fibre link connecting Molonglo and its partner dish is also necessary and this presents another challenge".

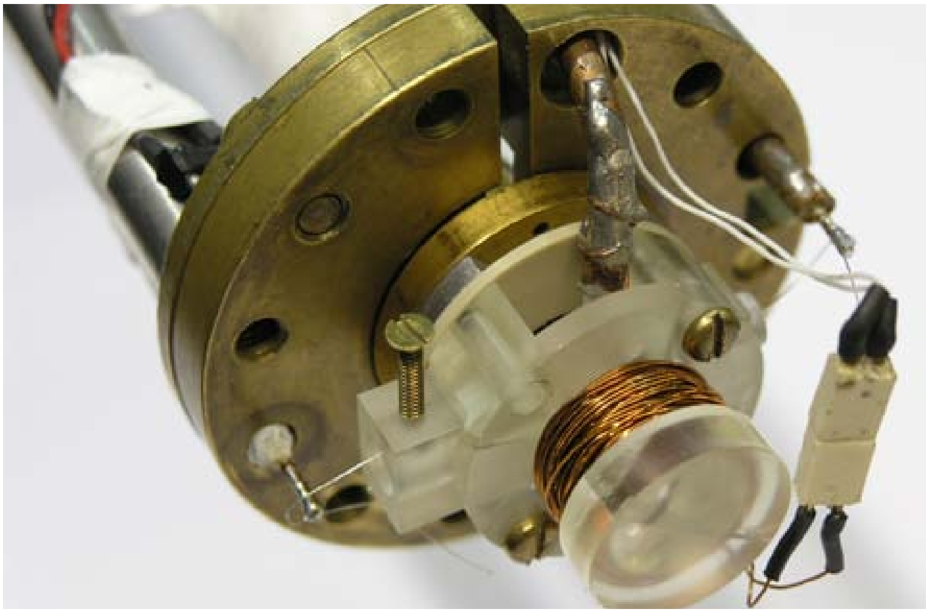
The funding for this may not be so hard to find, as NASA and the military in both Australia and the USA are interested in space debris tracking.

"The telecommunications companies, mining companies, and many other businesses have satellites now" says Professor Green. The Federal Government's Australian Space Research Program also sets a high priority on this kind of project. "Space is a frontier we should be strongly engaged with." she says.

Astronomical research may benefit too, as the linked telescopes could also be used as coupled receivers in a technique known as Very Long Baseline Interferometry, effectively creating a detector the size of the distance between the two telescopes, 30 km in the case of Tidbinbilla and Molonglo.

Professor Green's opinions of the challenges of creating a space detective agency at Molonglo? "It's all very challenging and speculative… but it would be fun to do!"

SPINNING INFORMATION FOR BETTER MEMORY



Dr Dane McCamey, a quantum physicist based in the School of Physics, and his international colleagues, have demonstrated that the spin of atomic nuclei in silicon can store information for over one hundred seconds and, importantly, that this information can then be read out electrically - a critical step in linking the emerging field of spintronics with classical electronics.

Whilst others have shown that spin information can be processed in silicon, until now no effective way to store that information had been found.

One limiting factor with current computers is the heat produced when moving electrons around. The heat limits the speeds at which computers can operate so using a system that needs less energy means information can be processed faster.

“Storing information in spins satisfies this requirement as it takes less energy to flip a spin over than to move an electron around,” explains McCamey, who is the lead author of a paper* to be published by Science on 17 December.

“Finding a system compatible with silicon, the main material used in the semiconductor industry is particularly useful as it has the potential to be incorporated into existing technology. We could then integrate spin based information storage and processing devices onto a single chip.” These are the first experiments to controllably flip the state of nuclear spins in silicon between a “0” and a “1” and then read out the effect this has on an electric current.

These experiments were only made possible by using unique equipment for controlling electronic and nuclear spins in high magnetic fields and at very low temperatures at the National High Magnetic Field Laboratory (NHMFL) in Tallahassee, Florida.

Carrying out the research, which is soon to be published in the journal Science, was an international team of quantum physicists - Dane McCamey, Hans van Tol, Gavin Morley and Christoph Boehme.

The paper is: “Electronic Spin Storage in an Electrically Readable Nuclear Spin Memory with a Lifetime >100 Seconds” by Dane R. McCamey (Universities of Sydney and Utah), Hans van Tol (National High Magnetic Field Laboratory - NHMFL), Gavin W. Morley (London Centre for Nanotechnology and University College London) and Christoph Boehme (University of Utah).

This groundbreaking work was supported by the Australian Research Council, the UK Royal Commission for the Exhibition of 1851, the UK EPSRC COMPASSS grant, the US National Science Foundation and the National High Magnetic Field Laboratory (NHMFL). The NHMFL is funded by the State of Florida, the US Department of Energy, and the US National Science Foundation.

