The University of Sydney
School of Physics & International Science School

Alumni News

SUMMER 2008

Mesoscopic lab@physics

Dr David Reilly, a Senior Lecturer in the School of Physics, is heading up a new experimental research group focusing on mesoscopic physics, the behavior of matter on scales below a micron, where quantum mechanical effects become important. With the establishment of a new laboratory in the School's basement, he will carry out ultra low temperature experiments that probe quantum objects such as single electron charges or spins, often on fast (nanosecond) time scales. *Alumni News* caught up with David, fresh from Harvard and asked him about his research.

Alumni News: What is Mesoscopic Physics and is it a relatively new field of research?
David Reilly: Mesoscopic physics is a bridge between the macroscopic everyday world and the realm of microscopic objects like atoms and molecules. Mesoscopic physics really got going in the 1980s, as researchers started to fabricate structures small enough to see quantum effects. Today we are able to create devices that are completely dominated by quantum mechanical behaviour and, in this sense, we are embarking on a new field of research – how to scale back up to the macroscopic world using controllable quantum systems as building blocks.

AN: When did you become interested in this area and why?
DR: During my Ph.D., I had the opportunity to carry out experiments dominated by quantum effects. The results were starkly different from the laws of physics at the macro-scale and were in some ways mysterious. That it's possible to come face-to-face with the quantum world in a university laboratory is extremely interesting to me.

AN: The School of Physics recently built a mesoscopic laboratory featuring a $400,000 'bar fridge'. Why are extremely cold temperatures so important in your research?
DR: Coaxing truly quantum behaviour from matter is a delicate undertaking as these effects

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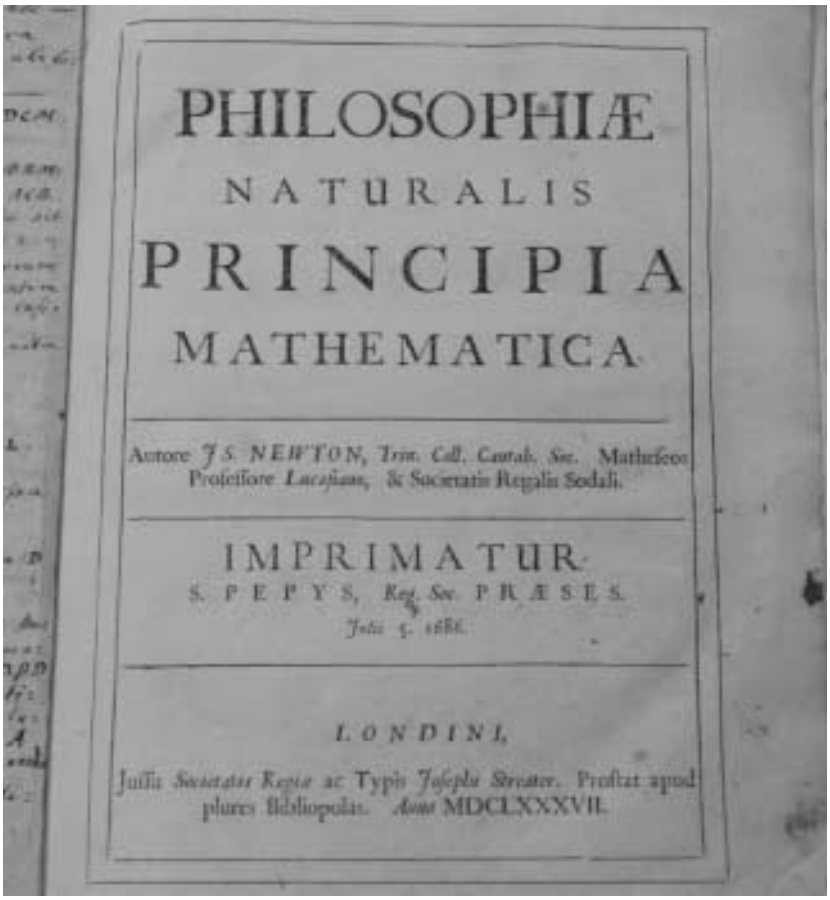
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Autore J.S. NEWTON, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.
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S. PEPYS, Reg. Soc. PRÆSES.
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Rare Science

In keeping with its motto 'The Pursuit of Excellence', the Science Foundation for Physics was very pleased and excited hold a special event in winter which highlighted Australia's leading collection of some of the greatest works of science from the past 500 years.

