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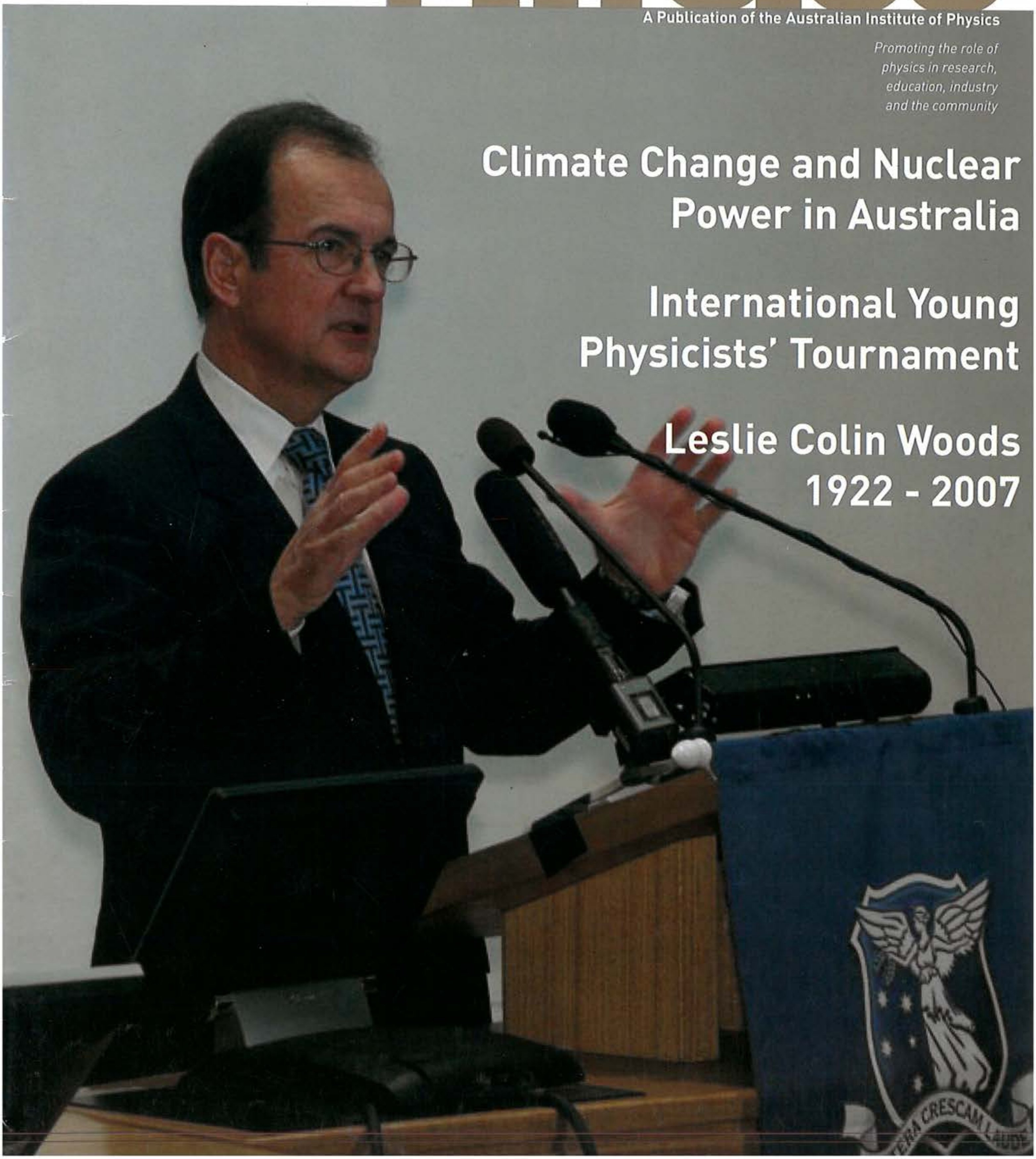

Climate Change and Nuclear Power in Australia

International Young Physicists' Tournament

Leslie Colin Woods 1922 - 2007

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Australian Physics
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Contents

Volume 44 Number 3

Cover image: Climate change and nuclear power in Australia. Dr Ziggy Switkowski summarises the findings of the Prime Minister's Review of Uranium Mining, Processing and Nuclear Energy (see p. 90)

Image credit: Christina Fargher, University of Melbourne

Contributions should be sent to
A/Prof Brian James
Australian Physics
School of Physics, A28
University of Sydney
NSW 2006
Tel: 02 9351 2471
australianphysics@aip.org.au
australianphysics2@gmail.com

Design
Sophie Campbell
Tel: 0402 101 090

Printing
Cliff Lewis Printing
91-93 Parraweena Road
Caringbah NSW 2229
Tel: 02 9525 6588
Fax: 02 9524 8712
matthew@clp.com.au

Layout
Corinna Horrigan
bedlam@iinet.net.au

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President's Column - What makes science research good?

The mantra of the Australian Minister for Science, Julie Bishop, is that Australia should be "attracting and funding the best and brightest scientists in our community"[1]. Research grants, merit promotions, awards and prizes have always been decided on a competitive and comparative basis. Recent times have seen the introduction of new policies for government funding of research; even the appropriation funding of government research laboratories such as CSIRO and universities is now decided by the assessment of the research quality and its impact. In CSIRO, research funding is via a competitive process to research programs called "Themes", and universities are about to be assessed by the Research Quality Framework (RQF). Such approaches[1] to determine the distribution of limited research funds require fair comparison of research proposals and assessments of the track record of the lead researchers and their team. So if we are to use merit to decide on research funding, what does make research "good quality with high impact"?

The common way to determine research quality is by the measurement of science metrics which includes a range of factors that cover productivity (number of research outputs such as publications and patent applications), connectivity to the wider science community (such as refereeing papers, involvement with professional society, invited lectures and organising conferences) and the impact of the work (as determined by the number of citations, awards, transfers of technology to application and commercial or community adoption). However, each of these measures has the potential to be manipulated. The number of papers published does not necessarily reflect the quality of a paper, conference invitations can be based on cronyism and activity in the science community is dependent on your availability and willingness to give your time. These are obvious areas for potential manipulation of these metrics. Impact is the hardest to measure and, furthermore, it is a lag indicator; however, determination of impact via citation counting has been made far easier with the web based information services such as Thomson Scientific ISI Web of Science and Google Scholar. It is becoming the science metric of choice for decision making in many aspects of our science community.

In 1955 Garfield [2] identified the use of citations as a way to determine the usefulness of a research publication and the ISI web of science data base has been collecting this information. Now any author who connects to the Web of Science can select all their papers and determine their lifetime citations, the average citations per paper and rank their papers by descending citation counts, start from the top of the ranking, move downwards item by item, to the point where the listed items' rank is equal to the number of citations it has attracted. This point provides the value of the Hirsch Index or "H-factor" [3].

The H-factor is now the key method (especially as Thomson Scientific now provides the ability to rapidly calculate it with the press of a function key) to determine if a scientist is "hot" or not. Hirsch suggests that a typical impact factor for a professor is about 18. However, some research groups and individuals may have their citation impact concentrated in a limited number of highly cited "star" papers (possibly even in one single paper), whereas other groups may have a series of papers, so that their citation impact is less concentrated. The latter groups may tend to have higher values of the Hirsch Index than the former, and it is questionable whether these differences reflect differences in research performance or quality. Differences in citation distributions, what they reflect, and how they influence the various citation-based indicators, particularly the Hirsch Index, represent one set of issues that need to be fully understood before blindly using such a method to determine quality. Just this week, letters to the journal Nature [4] have questioned the H-factor reliability when age, gender, gratuitous authorship and lack of context are not accounted for. While other detailed research has indicated the H-factor is a good predictor of future performance [5]; but does a poor H-factor mean there is no hope? And is it possible to turn a poor citation rate or H-factor around [6]?