IN BRIEF

Frontiers of Science

Frontiers of Science was an innovative comic strip, which enjoyed worldwide success. It was syndicated in over 600 newspapers from 1961 until it ceased in 1982. Professor Stuart Butler from the School of Physics, journalist and film-maker Bob Raymond, and artists Andrea Bresciani and David Emersen, each played a part in popularising science through the engaging series. Frontiers of Science communicated scientific concepts, theories, processes, discoveries and developments to the public in an entertaining style. The exhibition runs from February 21 to April 21, 2011 in the SciTech Library, Jane Foss Russell Building, City Road, Darlington for more information visit: **frontiers.library.usyd.edu.au**

CUDOS ‘Mark II’ Launch

CUDOS, an ARC Centre of Excellence based within the School of Physics, aims to be an international leader in nonlinear photonics with a mission of demonstrating all-optical processing applications and devices for ultra-high bandwidth optical telecommunications systems. In 2010 CUDOS secured $23.8M in an ARC Research Grant to continue its pioneering work.

The ‘new’ CUDOS is a collaboration across seven Australian universities and has major international links with partner organisations around the world. Senator Kim Carr, Federal Minister for Science, will launch CUDOS into its second phase on Wednesday 6 April 2011 at the University of Sydney. For more information about the launch visit: **sydney.edu.au/science/physics/cudos**

Sydney Science Forum

In 2011 a series of free public talks will held over a diverse range of scientific topics including:

– March 16 - Life and Death in Antarctica, presented by Tim Jarvis

– April 20 - The Blue Future- the robotic exploration of the oceans, presented by Dr Tony Haymett, Director of SCRIPPS

– May 11 - Curious and Curiouser, presented by Dr Karl Kruszelnicki

Bookings are essential and can be made online or by calling (02) 9351 3021 between 10am and 3pm, Mon - Fri. **sydney.edu.au/science/outreach/forum/index.shtml**

LIGHTNING'S SECOND STRIKE UNLUCKY FOR SOME

DR KARL KRUSZELNICKI ,
JULIUS SUMNER MILLER FELLOW

After someone has had a near-death experience, or survived an unusual accident, well-wishers will often say, "Don't worry. After all, lightning never strikes twice in the same spot."

They are saying, with only best wishes and calming thoughts in mind, that if you have had one close call, well then, you are safe from getting a second one.

But, if that is what they are trying to say, then lightning is a bad example. In fact, if you look at how and where lightning strikes occur, you'll find the exact opposite is true.

The city of Darwin is the lightning capital of Australia and attracts many visiting lightning scientists. A recent summer thunderstorm in Darwin generated an amazing 1634 lightning bolts in just a few hours, which is roughly the number of bolts the city of Perth receives in an entire year.

Darwin is in the tropics close to the equator, and so it gets a lot of heat energy from the Sun. This heat energy then heats up the land, which makes the air above it rise. But this air is moist because Darwin is on the coast.

Now as the moist air rises, it cools into ice crystals. These ice crystals then collide with each other and somehow, set up a separation of positive and negative electrical charges.

Once the voltage difference between the positive and negative charges gets big enough, the negative charges head for the nearest positive charges and, hey presto, you have a lightning bolt. (This is the short explanation. I'll go into more details a bit later on.)

If this lightning bolt heads for the ground, it will usually head for the same high point that it hit last time there was a thunderstorm in that area.

So, in Darwin, many of the tall structures and power poles have been hit by lightning more than once, and they have the burn marks to prove it.

Lightning is one of the most beautiful and most destructive of all natural phenomena. On average, each year it kills more people than practically any other natural disaster, such as earthquakes, cyclones, floods, tsunamis and bushfires.

At any given moment, there are 1800 thunderstorms blasting away around the planet, usually in the later afternoon and early evening, when the land temperatures are at their highest. Most thunderstorms happen between 50°N and 50°S.

So that covers from the equator to a bit over halfway to the poles, each way.

About 80 per cent of thunderstorms happen over land, leaving 20 per cent over the oceans. They generate about 100 lightning strikes each second. About 80 per cent of these lightning bolts happen inside the cloud, or from one cloud to another. Fewer than 20 per cent run between the cloud and the ground.

Our understanding of lightning begins in 600 BC, with the Greek philosopher, Thales. He was also the first person to predict a total solar eclipse.

Anyhow, as an experiment, Thales rubbed a rod of amber with a dry cloth. (Amber is a semi-precious gemstone that seeped out of trees a long time ago.) The rod of amber then attracted feathers.

The amber was an excellent insulator, and once it had attracted some electrons from the dry cloth by mechanical friction, it hung onto them. The rod was, relatively speaking, negative with respect to the feathers, and so it attracted them. And so, as a result of attraction, the feathers flew to the rod of amber.

In the 1500s, William Gilbert, scientist and physician to Queen Elizabeth I, repeated Thales's experiment. He called the strange phenomenon 'electrica', because the Greek word for amber is 'electron'.

We're not exactly sure how, but we think that some kind of rubbing or collision causes electrons to get stripped off from their atoms in a thundercloud. This separation of electrons from their host atoms is probably associated with collisions between small ice particles.

The reason we think this, is because a thundercloud that has no ice, tends to have very little lightning. A typical thundercloud has an excess of electrons on its underside, making it negatively charged. Once you get enough of them, these electrons then repel other electrons in the ground below, say half-a-kilometre below.

The ground electrons then leave the area, resulting in the ground becoming positively charged. So next time, I'll come back with a thrilling conclusion to the negative cloud and the positive ground. And here's a hint: it might involve a lightning bolt.

www.drkarl.com

FACULTY OF SCIENCE

THE UNIVERSITY OF SYDNEY

Alumni News
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