Rare Science, the brainchild of SFP President, Trevor Danos, showcased extremely rare and valuable early editions of science books held by the University of Sydney's Fisher Library. Some of the books on view included: Sir Isaac Newton's *Philosophie Naturalis Principia Mathematica* (first edition, 1687); Copernicus' *De revolutionibus orbium caelestium* (1566) and Benjamin Franklin's *Experiments and observations on electricity*, made at Philadelphia in America (1769).

Continued page 8

SFP President Trevor Danos with Vice-Chancellor, Dr Michael Spencer at *Rare Science*

Top: Sir Isaac Newton's *Philosophie Naturalis Principia Mathematica*, 1687, in the collection of the University of Sydney's Fisher Library and featured in *Rare Science*

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Headline

Professor Anne Green
Director & Head of School

Welcome to the Summer 2008 issue of the School of Physics *Alumni News*. This is an opportunity to warmly welcome three new staff members. Dr David Reilly joins us as a Senior Lecturer, following a research appointment at Harvard. His research into the relatively new area of mesoscopic physics will see a new laboratory established in the School's basement, for experiments that probe quantum objects (such as single electron charges or spins) out at ultra low temperatures. David features on the front cover of this issue.

Welcome also to Dr Pulin Gong, from the RIICEN Brain Institute in Japan. Pulin is working in biomedical physics studying the organised behaviour of time-varying signals in neural circuits. The exploring why and how the brain processes information. Dr Roman Kompaneets is our third exciting new appointment who has joined the School as the Harry Messel Research Fellow. His research is in complex theoretical plasma and he is collaborating with Professor Don Melrose and Sergey Vladimirov.

Three of the School's physicists, Dr Kevin Varvell, Dr Aldo Saavedra and Dr Bruce Yabsley, of the School's High Energy Research Group, have been part of the international team of 35 countries collaborating on the Large Hadron Collider at CERN. Dr Karl Kruszelnicki and Dr Kevin Varvell gave an enlightening and informative talk that entertained and educated the 500 plus crowd. Alumni News talks to the three physicists firsthand about CERN.

The Science Foundation for Physics is organising the 35th Professor Harry Messel International Science School (ISS) themed "Genes to Galaxies" as 2009 is the International Year of Astronomy (IYA) and honours the 150th anniversary of Darwin's *The Origin of the Species*. We look forward to applications from Year 11 and 12 science students from Australia, China, Japan, India, Malaysia, New Zealand, Singapore, Thailand, the UK and the USA. If you're one of our ISS alumni and know of a potential ISS scholar direct them to the Foundation's website – www.physics.usyd.edu.au/foundation – for the ISS application form posted by March 2009.

Information about the ISS including past lecures and a PDF of the 2007 ISS book of lectures *EcoScience* can also be accessed from the website.

Finally, thank you to all our ISS and Physics alumni who support us and stay in contact. A particular thank you to one of our younger ISS alumni – Chen from China – who has written of his experience at the Beijing Olympics and provided us with some first hand images. Thank you Chen! Remember – this is your alumni newsletter and we are always pleased to have your input. I hope you enjoy this issue of *Alumni News*.

New Horizons

One hundred and sixty six high school science teachers recently converged on the School of Physics to attend the 2008 Science Teachers' Workshop (STW) 'New Horizons'. The event, held at the School on 12–13 June, was so popular that not only were we bursting at the seams, but we also reluctantly had to turn some teachers away.

The program, as in previous years, was packed with workshop sessions covering physics concepts and ideas, and hands-on sessions providing practical ideas and classroom resources. The program also included plenary lectures by Dr Karl Kruszelnicki, Professor Ben Eggleton, Dr Mark Butler, and Dr Manjula Sharma and her Sydney University Physics Education Research (SUPER) team.

One of the highlights of the Workshop was the 'meet a physicist' session held at the Old Teachers' College. The session commenced with the launch (with customary ribbon-cutting ceremony) of the AMPS online kit of syllabus-based physics tools, developed by Dr Manjula Sharma and Derek Muller from the SUPER group. This was followed by the meet-and-greet session, where teachers were able to approach a physicist in their area of interest and ask those tricky questions they always wanted to ask. The event was extremely popular with Devonshire Tea strategically placed on researchers' tables working a treat as an icebreaker.

Another highlight from the Workshop was the wonderful after-dinner talk given by Prof. Fred Watson, Astronomer-in-Charge of the Anglo-Australian Observatory. The dinner was held in the historic Brennan Hall at St John's College where the guests were thoroughly entertained by Prof. Watson's cheekily entitled talk – 'Astronomers Behaving Badly'.