We also need to recognise that not all research is the breakthrough science in what is referred to as "hot" topics that can lead to early high levels of citations and recognition. Research in areas that leads to incremental research and the detailed research that enables a full understanding of a field may not attract early citations even though it is high quality and very important. Furthermore, applied research, which more readily leads to commercial and community benefits, is often poorly cited as the number of researchers in a specific application area is usually limited and yet is the research that leads to the greatest impact for the community. There is also the potential for applied research to be held up from publication as commercial sensitivities require intellectual property protection adding to further delay of recognition. Just the size of the scientific discipline has impact on the number of citations; general physics citations are lower on average compared to molecular science or biology by a ratio of about 1:3.

So do science metric indicators really identify good quality research? What constitutes a quality research program? Google Scholar reminds us that we stand "on the shoulders of giants" (Newton). Good research needs to be reported providing a thorough examination of the related literature, placing research into the context of the current knowledge, issues and problems and then reporting on the detailed research with a deep analysis of the results and the interpretation as related to what is known and what this new information tells us. In experimental research in physics, it is important that we are measuring what we think we are measuring. It is not always easy to be sure. Doing enough experiments to make sure that statistically there is enough evidence that the response observed is not just a "one-off" or a result of a sample anomaly and the results are reproducible. Generally, interpretation of results by comparing to theory and modelling clearly show that

continued on page 81

[1] This column does not discuss the merits, or not, of the RQF and related funding. Some discussion of this is given in a paper "Will the RQF improve research productivity? Some empirical evidence." D. Marinova and P. Newman, *http://www.sustainability.murdoch.edu.au/publications/marinovanewman/MarinovaNewman_RQF.pdf*

Guest editorial

Congratulations to our International Young Physicists' Tournament champions for 2007. Australia's team of Antonia Morris, Christopher Bentley, Mitchell Stevens and Team Leader Kathryn Zealand competed against teams from Europe, Asia, the UK and the USA.

The process for winning this competition is a superb illustration of the workings of physics, or any science for that matter: "Each team receives the list of...problems...about six months before the event. They then spend all of their spare time...theorising and experimenting to prepare solutions." The teams are then required to present and defend their solutions to a panel of their peers – now that is great experience for a future career in physics.

Keeping to the young physicist theme, in L'Oreal for women, Dr Ilana Feain uses her work on galactic black holes at the Australia Telescope National Facility to get young women interested in astrophysics through the Global Jet Watch project through Oxford University.

Leslie Woods' obituary is a fascinating read to see just how circuitous a life can be and yet remain focused on physics. Woods spent much of his life trying to uncover the intricacies of plasma physics and its relation to harnessing the genie that is fusion power. Sadly that genie remains hidden still; but it may soon be released due to the past efforts of physicists like Woods. A career that spanned over 50 years, many nations and accolades is always worth celebrating.

When I began editing this current issue, an email arrived from the Victoria Branch with a link connecting me to an online survey about some of the services of the AIP. Of note were the survey questions about what role we would like the AIP to take, if any at all, on controversial or delicate issues. By definition controversial and delicate issues are "problems" needing a solution often in places most people are not prepared to look; and like our IYPT champions have shown us, solving problems is what we are good at. We should not shy away from challenging ourselves and the public from some of the important issues of today where physics is relevant.

In Life Outside Physics Gaby Bright takes us on her journey from a physics undergrad to student politics to CERN to a life using science in, and for, the Public Service. Of particular poignancy is her work on solaria given the recent death of Clare Oliver and her campaign against the damage they do to our skin. Gaby Bright writes about her work on the "...Solaria: Fashion to Die For campaign" which "aimed to educate young women about the dangers of prolonged and frequent solarium use." Understanding the physics is a crucial link in the solution to that problem.

Ziggy Swikowski takes us directly in to the belly of the beast that is nuclear power and how he believes it will play a large part in Australia's contribution to climate change action. In a speech to the University of Melbourne, co-sponsored by Victoria Branch, we get an itemized dissolution of the crucial points of this dilemma, a deep look at the possible options, and then suggestions on to move the issue beyond the starting point.

Maintaining our firm grounding in the search for information and data while keeping our heads in the face of problems will remain the best way to deal with difficult issues.

Growing up Canada I remember hearing a joke something like this: two hikers get ready for a long hike through the deep woods. The first hiker ties up his running shoes while the second ties up his hiking boots. The second hiker asks: "Why are you wearing running shoes for our hike?" "In case of bears," says the first. "But you can't outrun a bear in running shoes," replies the second hiker. "True, but I can out run you." Now that I have been formally appointed the Editor for Australian Physics, I feel a little like the second hiker wearing my hiking boots. Wish me luck.

Enjoy the issue.

John Daicopoulos

Deadline for next issue: 30th November 2007

Submission guidelines

All articles for submission to Australian Physics should be sent in electronic format. Word or rich text format are preferred, but other formats, such as PDF, may also be accepted. Please check with the editor if your article is in a different format.

Images should not be embedded in the document but should be sent separately in high resolution JPEG or TIFF format.

President's column - continued from page 79

there is a full understanding of the research. Being able to provide a simple schematic to demonstrate the phenomena can demonstrate a deep understanding. Einstein and Infeld tell us that physics research is "to raise new questions, new possibilities, to regard old problems from a new angle..." and that it "...requires creative imagination and marks real advance in science" [7]. The size, complexity and diversity of research efforts, among other factors, contribute to excellence in a changing and competitive scientific research environment. "Science does not progress in an easy, linear fashion. It's not like you have an idea, set up an experiment, prove your theory and then cure cancer. In science, you learn as much from your failures as you do from your successes. Every paper, every theory and every experiment builds on those that came before" (David Suzuki).

The peer review process, which is the corner stone of the scientific method, is meant to check that the research presented reaches a certain standard; however, peer review may not always be undertaken with the level of diligence necessary. Just considering the statistics of the number of scientific journals and the number of papers published per year suggests that the load on reviewers is so great that excellent reviewing may not be always be achieved. As a result many papers are currently being published which lack quality.

Using citation analysis can only be appropriate if it is carried out openly according to transparent procedures with clear objectives; researchers are able to verify data and comment on results; potentialities and limitations, technical and validity issues are explicitly stated; its outcomes contribute to insight, or pose problems or address particular questions that participants in the process seek to answer; and the process ensures the availability of expert knowledge on the entities involved and the fields in which they are active. Such judgments, which influence significant decision making on research funding and career opportunities, need the qualitative analysis to be undertaken by experts in the field which is time-consuming and expensive. Let's hope that our Physics Community takes heed of the limitations as well as the potential of science metrics and apply them in ways that lead to better research outcomes rather than using them as a means to achieve personal agendas.

This edition of Australian Physics recognises our future top physicists who won the AIP/DSTO honours year scholarships in 2006 and 2007, and closely follows the award of The Malcolm McIntosh Prize for Physical Scientist of the Year to Professor Mark Cassidy, a civil engineer. I hope these events will ignite your enthusiasm to consider submitting applications for the range of prizes, medals and awards that are on offer (see the AIP web site for a list of these). Even if you are not a winner, the process of reviewing your work and placing it in context of research in the wider science discipline is a fruitful and worthwhile exercise to see how much you have achieved!

Cathy Foley
AIP President

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AIP QLD Branch

Chair: Dr Brad Carter
Department of Physics,
University of Southern Queensland.

Secretary: Dr Kevin Pimbblet
Department of Physics,
University of Queensland
pimbblet@physics.uq.edu.au

AIP SA Branch

Chair: Dr Jamie Quinton
Chemistry, Physics and Earth Sciences
Flinders University
GPO Box 2100, Adelaide, SA 5001
Tel: 08 8201 3994 Fax: 08 8201 2905
jamie.quinton@flinders.edu.au

Secretary:
Dr Laurence Campbell
Chemistry, Physics and Earth Sciences
Flinders University
GPO Box 2100 Adelaide, SA 5001
Tel: 08 8201 2093 Fax: 08 8201 2905
laurence.campbell@flinders.edu.au

AIP TAS Branch

Chair: Dr John Humble
Private Bag 21, Hobart,
TAS 7001
University of Tasmania
Tel: 03 6226 2396 Fax: 03 6226 2867
John.Humble@utas.edu.au

Secretary:
Dr Elizabeth Chelkowska
Maths and Phys, University of Tasmania
Private Bag 21, Hobart, TAS 7001
Tel: 03 6226 2725 Fax: 03 6226 2867
Elzbieta.Chelkowska@utas.edu.au

AIP VIC Branch

Chair: Dr Andrew Peele,
QEII Research Fellow
Department of Physics
LaTrobe University
Bundoora, VIC 3086,
Tel: 03 9479 2651 Fax: 03 9479 1552
a.peele@latrobe.edu.au

Secretary: Ms. Gaby Bright
PO Box 4355
Parkville Vic 3052,
Tel: 03 8344 3768
gabrielle.bright#versi.edu.au

AIP WA Branch

Chair: Prof. Ian McArthur
Department of Physics
University of W.A.
Stirling Highway
Nedlands, WA 6009
Tel: 08 6488 2737 Fax: 08 6488 1014
mcarthur@physics.uwa.edu.au

Secretary: Dr Ron Burman
School of Physics, The University of Western Australia
Mailing Address: M013 The University of Western Australia Crawley, WA 6009
Tel: 08 6488 2729 Fax: 08 6488 1014
john@physics.uwa.edu.au

News

AKARI sees star formation on the edge

A new image taken by the Japanese/European space telescope AKARI turned up huge regions of star formations on the outer edges of galaxy M101. That is strange since normally galaxies will have the rapid star formation going on near their centres, and not out at the edges. Astronomers think that it is all thanks to a recent collision.

M101 is a spiral galaxy in the constellation Ursa Major, and lies about 24 million light-years away. Its diameter is 170,000 light years across, and it has roughly double the mass of the Milky Way. In a galaxy like this, you would expect to see star formation near the middle and along its spiral arms. But in this latest image captured by the AKARI satellite, astronomers have discovered vast regions of star forming regions right out to its outer edges – they are the bright red blobs in the picture. (Fig 1)

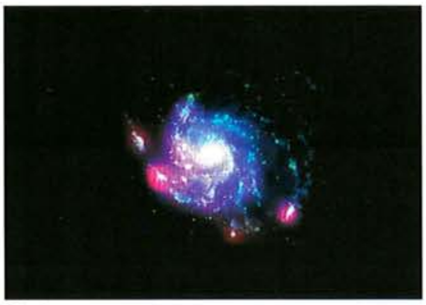

Fig 1

It is not alone. Astronomers know that M101 interacted with another galaxy recently, tearing out vast quantities of gas with its gravity. This gas is now falling onto the outer edges of M101, triggering the active star formation. Astronomers have turned AKARI towards several other galaxies nearby, so they hope studying them will help put the puzzle together.

The Universe Today

New laser makes waves in Japan

The University of Adelaide's Discipline of Physics is making its mark on the world stage by designing, building and exporting a high-tech laser to Japan.

After several years of development, students and staff have this month installed a super-stable laser on the Japanese TAMA-300 Gravitational Wave Interferometer, located at the National Astronomical Observatory on the western outskirts of Tokyo.

The laser is a 10 watt, single frequency, single mode, ultra-stable laser developed at the University of Adelaide, with a purely South Australian heritage linking it back to a pulsed laser range finder originally developed by the DSTO.

"The collaboration with Japan was developed through workshops with the Australian Consortium for Interferometric Gravitational Astronomy, of which the University is a founding member along with Australian National University and the University of Western Australia," said Professor Jesper Munch, Professor of Physics in the School of Chemistry and Physics.

"Our laser was chosen because of its superior performance and design, and will replace a laser manufactured by a large Japanese company."

Professor Munch said the scientific collaboration is expected to continue once the laser is incorporated into the interferometer.

"At that time the laser will have to work continuously, 24 hours per day, seven days a week, often completely unattended.

"It is required to emit 10 watts continuously, and be locked to the interferometer to result in an ultra-stable laser beam with extremely tight specifications for amplitude and frequency noise.

"Our laser is one of a very few in the world that can comfortably meet these requirements."

The development and fabrication was carried out in the Physics Department, primarily by PhD student, David Hosken, and post-doctoral research fellow, Dr Damien Mudge.

They received expert technical assistance from technical officers, Blair Middlemiss, Trevor Waterhouse, Neville Wild and Bob Nation, and guidance from Dr Peter Veitch and Professor Munch.

"The complex hardware and electronic control system were all designed and built in the Physics Department, which for the past 15 years has established itself as a leader in laser and photonics research, including worldwide recognition as a leader in stable lasers for remote sensing," Professor Munch said.

Adelaide University

Australian telescope helps Google reach for the Sky

With a new feature called "Sky in Google Earth", Google is today extending its "Google Earth" product to the heavens—and almost all of the data for the southern sky comes from a telescope in Australia, the UK Schmidt Telescope run by the Anglo-Australian Observatory (AAO). (Fig 2)

Fig 2 The UK Schmidt Telescope
(Image Credit: Shaun Amy)

To access the Sky feature, users must download the newest version of Google Earth.

Sky in Google Earth will let users view 100 million individual stars and 200 million galaxies, and see how planets move across the sky.

Seven layers of information can be called up about celestial bodies and events. These range from Hubble Space Telescope images to a "Users' guide to galaxies" and information for amateur astronomers.

The southern sky data came from 894 photographic plates taken by the Anglo-Australian Observatory's 1.2-m UK Schmidt Telescope at Siding Spring Observatory in northern New South Wales.

"The Schmidt Telescope collects as much information from the sky as a conventional telescope that is much larger, because it can see a bigger piece of sky in a single glance," says the AAO's Professor Fred Watson.

"It's been a tremendous workhorse for astronomy over several decades."

Other data came from the Space Telescope Science Institute (STScI), the Sloan Digital Sky Survey (SDSS), the

News

Digital Sky Survey Consortium (DSSC), CalTech's Palomar Observatory and the UK Astronomy Technology Centre (UKATC).

"Sky in Google Earth will be a fantastic resource for just about everybody," says Watson. "You use it just like Google Earth, and it lets you to view the sky from any place on Earth."

Even professional astronomers are likely to use Sky in Google Earth.

"It will be a great way to for professionals to share new images and science results with each other and with the public. For instance, we could use it to point out where a new supernova has been seen on the sky, or to share new images," Watson says.

Anglo-Australian Observatory

Chinese law to promote honest research

Scientists in China who feel under pressure to report only breakthrough results could soon be put at ease if a new law is passed. Legislators are drafting an amendment to the existing Chinese science law that will prevent researchers from losing their funding if they occasionally fail when tackling difficult research problems.