Professor Fred Watson, astronomer and STW guest speaker

Feedback from the attendees for the Workshop has been very positive with comments such as: "I learnt so much and felt incredibly supported. I have benefited and even more importantly, my students will benefit for your efforts" wrote Karen Hagan, a science teacher from Macquarie Anglican Grammar School in Dubbo. Belinda Cloumassis, science teacher from Sir Joseph Banks High School in Revesby sent an email saying, "Just a quick note to let you all know how much I enjoyed the experience last week at the Sydney Science Teachers Workshop!!! It was inspirational, informative, helpful, enjoyable, delicious, refreshing, stimulating, practical, reassuring, and really fun. I was so glad to be there".

Forty-four high school science teachers also attended the regional Science Teachers' Workshop, which was run in conjunction with the 2008 *Kickstart on the Road* program in Wagga Wagga, Dubbo and Armidale recently.

For more information on the STW please go to
http://www.physics.usyd.edu.au/foundation/

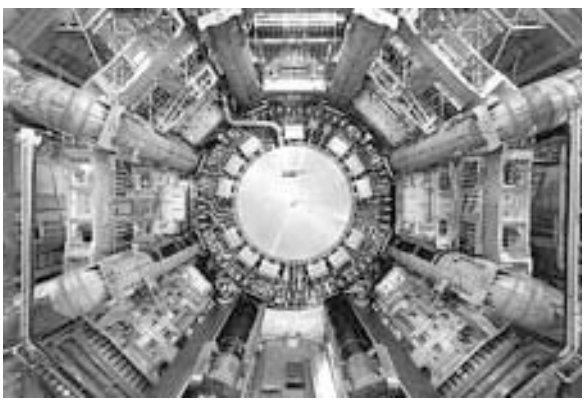
For information on the online HSC physics resources please go to:
www.hscphysics.edu.au/home.

The Large Hadron Collider: CERN

The University of Sydney is involved in an international collaboration known as the ATLAS experiment, located at the European Organisation for Nuclear Research (CERN) in Geneva, Switzerland. The ATLAS detector is a part of the Large Hadron Collider (LHC), a particle accelerator that collides protons at energies never before seen in a controlled experiment, allowing physicists to probe the fundamental properties of the universe we live in.

Dr Kevin Varvell leads the High Energy Physics Group along with ARC Fellow Dr Bruce Yabsley. They say the 'point' of the LHC is to find out new things about matter at the smallest scale: the fundamental 'building blocks' of the world [not "life": that would imply things like proteins] and how those blocks interact with each other. Dr Yabsley explains, "Current theory explains this very well at the energies we can reach using existing particle accelerators, but at LHC energies we expect to see something new. The simplest new thing would be a particle called the Higgs boson, which is the one part of our current theory we haven't yet seen. Other alternatives are possible. For instance we may see a bunch of particles like the Higgs, but with different behaviour, and, if the theoretical model called 'supersymmetry' is correct, we'll see lots of new types of particles, maybe including the still-unknown 'dark matter' that contributes 85% of the stuff in galaxies." If some recent suggestions about gravity are true, there's a chance scientists might even see miniature black holes albeit infinitesimally small ones, tinier than a proton and evaporating in an instant. Dr Varvell says, "Once the LHC data is sorted and we understand it, we'll know which of these ideas correspond to reality, and which don't. The correct answers may be things we haven't thought of yet."

Dr Aldo Saavedra, a Research Fellow in the Group, has been a part of the ATLAS experiment since the mid 1990s. He has contributed to the development and production of high precision silicon wafers used to detect high energy, charged particles coming from the interactions of the LHC. Currently he is involved in the development of software that will search for tau leptons, an important decay product of the elusive Higgs boson. During the early stages of the experiment there was a large research and development effort directed at creating the components of the ATLAS detector. Australia, through the Universities of Sydney and of Melbourne, was involved in testing and developing the units that measure the position of charged particles as they travel through, called strip detectors. Hundreds of them are mounted in layers around the collision to recreate the path of the charged particles created.



School of Physics' student Jason Lee, standing in front of the "Big Wheel".

Dr Saavedra, says that now the detector is built the focus has been contributing to the software that analyses the data from ATLAS. "It has been said that if all the data from ATLAS was recorded, it would fill 100,000 CDs per second. In reality this is cut down to 27 CDs-worth per minute to keep it reasonable by the ATLAS trigger. One of our current projects is to decrease the amount of data saved by increasing the efficiency of capturing the interesting information as that information may contain a new discovery." He continues, "There are lots of ways to trigger the detector to save the data. In Sydney our interest is triggering with the tau lepton, which is a heavy cousin of the electron, which gives it two advantages. Firstly it produces a striking signature in the detector and secondly, the particles we want to discover should decay into them."