China's current law on science and technology progress, which has been effective since 1993, states that institutions can "enjoy decision-making power in their conduct of research and development" and that the government should "protect their legal rights and interests against any encroachment." It also notes that there should be sanctions for funding bodies that make deliberate attempts to falsely appraise research.

However, there is no specific statement in the law to protect scientists from having their funding withdrawn if they fail to make any breakthroughs with their research. For this reason, some scientists in China worry that this encourages researchers to fabricate results rather than report failures. Earlier this month, Chinese state media reported that 13 scientists had been blacklisted for falsifying scientific data.

According to the Xinhua news agency in China, legislators are suggesting that an amendment to the 1993 law should state: "Scientists and technicians, who have initiated research with a high risk of failure, will still have their expenses covered if they can provide evidence that they have tried their best when they failed to achieve their goals."

Chen Nanxian, a member of the National People's Congress standing committee in China, said that it should also be amended to encourage scientists to report all failures so that others can learn from the experience.

Xinhua reported that Bai Chunli, the vice-president of the Chinese Academy of Sciences, was concerned about the "atmosphere of fear" surrounding failure in scientific field. "It's difficult to make achievements in independent innovation if the scientific research departments and scientists don't tolerate failures," Chunli told the agency.

Most scientific research in China is funded by the government through bodies such as the Ministry of Science and Technology or the National Natural Science Foundation of China, and compared with the US or the UK there is less funding from the private sector.

PhysicsWorld

Single-photon transistor plans unveiled

Physicists in the US and Denmark have unveiled plans for an all-optical transistor-like device that can be turned on by a single photon. The device -- which has not yet been built -- consists of a single atom that can control the passage of individual photons travelling along a thin nanowire. Single-photon transistors of this type could someday be used to make highly-efficient photon detectors, optical communications systems and quantum computers (Nature Physics doi:10.1038/nphys708).

It is normally very difficult to use single photons from one beam of light to control another beam because photons rarely interact with each other. Physicists believe that the way to get photons to interact with each other is to "squeeze" them into tiny spaces such as a quantum dot or even a single atom in an optical cavity. Squeezing the photons is essential because it intensifies their electromagnetic fields, thereby increasing the chances that they will interact.

Now, Mikhail Lukin and fellow physicists at Harvard University along with a colleagues at the Niels Bohr Institute in Copenhagen have proposed a new way of doing this by focusing photons onto tiny metallic nanowires. Here they are converted into surface plasmons – oscillations of conduction electrons – which travel along the nanowire. This process is analogous to sending a radio wave along a coaxial cable and squeezes the photons into a space that is smaller than their wavelength.

Lukin and colleagues have calculated that if a single atom is placed near the nanowire, it will absorb the first plasmon pulse that passes by, leaving the atom in an excited state. The excited atom will be unable to absorb subsequent photons and the transistor will be in the "on" position. The device could be switched "off" by firing either another single photon or a conventional laser pulse at it, causing the excited state to decay.

According to Lukin, the advantage of using a nanowire – rather than an optical cavity – to squeeze the photons is that a nanowire device would work over a wide range of wavelengths, whereas optical cavities are tuned and therefore will only work at certain frequencies.

The researchers believe that the device could someday be used as a very efficient single-photon detector in optical communication. They also point out that the device could function as a quantum logic gate that could be used

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in quantum computers. Key challenges in building a real device include identifying a suitable atom that can be strongly coupled to nanowire plasmons and connecting a fibre-optic cable to the nanowire to ensure that the photons are transmitted in and out of the device.

Lukin told physicsworld.com that the team is trying to build a device in the laboratory using artificial atoms such as quantum dots.

PhysicsWorld

Chipping in to microfluidics

Devices that allow nanolitre volumes of liquid to be manipulated on "labs-on-chips" are revolutionizing the way biological research is carried out, describe Carl Hansen, Kaston Leung and Payam Mousavi

Imagine stepping off the edge of a swimming pool, only to find that your foot deflects the surface of the water without breaking it, as if held by some impenetrable skin. As you walk forward, the water continues to support you; but if you take a running leap and bring your full weight down on the surface, then it snaps open to envelop you without a splash. Rather than plunging to the bottom of the pool, however, you stop abruptly as your kinetic energy is instantaneously dissipated in the fluid. You flail your arms in an attempt to return to the pool's edge but make no progress, merely bouncing back and forth with each stroke.

While such an experience would come as some surprise to a human used to experiencing life on the macroscopic scale, this is precisely how fluids behave when confined to micrometre-wide channels. On the micro-scale, surface tension and viscosity dominate fluid dynamics, as our imaginary swimmer would discover. These phenomena cause the chaotic turbulence that characterizes macroscopic flow to disappear and be replaced by "laminar flow" in which fluid flows in parallel layers with little or no mixing between them.

PhysicsWorld

Synchrotron spurs scientific research in schools

Premier John Brumby launched the Australian Synchrotron's Educational Virtual Beamline (Sept 6 2007) to help students study the nature of light using the Synchrotron, from their classroom.

The new initiative allowed Year 12 physics students at Williamstown High School to connect via computer to a Synchrotron beamline. Students then manipulated the equipment for their experiments and gathered images and light intensity data.

"The Australian Synchrotron is already contributing to major research breakthroughs in Australia," Mr Brumby said.

"In a first for Australia, we are now opening up this major national research facility and making it a virtual physics laboratory for every high school in Victoria.

"The powerful light of the Synchrotron has already helped break new ground in cancer research, the first of many new discoveries Australia's leading scientists could make using this world-class infrastructure.

"By enabling students to use the Synchrotron we hope to inspire the researchers of tomorrow and continue world-leading, pioneering research."

Mr Brumby said schools will be able to register online, book time for experiments, and give more than 6000 Victorian physics students the opportunity to work with a light source among the brightest in the world.

"The experiment the students undertake using the Synchrotron – the Young Experiment – was first performed in 1880 to discover the wave properties of light," Mr Brumby said.

"Studying the dual properties of light is one of the basic building blocks of scientific research which is why it is part of the core physics curriculum.

"Outside the classroom, studying light has helped understand the stars, led to medical discoveries such as the x-ray and fostered inventions such as lasers which have revolutionised telecommunications.

"Victoria needs bright minds to build a brilliant future. By bringing the Australian Synchrotron into students' own classrooms we hope to inspire the next generation of scientific researchers."

Innovation Minister Gavin Jennings said the Educational Virtual Beamline was more than a teaching tool and would lead to 'eResearch' at the Australian Synchrotron. (See the article in this issue about Gaby Bright.)

"This project uses technology which could lead to remotely-controlled experiments on the Synchrotron's other beamlines," Mr Jennings said.

"Eventually we want to make it possible for scientists anywhere in Australia to send their samples to the Synchrotron and control sophisticated experiments and capture data remotely.

"The aim is a virtual Synchrotron node in each state capital and ensuring this fantastic piece of infrastructure is linked to universities and research institutions across Australia.

"This will be a major advance for Australian science and a new platform for expanding the nation's skills base."

The Educational Virtual Beamline was developed by the Victorian eResearch Strategic Initiative, funded by Multimedia Victoria. It uses the intense blue light of the Australian Synchrotron's diagnostic beamline, normally used to tune and monitor the synchrotron's performance, or a laser beam.

"The Australian Synchrotron is the first in the world to allow high school students hands-on remote access," Mr Brumby said.

"Victoria's investment in the Australian Synchrotron will now be returned to the education system as well as the scientific community."

Australian School Science Education National Action Plan, 2008-2012

A report in two volumes setting out priority actions for Australian school science education.