University of Sydney Particle physics students, Jason Lee and Anthony Waugh, are developing software for the modelling and reconstruction of electrons within the detector. "The LHC is the next frontier in physics," says Jason Lee, "Discovering the maths of mass, will enable us to better understand the universe." Dr Saavedra is pleased that the students have the opportunity to work with the CERN scientists. "It's great they have this chance to meet other students from all over the world. Jason and Anthony work on reconstructing and identifying the different particles that were recorded by ATLAS and finding ways to more efficiently model the detector in order to understand how it will respond."

Drs Varvell, Yabsley and Saavedra all agree this is an exciting time to be working particle physics. Saavedra says, "It's exciting because this new accelerator is giving us a window to a new regime of matter never before studied. It is uncharted territory and after a lot of work finally the voyage is about to begin. We do live in interesting times. After all it's not every day that you are able to be involved on something new and have the chance to peek at Mother Nature's book."

Left: Inside the massive CERN particle accelerator.

International Year of Astronomy

In 1608 the development of the optical telescope changed the world of astronomy forever. The magnifying ability of lenses had been known since ancient times but it was the combination of two lenses to form a practical telescope, first achieved by spectacle makers in the Netherlands, that set Galileo Galilei, in mid-1609 at the University of Padua, making his own instruments. He wasn't the first person to observe the sky with a telescope but his influence was immense. In March 1610 he published a short record of his remarkable early observations and this was the beginning of 'modern' instrumental astronomy – a milestone in the history of science.

To mark the 400th anniversary of Galileo's first observations of the sky, the United Nations has declared 2009 as the International Year of Astronomy (IYA), a year-long, community-based celebration of the science, history and cultural impact of astronomy that will draw attention to the night sky as the common cultural heritage of all humanity. Globally coordinated by the International Astronomical Union, which represents the world's professional astronomers, there are 11 'Cornerstone' projects. These are global activities centred on specific IYA goals such as '100 Hours of Astronomy' a (you guessed it)100-hour, round-the-clock-and-globe event that includes live webcasts from worldwide research observatories and public observing events. Like Galileo a key goal is to have as many people as possible look through a telescope.

In Australia, a Working Group and an associated Advisory Group are responsible for coordinating IYA activities. A variety of national events are planned, however the key to the success of IYA is local activities and so the School of Physics and the Faculty of Science are planning a program of events at the University of Sydney. One highlight will be *Music and the Cosmos*, featuring talks by astronomers Professors Tim Bedding, Joss Bland-Hawthorn and Bryan Gaensler with the Sydney Conservatorium of Music Ensemble playing an excerpt from Holst's *The Planets*. This special event will be heldin the Great Hallon 6 May as part of the Sydney Science Forum.

The 35th Professor Harry Messel International Science School, *Genes to Galaxies*, will build on IYA themes and feature a several renowned astronomers. Other regular School and Faculty outreach programs will adopt an astronomical flavour during IYA. The regular Physics Calendar, distributed to secondary schools throughout New South Wales, also highlights our astronomical research.

A series of lecture courses as part of the University's Continuing Education Program will build on the School's long history of astronomy education for the public. Our astronomy research is stronger than ever and serves as the basis of the broadest CEP courses in astronomy yet presented. Courses include 10-week reviews of planetary astronomy and stellar and extra-galactic astronomy. One-day courses will describe the use of the telescope, the quest for life in the universe and the 'big picture' of the universe as a whole. Capping the program will be a three-day tour offering special access to astronomical observatories in New South Wales.

For information on University of Sydney events, follow the IYA link on the School of Physics home page. Also keep your eye out for special local events, such as viewing nights run by local amateur astronomical societies. The Australian IYA website can be found at www.astronomy2009.org.au/

Dr John O'Byrne checking the School's telescope

On the Road Again

Kickstart on the Road 2008 combined nine physics students, two station wagons, one ute and a whole load of enthusiasm. Dr Phil Dooley led the crew who managed to pack in a Science Teacher's Workshop, two modules of Kickstart, a Nobel Prize talk and a Great Physics Airshow for kids for 300 NSW Higher School Certificate students and 44 teachers. Since 2004 Kickstart has hosted thousands of Year 11 and 12 students at the School of Physics and thanks to the generous sponsorship of IBM Australia, we also take physics to regional NSW. The 'on the road' program bases itself in Wagga Wagga, Dubbo and Armidale. Schools travel up to 200km to attend these sessions that allow the chance to do experiments and demonstrations of key ideas in the syllabus that are difficult to do in the classroom.