The Australian Government has released a proposed Australian School Science Education National Action Plan 2008-2012. The proposed Plan is the outcome of last year's announcement by Minister Bishop of a project to map key school science initiatives across the country, to identify gaps and recommend actions to improve science education.

The Plan was prepared by eminent science educators, Professor Denis Goodrum and Professor Leonie Rennie. It has been presented to state and territory education authorities with the aim of achieving agreement about priority actions to be pursued through national collaborative efforts.

New code on responsible research practices and handling misconduct

Integrity in research, meeting community expectations, and handling allegations of misconduct are the focus of a new national code released today by the National Health and Medical Research Council (NHMRC), the Australian Research Council (ARC) and Universities Australia.

The Australian Code for the Responsible Conduct of Research advocates and describes best practice in research for researchers and institutions, as well as setting out a

framework for handling breaches of the Code. While the document is aimed at universities and researchers, it can be applied by any organisation involved in conducting research.

While the overwhelming majority of researchers conduct research responsibly and within a sound ethical framework, it is important when incidents of misconduct do occur that they are managed appropriately.

'It is therefore very important that there is a source of advice to guide responsible conduct, and ensure that processes for dealing with allegations of misconduct are consistent,' NHMRC CEO Professor Warwick Anderson said. 'That's why my colleagues at the ARC and Universities Australia have been as keen as I have been to produce this code.'

The Code provides advice on how to manage research data and materials; how to publish and disseminate research findings (including proper attribution of authorship); obligations in peer review; how to collaborate across institutions; and how to manage conflicts of interest. The Code also provides guidance to institutions when establishing independent external inquiries to evaluate allegations of serious misconduct.

ARC CEO Professor Margaret Sheil said that the Code was a comprehensive document that would be a valuable resource for organisations undertaking research.

Universities Australia Chair Professor Gerard Sutton said the Code was a good outcome from the efforts of the three organisations.

'This is a demonstration that the university sector takes very seriously its responsibility to maintain the highest standards of quality and ethical conduct in its research activities,' he said.

The Code can be found at *www.nhmrc.gov.au*

OPAL reactor shutdown resolution progressing

Implementing a solution to the problem of dislodged plates in fuel assemblies of the OPAL research reactor, estimated last month to take eight weeks, will take longer to complete.

Analysis and testing of the fuel assembly fault has been undertaken by the fuel manufacturer in Argentina and is nearing finalisation. Once completed, these tests will enable a clear path forward to be established. Returning to power will then require approval by the independent safety regulator ARPANSA1.

Detailed examination and removal of the fuel assemblies, including taking high resolution video footage of the fuel elements at the bottom of the 13 metre deep reactor pool, has been painstaking and has required progressive approval and consultation with ARPANSA.

Dr Ron Cameron, ANSTO's Chief of Operations, explained "The processes to remove the fuel and establish the type of tests that need to be done has been thorough but also time consuming, with several steps requiring clearance by ARPANSA before proceeding.

The responsibility for fixing the problem is with the reactor designer under the reactor warranty.

"At this stage, ANSTO2 cannot give a firm time as to when the reactor will be back to full power and producing neutrons for research." explained Dr Cameron.

"It is a frustrating time for everyone, particularly our scientists who are keen to start using their state-of the-art neutron beam instruments which are ready and waiting," he said.

"We are making good progress, and are confident that we will soon have a clear solution to put to the regulator, ARPANSA.

"Because safety is paramount, resolving the problem takes time since activities must be subjected to thorough assessment and often independent regulatory approval.

"It is important to reassure the public, however, that there are no safety or radiation issues, and all ANSTO customers are being kept up to date. Supplies of the major reactor-produced nuclear medicines will also continue to be provided through import and distributed by ANSTO, so patient treatments will be maintained," concluded Dr Cameron.

During a routine fuel change last month, ANSTO discovered that there had been partial movement of plates within three fuel assemblies. A further two assemblies have since been found to also have minor plate movement. The cause is believed to be a manufacturing issue; however all possibilities are still being assessed.

The reactor and its 16-fuel assembly core had functioned very well since full power was reached last November. Each assembly has 21 fuel plates which are 'crimped' into an aluminium frame.

The shutdown has enabled the process to resolve the internal leak, which was causing minor heavy water dilution, to commence this week. This problem was identified earlier this year, and whilst not affecting the reactor's steady performance to date would have progressively affected its efficiency over an extended period of time, if left unremedied.

Nuclear Science exhibition launched - as IAEA turns 50

The year IAEA turns 50, nuclear science and technology will be highlighted at the official opening of an ANSTO sponsored exhibition called Nuclear Matters at the Powerhouse Museum, Sydney.

Mr Andrew Humpherson, ANSTO's General Manager Public Affairs, said the exhibition will give the public a unique opportunity to gain a greater understanding about the role nuclear science plays in our lives.

"The exhibition will give people the chance to really come to grips with what nuclear science is and understand that radioactivity, for example, is part of our lives and around us all the time. The important role that nuclear science plays in understanding our world is growing year by year.

"Nuclear tools can help us understand many things, from how our climate works, to diagnosing and treating diseases, to how a particular material responds to heat or external forces, right down to the atomic level," he said.

"The exhibition aims to educate the community and increase public awareness and knowledge about the many applications of nuclear science, including the generation of power.

"The exhibition not only looks at science and technology, but changes in social attitudes over the last century. It touches on the early 20th century support for radioactive products to today's divided views on all things nuclear, including the politics, economics and sustainability.

"It is significant to ANSTO that this exhibition launch coincides with the 50th anniversary this month of the IAEA, the international body that ensures non-proliferation and which Australia has been a mainstay of for 50 years as a founding member," said Mr Humpherson.

"ANSTO plays a key international role serving the IAEA in a number of areas, from analysing overseas samples to track clandestine nuclear activity, to playing a decision-making role on the IAEA Board."

Australia has been a member of the IAEA Board of Governors continually since it was established in 1957 and this reflects the high credibility of Australian nuclear science and technology and the active roles Australia plays in global nuclear safeguards.

The exhibition is divided into five areas:

- o Nuclear basics;
- o Nuclear in our lives including nuclear medicines and internal body scanning;
- o Nuclear sciences;
- o Nuclear power generation; and
- o Nuclear perspectives which includes changes in social attitudes over the last century.

The exhibition opened to the public 21 August 2007 at the Powerhouse Museum, 500 Harris Street, Ultimo, Sydney.
www.powerhousemuseum.com

Australia wins the International Young Physicists' Tournament

W R MacGillivray FAIP Southern Cross University

Three years ago I wrote an article for Australian Physics about the International Young Physicists' Tournament. At that time, the 2004 tournament had just taken place in Brisbane with Poland emerging as the winners and the two Australian teams achieving eleventh and nineteenth.

To the delight of all involved, the 2007 Australian team of Kathryn Zealand and Antonia Morris from Brisbane Girls Grammar School, Christopher Bentley and Mitchell Stevens from All Saints Anglican School and Thomas Milburn from Brisbane Grammar School won the 20th tournament recently held in South Korea. Team leaders were Mr Phil O'Neill and Ms Noel Chan from BGS and the team was accompanied by Dr Antoine Durandet from All Saints who acted as an independent juror during the tournament, and Mr Alan Allinson from BGGS, a member of the International Organising Committee.

The Australian mascot, Schrodiger, a metre high blow up kangaroo rounded out the party. His name had meant to be Schrödinger but the Koreans could not spell that!