For the students, a day consists of two three-hour sessions in the lab using equipment such as induction coils, AC and DC motors, and the all-important liquid nitrogen-fuelled superconductors. Over lunch they are treated to a detailed, interactive talk all about Relativity. We also took a large discharge tube, which wowed the students with its striped purple glow long before they had even begun their lab sessions. On the trip between Dubbo and Armidale the Kickstart team was treated to a hike through the Warrumbungles and a comprehensive tour of the Anglo-Australian Telescope at Siding Spring.

35th Professor Harry Messel International Science School

Genes to Galaxies

12–25 July 2009

"It's hard to believe that the Science School has been going since 1962. Of all the projects I have been involved in during the past 56 years, none has given me more pleasure or likely to have more impact. There are over 4000 former scholars, many among today's movers and shakers on this planet. It's great to meet many of them wherever I go and to hear how their attendance impacted on their lives. The rewards to society are great. My reward is equal."
Emeritus Professor Harry Messel AC CBE

With two weeks of first-class science, 140 of the best and brightest Year 11 and 12 students from Australia and overseas the 35th Professor Harry Messel International Science School (ISS) will surely be the Science Foundation for Physics (SFP) crowning event in a year celebrating the 400th anniversary of the first use of an astronomical telescope by Galileo Galilei - the International Year of Astronomy) as well as the bicentenary of Charles Darwin's birth and the 150th anniversary of the publication of "Origin of Species". Running from 12-25 July the ISS2009 Genes to Galaxies will highlight the wealth of knowledge that the astronomical and biological sciences have given us as well as showing ISS scholars how science and scientists work in bringing a greater understanding of the world around us.

ISS Scholars stay on campus for the fortnight long program attending a series of daily lectures, workshops and evening functions. With an advance copy of the ISS Book of Lectures, scholars have a chance to read up on the talks written by the featured ISS lecturer - scientists of world renown prior to their arrival - very helpful for students for whom English is a second language. A team of volunteer 'ISS Staffies', comprised of past ISS scholars, are on hand to orientate and welcome the current cohort. House Parents, John Bright and Karen Palmer, provide a warm and secure environment for all those far away from home, many for the first time.

The ISS is truly an international event with five students each from the UK, Malaysia, Singapore, New Zealand, USA, China and India; seven students come from Thailand and ten from Japan. Some 90 students from all states and territories of Australia make up the rest of the ISS scholars. As part of the ISS social program the Embassies and High Commissions of participating countries will often host receptions for their country's students, together with up to ten Australian ISS colleagues, which further honours the excellence of these students and increases knowledge and appreciation of other cultures. The ISS Indigenous Scholars Program was created in 2005 to address the shortage of indigenous Australians participating in science, technology and engineering related fields. Participation in this program has been solid and we look forwardtooncemore working with the University'sKoori Centre in selecting the 2009 Indigenous science scholars.

Chief Justice of the High Court of Australia, Robert French, ISS 1964 Alumnus, will open the ISS with an address on his experience from science through to law. Other brilliant lecturers include: Dr Jill Tarter, Director of the SETI (Search for Extra-Terrestrial Intelligence) Institute; Mr Wayne Lee from NASA, Professor Malcolm Walter, Director of the Australian Centre for Astrobiology and Dr Naomi McClure-Griffiths from CSIRO Telescope National Facility. We also welcome the University of Sydney's Professor Jennie Brand-Miller and Dr Alaina Ammit representing the ISS gene component. Physics' own Galactic researcher, Dr Helen Johnston, and ARC Federation Fellow, Professor Bryan Gaensler, will enlighten scholars about the universe. Our regular and most popular speaker is Julius Sumner Miller Fellow and media personality, Dr Karl Kruszelnicki, getting his autograph and photo are an ISS must!