The IYPT is a competition designed for senior high school students. Teams consist of up to five students, with a minimum of three. Each team receives the list of seventeen problems for the tournament about six months before the event. They then spend all of their spare time, and one suspects some of their core time, theorising and experimenting to prepare solutions.

The tournament consists of five preliminary rounds and a final. Each contest or physics "fight" takes place between three teams who take on the roles of Reporter, Opponent and Reviewer in turn. A fight commences with the Opponent challenging the Reporter to present their solution to a particular problem. The Reporter can accept or decline. During the preliminary rounds, a team can decline a maximum of a total of three times before penalties are invoked. A team cannot report on the same problem more than once.

Once the team reporting has accepted a challenge, they have a fixed time to prepare their presentation which is given by a single member of the team, again within a fixed time. It is then the Opponent's turn. During their time allowance, they are able to ask clarifying questions followed by one member delivering a critique of the report. This is followed by a "discussion" between the representative of the Reporter and that of the Opponent. Some of the discussions were vigorous to say the least!

It is then the Reviewer's turn to ask clarifying questions of the Reporter and the Opponent before presenting a critical review of their performance and the physics. The presenter from the Reporter has the last say with a two-minute wrap up.

Each fight is judged by a panel of physicists, teachers

Fig 1. Winning Australian team following presentation of trophy and medals: from left Schrodiger, Christopher Bentley, Thomas Milburn, Kathryn Zealand, Mitchell Stevens, and Antonia Morris

and the odd engineer. At the conclusion of the fight, panel members are able to ask questions of the participants. Then they allocate a mark out of ten to each. The highest and lowest scores are discarded and the remaining averaged. The score for the reporter is weighted by three (unless penalties for too many refusals have been invoked) and the Opponent's mark by two. The maximum score a team can receive from a fight is sixty.

Why did this Australian team win against mainly older competition from twenty countries from six continents? Like all good scientists, this team built on the experience of previous Australian teams over the past thirteen years under experienced leadership. But more than just this, those of us who have been involved in this event for many years, physicists and teachers, all agreed that the final of the national competition between teams from these three schools, was the highest standard yet, and worthy of an IYPT final. Finally, team captain, Kathryn Zealand, was a member of the 2006 team as a Year 10 student and brought outstanding talent, experience and leadership to the rest of this excellent team.

While the Tournament has yet to achieve the profile of the Olympiad competition in Australia, overseas it attracts significant attention. In Korea, the Tournament had intense national media coverage, including all three main Korean Television channels (SBS, MBC and YTN) that filmed the opening ceremony, closing ceremony and the Final. Also during the competition a documentary was filmed about IYPT which will be broadcast on the Korean Education Network. The tournament had logistic support from the Government, University and Industries in excess of US$1,200,000. As a country, Korea has shown a tremendous interest and commitment in

Australia wins the IYP T

Fig 2. Australian team in front of the venue: from left Thomas Milburn, Kathryn Zealand, Antonia Morris, Mitchell Stevens, Schrodiger and Christopher Bentley

developing young physicists via this competition.

The draw for the Australian team was:
Round 1 Germany, Hungary, Australia
Round 2 Australia, Austria, Czech Republic
Round 3 Bulgaria, Australia, Korea 2, Korea 1
Round 4 Kenya, Australia, Switzerland, Croatia
Round 5 USA, Australia, UK

The first round saw Australia meet Germany, a perennial finalist, and gave the team the opportunity to be challenged from the start; the third round involved meeting both Korean teams, the fourth round included last year's champions Croatia, and a fifth round against two English speaking nations in the United Kingdom and the USA.

The problems reported by the Australian team in the preliminary rounds were: Condensation, Rheology, Fluid Lens, Slinky and Water Jets. Details of these and the other problems can be found at *www.iyptaustralia.org*.

Australia finished the preliminary rounds in first place with Korea 2 in second and New Zealand third. In the final, staged before a large audience of around 700 including the Ministers for Education, and telecast live by the three main Korean networks, Kathryn again presented Water Jets, Tom opposed New Zealand's Blowpipe and Mitch reviewed Korea 2's Steam Boat.

It is necessary to correct the notion that Kathryn just repeated her presentation from round 5. In the intervening time, she undertook new experiments, devised a new mathematical model and revised her power points. And it was all worth it with Australia scoring 50.4 to Korea 2 and New Zealand tied on 49.7.

I asked Kathryn to provide me with some quotable quotes for the article. This was her response:

"I was asked to give some 'quotable quotes' for an article on IYPT, but good quotes tend to follow the same pattern: they have a beginning – to catch your attention, a middle – to set up a story, and a punch line - some unexpected, witty, thought-provoking final statement.

But, I find physics isn't like that. IYPT problems might begin that way: you observe a phenomenon for the first time and go "wow!" And it certainly is a catchy start. You get that desperate urge to find out why. Why it does that particularly interesting thing, and why it keeps giving unexpected results?

There is also a comparable 'middle' – the research – reading papers, thinking about the physics, experimenting and trying different things and trying to develop a possible solution or explanation. This is the bit I enjoy most. Sitting down with a pen and paper and trying to write down the physics. Good basic physics. And the freedom to take it where ever you want, often one particular aspect of a problem will be particular appealing, or particularly elusive, and I get such delight from finally graphing the result of some horrible theoretical function, and having it actually look something like the experimental data!

Fig 3. Captain of the winning Australian team, Kathryn Zealand, with 2007 IYPT trophy

Australia wins the IYP T

Fig 4. Winning Australian team following presentation of trophy and medals: from left Kathryn Zealand (captain), Mitchell Stevens, Thomas Milburn, Christopher Bentley, Antonia Morris, Noel Chan (leader) and Phil O'Neill (leader)

The main reason I think an experience like IYPT is completely unquotable is the lack of punch line. The IYPT experience never ends, the physics research doesn't conclude, and the solutions are never complete."

The Teacher/Leaders form a vital part of the team. Their role is probably most vividly relayed in the following description from one of the Australian leaders at IYPT 2007 of the scene deep into the preliminary rounds.

"At this stage of the competition, the teachers are surviving on less than 6 hours of sleep each night (or even dreaming of solutions to problems!) and copious amounts of coffee. Whilst the students are working on their presentations, we are guiding them along with encouraging words, re-reading their presentations, checking the maths in the derivations or actually telling them to stop working because it is getting too late. For me, this is by far the most physically demanding and rewarding part of the trip. It is great to witness a student's grasp of difficult physics concepts, their growing ability to explain it and their passion for the Physics itself! It is a big step for students to accept that their solution is by no-means a perfect solution (unlike most high school physics) in terms of describing all aspects of the phenomenon but it is a part of their continual process of discovery."

To win this tournament is a wonderful achievement. Put in context, most of the competitors from Europe and North America are on average a year older than the Australians. There were a number of Olympiad gold medallists in other teams. In some countries, team members receive intensive training in a university department with staff and resources made available to assist them in their problem solving.

The vision for the IYPT in Australia is for it to become a truly national activity. Teams would prepare and compete in each State or Territory, with the winning teams from each coming together in a national selection final. There has been some interest from schools outside Queensland but efforts for them to attend the selection tournament have foundered due to lack of financial support.

A sponsor, or sponsors, for a national competition are needed for the vision to become reality. Any suggestions? In the meantime, we can bask in the glory of Australia's latest international champions: the 2007 IYPT team.

Leslie Colin Woods 1922 - 2007

Leslie Woodhead (later changed to Woods) was born on December 6 1922 at Reporoa, a small settlement between Rotorua and Taupo in New Zealand. When Leslie was 9 years old the family moved to Auckland.