Dr Karl Kruszelnicki surrounded by ISS fans

- ISS scholars visit many Sydney attractions and have the opportunity to put their own creativity on show with a talent quest and other activities organised by the Young Scientists Association. Many life-long friendships (and some marriages) are attributed to the ISS with scholars telling us their experience at the Professor Harry Messel International Science School was life-changing. If you know of a potential ISS scholar, applications are available online February/March 2009, visit: www.physics.usyd.edu.au/foundation/

Outreach continues to thrive in the University of Sydney. 'Gifted and Talented' held in Spring had a radioactivity theme in recognition of the Large Hadron Collider launch. 'Degree in a Day' in Summer starts ramping up to IYA with telescope activities. The School enthused Year 8 and 9 students with the NSW Office of Science and Medical Research's *Science EXPOsed*; primary school children with *Giant Science*, and *Science in the Bush* visited the Hawkesbury and Albury for *Flying, Floating, Freezing Physics* shows. As far as the kids are concerned too much physics is barely enough!

Kickstart in action

One World, One Dream

By Zhang Chen

With the extinguishment of the holy flame, the Beijing 2008 Olympic Games came to an end. The past 16 days in August saw myriads of precious and spectacular moments, which vividly displayed man's Olympic spirit of "Citius, Altius, Fortius" and embodied man's noble spirit of trying to pursue and build friendship together.

As a Beijinger, I too participated in the Olympics as a volunteer of the community where I live, helping visitors with their problems and also keeping an eye on the realm of the community in case any emergency took place. I had a great time and felt proud of being a volunteer for the Olympic Games held in my hometown.

Of course, there was no excuse for me not to go to the Games in person. On the afternoon of 22 August, my mother and I went to the Workers Stadium to cheer for the boxing games. To our surprise, Jacques Rogge, the International Olympic Committee (IOC) President, was also there to watch the games. Despite the fact that I had been watching the Olympics every day on television, the real experience of the Games as a spectator inside the stadium was quite different, when you were truly impressed and greatly inspired by the games and the athletes and also people around you. It was just like a big party filled with excitement and joy.

The Beijing 2008 Paralympic Games were also held and, as Rogge said in the closing ceremony of the Beijing Summer Olympics, "They also inspire us." We all wish the best for the talented athletes who participated in the Paralympic Games.

Our Chinese dream of holding the Olympic Games finally came true in August 2008, and the 16 glorious days will be long remembered, and the friendship we built and the joy we had will be forever cherished by people from all across the world.

Top: The 'Bird's nest' stadium

Left: 2008 Beijing Paralympic Games 400 metre sprint

Photos courtesy of Zhang Chen

Teachers Awarded

Joe Khachan, Manju Sharma and John O'Byrne at the 2008 Australian Learning and Teaching Council (ALTC) Awards

Congratulations to Dr John O'Byrne, Dr Joe Khachan and Associate Professor Manjula Sharma from the School of Physics who recently won a 2008 Australian Learning and Teaching Council (ALTC) team award for a program they've developed that encourages collaborative and interactive learning in large first-year physics classes. Using hand-held devices similar to a TV remote control, students in a lecture 'phone in' their answers to questions posed by the lecturer and the collective responses can be immediately gauged and discussed. Some students form groups and decide on the answer before sending in their 'vote', in others each student votes individually. The three say it's a non-threatening way to promote interaction as everyone gets to vote and engages in the discussion.

Mesoscopic physics

Continued from page 1

can be exquisitely fragile. Cooling our samples to 1/100th of a degree above absolute zero takes away the thermal energy that would otherwise blur out the physics for which we are searching.

Dr David Reilly who is heading up the mesioscopic physics laboratory

AN: With the desire to create objects that are smaller and smaller e.g. electronics, just how far do you see mesoscopics going in relation to industrial applications?

DR: Mesoscopic physics is one of the key areas of research underpinning the multi-trillion dollar semiconductor industry. The future of computing hinges on our ability to construct ever-smaller transistors and integrated circuits that function despite quantum effects. At the same time we know that an entire new paradigm of computation exists if we can directly harness quantum properties. Building devices that work in the presence of both dirt and quantum effects will be a big challenge for mesoscopic physics in the next decade.

AN: Could mesoscopics also have implications in terms of medical physics e.g. unlocking the secret of growing back a body part such as fingertip?

DR: Certainly in the area of imaging and sensing, mesoscopic physics can make significant contributions to biomedicine. Right now at the University of Sydney, we are using the techniques of quantum control to explore new technologies for medical imaging using magnetic resonance. By precisely manipulating electrons and nuclei we hope to create new tools that can be used, for instance, in the early detection of cancer.

Stop Press

Promotions

Congratulations to the following Physics staff who have recently received promotions to Associate Professor – they are (formerly Drs) Scott Croom – Astronomy, Andrew Hopkins – Astronomy, Mike Wheatland – Astronomy and Manju Sharma – SUPER. The selection process was rigorous and these promotions are very well deserved.

Grants and Awards for the School of Physics

Congratulations to Dr Zdenka Kuncic and Professor Clive Baldock on their success with the National Breast Cancer Foundation. Clive and his colleagues have received $118,424 for a pilot study: *Determination of Clinical Correlates of Lymphoedema.*

Zdenka and her colleague have received $105,000 Towards more effective radiotherapy treatment of breast cancer.

ARC Discovery Projects Proposals For Funding To Commence In 2009

Congratulations to all of the Physics Research staff listed below who will receive ARC Funding.

ASTRONOMICAL SCIENCES

Prof J Bland-Hawthorn; Prof KC Freeman; Dr SC Keller; Prof M Asplund

Project Title: *Galactic Archaeology: a Challenge for the Cold Dark Matter Paradigm*

2009 :	$ 170,000	2011 :	$ 170,000
2010 :	$ 170,000		

Dr S Chatterjee; Prof BM Gaensler

Project Title: *Snap, Crackle, Pop: Opening the Window on the Variable Radio Universe*

2009 :	$ 190,000	2012 :	$ 166,000
2010 :	$ 190,000	2013 :	$ 160,000
2011 :	$ 170,000		

Dr AM Hopkins; Prof J Bland-Hawthorn

Project Title: *The mass assembly of galaxies and structure in the universe*

2009 :	$ 130,000	2011 :	$ 80,000
2010 :	$ 80,000		

COMMUNICATIONS TECHNOLOGIES

Dr SD Jackson

Project Title: *Microfibre photonics: function densification on a wavelength scale*

2009 :	$ 160,000	2012 :	$ 120,000
2010 :	$ 85,000	2013 :	$ 130,000
2011 :	$ 85,000		

Dr DJ Moss

Project Title: *Silicon All-Optical Nanophotonic Devices for 160Gb/s Systems*

2009 :	$ 150,000	2011 :	$ 120,000
2010 :	$ 100,000		

OTHER ENGINEERING AND TECHNOLOGY

Prof SC Fleming

Project Title: *Compact Tunable Visible Lasers – New Approaches to Phase-Matching*

2009 :	$ 170,000	2011 :	$ 120,000
2010 :	$ 120,000		

A/Prof SR Meikle; A/Prof RR Fulton; Prof RB Banati

Project Title: *Simultaneous measurement of brain function and behaviour in fully conscious laboratory animals*

2009 :	$ 130,000	2011 :	$ 100,000
2010 :	$ 100,000		
2011 :	$ 100,000		

ENVIRONMENTAL SCIENCES

Prof M Lenzen

Project Title: *Developing a global environmental, social and economic information system*

2009 :	$ 125,000	2011 :	$ 95,000
2010 :	$ 95,000		

THEORETICAL AND CONDENSED MATTER PHYSICS

Prof CM Stampfl; Dr S Piccinin; Prof MR Scheffler; Prof AJ Freeman

Project Title: *First-Principles Engineering of Advanced Multicomponent Materials for Clean, Energy Efficient Thermoelectric and Catalytic Technologies*

2009 :	$ 150,000	2011 :	$ 120,000
2010 :	$ 100,000		

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from previous page

AN: What are some of the burning questions you hope to answer with your research?

DR: We would ultimately like to understand how our macroscopic world of bricks, tables and people emerges from the bizarre microscopic quantum world of electrons, atoms and molecules. Is it possible to scale up quantum systems, or does their 'quantum-ness' always vanish as things get bigger and more complicated? What new technologies become possible if we can precisely control the elemental constituents of matter? From where we stand today, these are ambitious questions and we are just starting to learn how to control the quantum world.

AN: What have been your major discoveries to date?

DR: I've been very fortunate in my career to have the opportunity to work on some really interesting problems. During my Ph.D., I focused on an open question in mesoscopic physics, the resistance of a one-dimensional channel of electrons. This simple system turned out to behave in a not-so-simple way and earned a reputation as THE outstanding problem in mesoscopics. As I was taking data I got lucky and found a model to explain a lot of the key physics.

Recently, at Harvard University, we discovered a method of preparing nuclei in devices called quantum dots. This resulted in long-lived quantum properties for electrons, an import requirement for technological applications. Our discovery was published in the journal *Science* this year.

AN: When do you hope to see some of your research put into action?

DR: Our vision is firstly one of basic physics, learning the quantum rules of Nature at scales between macro and micro. Applying this understanding to create new quantum technologies, from information processing devices to new medical imaging techniques, is a process that is already underway. I would hope to see our work having technological implication in the next decade.