In 1936 Leslie's father sent him to Seddon Memorial Technical College to train as a mechanic. He sat the Entrance Scholarship examination in December 1939 and came 26th on the list of 30 winners - the first ever winner from Seddon Tech. Leslie enrolled in 1940 to study engineering; but early in the war he resigned his scholarship to volunteer for the RNZAF. In November 1943 he went to Auckland University College and passed examinations in Pure and Applied Mathematics and gained his first degree (B.Sc). In December 1943 Leslie applied successfully for active service in the Pacific War, where RNZAF pilots flew American aircraft. In 3 tours of duty at Bougainville, Flying Officer Leslie Woodhead flew 76 missions, with many raids on the Japanese fortress at Rabaul

In 1946 Les resumed studying at Auckland University College School of Engineering. In 1947, he was awarded the prestigious Rhodes scholarship, completed his B.E. and was appointed as Temporary Junior Lecturer to teach Fluid Dynamics and Aeronautics. In August the Woods' family went to London. Les had been accepted by Merton College in Oxford and where he joined the University Air Squadron.

At the Engineering Laboratory, Les studied under Alexander Thom and worked on transonic flow around a 2-dimensional aerofoil, laboriously solving finite-difference equations with the aid of a Brunsviga calculator. In 1950 he was awarded a D.Phil. for his thesis on *The flow of a compressible fluid about a body*, which resulted in 7 publications. Much later he gained a D.Sc. (N.Z.) and D.Sc. (Oxon), and in 1983 the University of Auckland awarded him an honorary D.Sc. at its centennial celebrations.

In 1951 the NZ Defense Corp seconded Les to the National Physical Laboratory at Teddington, where he worked on aerofoil theory. He applied successfully for a Senior Lectureship in Applied Mathematics at Sydney University to start in February 1954. Then in May 1956, at the age of 33, Les became the second Nuffield Research Professor of Mechanical Engineering at the University of Technology at Sydney. When the Australian Mathematical Society was founded in 1956 he was elected a foundation Council member, and in 1958-1959 he became the vice-president. His extensive research on aerofoil theory was summarized in his treatise **The Theory of Subsonic Plane Flow** (CUP, 1961), which remained in print for 25 years. His lecture notes on reactor physics was published as the Methuen monograph **An Introduction to Neutron Distribution Theory.**

At the end of 1959 the Woods family moved back to England, where Les became an associate of the "Controlled Thermonuclear Reaction Division of the Atomic Energy Research Establishment" at Harwell, for 1960. Previously there had been many attempts to generate power by controlled thermonuclear fusion, with plasma confined by magnetic fields. Les started work at Harwell on investigating the basic magneto-plasma problem of why, in all attempts to confine plasma, it escaped across the magnetic field at *thousands* of times the rate predicted. The early optimistic forecasts of the imminence of power production by controlled thermonuclear reactions looked increasingly improbable. Then Balliol College invited him to become their Foundation Fellow in Engineering. Les began his duties as Balliol Tutor in January 1961, and was appointed as a consultant in plasma physics for Harwell. (Until 1977 he spent one day a week at the Laboratory, situated at Culham, studying mostly instabilities in plasmas.) In 1965 he was promoted to Reader in Applied Mathematics, and in 1969 he was appointed as Professor of the Mathematics of Plasma. Also he accepted many visiting appointments at universities around the world, including visits to NZ.

The marriage of Les and Betty had mostly been happy, however in 1973 the marriage broke down, with divorce in 1977. And 2 later marriages also ended in divorce.

The favourite device for fusion research is the Tokamak, with the Joint European Tokamak (JET) at Culham being the largest, It was designed to generate power by heating deuterium and tritium to 300 million K and confining that plasma for 25 minutes, so that the nuclei would react to produce helium and neutrons. Only in recent years has JET succeeded in confining plasma for a period approaching 1 second. Many types of instability have been discovered by Les and others, and attempts were made to patch up the apparatus to cope with them.

Les wrote **The Thermodynamics of Fluid Systems** (OUP, 1975). In 1979 he found that a basic equation used by plasma physicists was incorrect - the pressure used in that formula does not correspond to the collision of particles. Les then wrote 3 major texts on plasma physics: **Magnetoplasma Dynamics** (OUP, 1987), **Kinetic Theory of Gases and Magnetoplasmas** (OUP, 1993) and **Thermodynamic Inequalities with Applications to Gases and Magnetoplasmas** (Wiley, 1996). Those texts were reviewed dismissively by some in the thermonuclear establishment. In 1984, Les became Chairman of the Mathematical Institute at Oxford University. Then in 1985 and 1986 he was in Muscat, Oman as the Foundation Professor of Mathematics for Sultan Qaboos University. He resigned as Chairman of the Mathematical Institute in October 1989, and his Professorial Fellowship in Balliol terminated in 1990, but he continued research into solar physics.

When Les' eldest daughter Coral was dying of cancer at the age of 49, he wrote for her a brief account of his early life in New Zealand. Under her urging it was expanded and published as **Against The tide: An autobiographical account of a professional outsider**, Institute of Physics Publishing, 2000.

Les summarized his views on Tokamak in his treatise on **Theory of Tokamak Transport: New Aspects for Nuclear Fusion Reactor Design** (Wiley, 2006).

On 2007 April 15, Les Woods died in his sleep at Oxford, aged 84.

Garry J. Tee & Graeme C. Wake
Auckland, NZ
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Climate change and nuclear power in Australia

Ziggy Switkowski
Former Chair of the Prime Minister's Review of Uranium Mining, Processing and Nuclear Energy

Notes from a talk on 12 June 2007 sponsored by the University of Melbourne and the Victorian branch of the Australian Institute of Physics

Ziggy Switkowski with Andrew Peele, chair of the AIP Victorian branch.

Context for the nuclear debate
In introducing the topic of the nuclear fuel cycle to public debate last year, the government probably had three considerations in mind:

(1) The demand for electricity is expected to grow by 1.5%–2% per year into the future. This means that Australian use of electricity will be double today's levels during the 2040s and planning for, and investing in, electricity generation needs to happen now; and all available platforms for generation must be on the table. For baseload generation there are probably only four options: coal, gas, hydro (now in question) and nuclear.

(2) There has been a 20 year hiatus in discussion of nuclear power in Australia following the abandonment of plans to construct our first power reactor in 1973, followed by restrictions on uranium mining from 1983. If nuclear energy is to be thoughtfully considered, public understanding of the technology, recent experiences of nuclear powered countries, possible domestic scenarios, and answers to many thorny questions including waste and proliferation, need to be updated.

(3) There is no difficulty in generating electricity in Australia. Our reserves of coal and gas are the envy of all countries and fossil fuels provide 90% of our power. The challenge is not how to power growth, our prosperity and quality of life; the issue is what environmental price are we prepared to pay? Nuclear energy may offer the possibility of truly clean, green and safe electricity.

Findings of the 2006 Nuclear Review
The Review commenced its work in July 2006, and issued its Report at year end. Its mandate was to inform the public debate—to help Australians understand the issues in the context of contemporary developments. Its role was not to be an advocate of nuclear power. The work has been comprehensively reported, broadly reviewed and debated in the media and academia (insightful and balanced) and continues to contribute to an informed public debate.

The four headline findings were:

Uranium Mining. There is no reason to limit our prospecting, mining and export. Demand is solid and will grow (prices are currently very high); overseas companies like dealing with Australian suppliers because our mines are world class, have excellent safety records, our supply chain management has integrity, and we are compliant to the most stringent international nuclear protocols. The business opportunities are compelling.