Dr.Karl says 'Black Holes suck'

Black hole! Even the name has a certain menace about it, not to mention their reputation. We think they are some kind of cosmic vacuum cleaner, sucking anything around them into their voracious maw. But if our sun were to be replaced by a black hole weighing the same, the Earth would still travel in the same orbit. The only real difference is that it would be cold and dark, because the black hole would not emit any heat or light.

To understand a black hole, think about the concept of "escape velocity". If you throw a rock upwards, pretty soon it falls back down again. If you throw it upwards 10-times faster, the rock takes longer to fall down but it will still fall back to earth. But if you propel the rock up with a speed of 11.2 kilometres per second, it will never fall back down to earth. So the escape velocity of planet Earth is 11.2 kilometres per second.

A black hole has such a massive density compared to its size, that the escape velocity is equal to the speed of light, or even greater, so light itself can never escape, and we can never see it, hence the name 'black hole'. The size of our sun is about 1.4 million kilometres across. There are two forces keeping it balanced at that size, the outward pressure of the nuclear fires, and the inward suck of gravity. These nuclear fires consume about 600 million tonnes of hydrogen each second. At some stage in the distant future (several billions of years away) the nuclear fires will run out of fuel. So gravity will be the dominant force, and the sun will shrink. As part of the natural evolution of stars, at some late stage in the nuclear burning, most stars toss much of their mass out into space.

If, at the end of nuclear burning, the amount of mass remaining in a star is less than one solar mass (the current mass of our sun), then gravity shrinks that star down into an object called a white dwarf. Most white dwarfs are roughly the size of planet Earth, about 12,000 kilometres across, but with a mass of about 60% of the sun. This gives them a density about one million times greater than water. Astronomers have found about 9000 white dwarfs, in fact, they make up about 6% of the stars in our immediate neighbourhood.

A white dwarf is the fate of all stars left with a mass less than 1.4 solar masses, after the nuclear fires fade. So about 97% of all the stars in our galaxy will end up as white dwarfs. But suppose you start with a heavier star. If, after the nuclear fires run down, the mass of the star is 1.4–2 solar masses, its gravity will be stronger, and it will shrink itself even smaller down to a neutron star, about 10–20 kilometres across. A neutron star is about 100 million–1 billion-times denser than a white dwarf. This gives them a typical escape velocity of about half of the speed of light. So far, astronomers have found about 2000 neutron stars in our Milky Way galaxy, and in its neighbouring galaxies, the Magellanic Clouds. But things are very different if, after all the nuclear burning, the star weighs more than about two solar masses. In this case, it will shrink so far that it will collapse into a point with infinite density and zero volume let me just emphasise that, not just a colossally high density, but infinite.

The technical name for this is a "singularity" – the famous black hole. This point is hidden inside the so-called "event horizon". Black holes can cover a range of sizes. If our Sun were to be turned into a black hole, the event horizon would be about six kilometres across. If an object such as a comet, or even a planet, were on a collision course with the event horizon, yes, it would vanish inside the black hole. But if it started off in a stable orbit around the sun, then it would continue in the same stable orbit after the sun had been magically turned into a black hole. So black holes are very weird, but they do not suck everything into themselves. But, as with all the forces of darkness, it's better to stay out of their way.

Dr Karl Kruszelnicki's latest book, *Science is Golden*, (Harper Collins) is in Australian stores now RRP $25.95. STOP PRESS – the Science Foundation for Physics has a special offer for alumni: purchase *Science is Golden* and *Lots of Scars* by Professor Dick Collins for only $A30.00 (plus $5.00 P&H). Visit www.physics.usyd.edu.au/foundation for more details, or email Alison Muir at a.muir@physics.usyd.edu.au. Makes a great holiday gift and funds raised help support the ISS2009.

Rare Science

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All books that were on display are extremely valuable and rarely made available for public viewing. Some feature marginalia in the author's own handwriting. For example Sir Isaac Newton's *Principia* (first edition – seen left) is estimated to be worth around $6-$8 million. Dr Neil Boness, Senior Rare Books Librarian, spoke about the books explaining how they came into the possession of Fisher Library and the correct ways to handle and conserve rare books.

All in all it *Rare Science* was a memorable experience and the SFP sincerely thanks Neil Boness, Ross Coleman, Julie Price and John Shipp, for their enthusiasm, hard work and collaborative spirit in ensuring such wonderful events.

To see more *Rare Science* images please visit: www.physics.usyd.edu.au/foundation To learn more about the Friends of Fisher visit: friends@library.usyd.edu.au