Value Adding. Substantially this is about the enrichment of uranium to power reactor grade level (from 0.7% to 3–5% U-235). It is presently illegal to enrich uranium in Australia. The Review concluded that, while there was little reason to explicitly prohibit downstream processing of uranium, the business case for any multi-billion dollar investment was a difficult one since the technology is tightly controlled and current enrichment capacity sufficient to meet global demand for more than the next decade. Although a year ago the value split between mining and downstream processing was 40:60, with the sharp recent increase in uranium prices, that ratio will move closer to 70:30, suggesting that Australian miners will capture most of the value in the production of nuclear fuel for reactor operations.

Climate change and nuclear power in Australia

Nuclear Power. Presently there are 31 nuclear powered countries, with 20 more in the queue. A total of 443 reactors (plus about 150 nuclear powered aircraft carriers and submarines) generate 15% of global electricity, and 23% in OECD countries. Nuclear power has some appeal for desalination and hydrogen production, but is 20–50% more costly at the generation stage (although this differential goes away with moderate carbon pricing). Its introduction would take 10–20 years. There would be a potential need for government to kickstart the industry as has happened in all other countries. Beginning in the 2020s, Australia could have 25 reactors by 2050 producing a third of our electricity needs with near zero greenhouse gas (GHG) emissions. Total GHG abatement would be 18% versus business as usual. Nuclear power could be a valid part of a portfolio approach, but not itself a 'silver bullet'.

Waste & Proliferation. Spent fuel rods can be kept in long term storage in 500 metre deep wells. There is a globally agreed strategy but no operating repository yet for long-lived high level waste. There is a need for a geologically and hydrologically stable location some distance from population centres. About 90% of the Australian continent qualifies as a possible location. One national facility over a few square kilometres available from around 2080 would be sufficient for Australia. The proliferation and illegal diversion of nuclear materials have not been issues for compliant regimes (our region is already in a community of nuclear powered countries). But the management of long-lived radioactive waste remains a concern for many people who argue the risks to the environment from any misadventure, and the burden bequeathed to future generations. No country accepts nuclear waste from any other country for permanent storage—a position supported by the Review. Some countries have enacted laws that require them to have in place acceptable plans for permanent local storage of the spent fuel and prohibit consideration of exporting such materials.

Current status

Over the past 12 months, quite remarkable progress has been made:

(a) There is now bipartisan support federally for the removal of impediments to uranium mining and export, but this is still a State matter.

(b) There is also bipartisan support for an Emissions Trading framework with (key) details still to be developed.

(c) Steps have been proposed to overhaul federal legislation to permit broader involvement in the nuclear fuel cycle.

(d) Investment in skills and training, and curriculum design, to address a 20 year gap in our competency building regarding nuclear technology (we need nuclear engineers, radiation chemists, geophysicists, occupational health technologists, regulators, etc.). Interestingly, the successful completion of the OPAL Research Reactor at Lucas Heights and the Australian Synchrotron in Melbourne—both in recent months—demonstrate world class capabilities in nuclear project management and engineering.

(e) The decision for ANSTO to join the international Gen 1V consortium to help develop the next generation of nuclear reactors.

(f) The announcement by the government of an education program to continue the public conversation about the nuclear fuel cycle.

At the first anniversary of the beginning of the Nuclear Review, we have come from a position where nuclear power was not an acceptable topic within polite Australian society, to one where many people have an informed view and are open to debate—though not necessarily supportive.

Community attitudes

In 2006, the top three objections to the introduction of nuclear power to Australia were: (1) long-lived toxic waste; (2) the possibility of a catastrophic accident like Chernobyl; and (3) terrorism and proliferation. In 2007, these concerns, although still there, have been overtaken by: (1) the costs of nuclear power; (2) the long 10–20 year lead times; and (3) the proposed location of reactors. The waste problem remains a broad general concern. These changes reflect a shift from opinions formed during the Cold War, Three Mile Island (1979), Chernobyl (1986) and upper atmospheric testing of atomic weapons by the French in the 1970s, to what are now largely commercial challenges: 'It costs too much, takes too long, and won't get environmental approval for site selection'. If these orthodox business case challenges cannot be overcome when translated to the 2020s, then nuclear power cannot and should not be an option for Australia.

Why the urgency?

Given that investment decisions for new electricity capacity play out over the years (and commit us to a specific technology for 30-50 years), and climate change itself is measurable over generations, not months, why is there a national urgency to establish policies in this area?

There are three possible reasons:

(1) 2007 is an election year with energy and climate strategy a matter of sharp policy differences between the parties, or at least a perception of differences. Positions will be taken in the months ahead which will define government policy for some years ahead.

(2) Global decisions will be made around us by our trading partners. We need to get to 'the main table' to help shape international thinking, and to protect and advance our commercial interests.
(3) Significant infrastructure investments have been queued up awaiting more certainty about future rules, especially regarding carbon costs, targets for renewable energy, etc. The past hesitation to invest may yet cause energy shortages in the years ahead. Investments need also to properly reflect long term national aspirations as they will bind us to particular technological platforms for up to 50 years, and for which retrofitting environmental filters may not be a practical option.

Challenges specific to nuclear power

Overseas experience suggests that once nuclear power is up and running, some communities move progressively to a position of neutrality or support for nuclear electricity, indeed sometimes competing to be the preferred location for future facilities.
But the process to fund and install the first reactor almost always faces significant challenges and, in Australia, these include:

- Lack of bipartisan support for nuclear power—a sovereign risk.
- Nuclear power is the most capital intensive of energy technologies, around $3 billion per reactor. Such an investment in a project with long lead times, with some technology risk, and with regulated retail prices makes any business case quite difficult. (Nevertheless, nuclear power holds the promise of being the lowest cost, near zero GHG emitting source of electricity in the 2020s.)
- The structure, including diverse ownership, of the country's electricity grid makes any reactor decision a very significant one for the utility or state government involved. There is a potential lack of scale to accommodate the most efficient large reactors.
- There is no regulatory framework yet in place for an industry highly dependent on appropriate licensing and compliance processes, with expensive projects vulnerable to unplanned delays.

Notwithstanding such hurdles, another 20 countries are queuing up to install their first reactor.

Climate change

The science of climate change is sound. The forecasts are the outputs of the most sophisticated climate models available to us. We are living through a significant warming period largely driven by the accumulation of GHG in the atmosphere, arising from our use of fossil fuels such as coal, gas and petrol. The vivid depiction of the consequences of a warmer environment (droughts, water shortages, bleached corals, receding glaciers, melting icebergs, species destruction, rising sea levels, more intense cyclones and hurricanes, etc.) are consistent with the scientific analyses. To limit temperature increases to below 3 degrees (beyond which climate models suggest dangerously unstable global conditions to occur) by the end of this century requires changing the trajectory of current global emissions from a possible doubling by 2050 to a level 60% below the 1990 level.

The Intergovernmental Panel on Climate Change (IPCC) does not recommend targets—it describes various scenarios. But many countries have adopted this 60% GHG reduction goal, although none has a coherent plan to achieve it, and global emissions continue to rise. While some regions in the world will benefit from a warmer climate (e.g. Scandinavia, Russia, parts of the US), and therefore welcome a degree of warming, Australia will find it more difficult. Warming across the continent is predicted to be uneven—most severe in the South East; little change in the North. It is in our interests to limit global warming in the generations ahead—accepting that no intervention can affect the warming trend for perhaps 30 years given the legacy of global emissions which live in the atmosphere for over 100 years, and the reality of our installed base of fossil fuelled infrastructure.

What should we do? Australia's contribution to global GHG accumulation in the decades ahead will be about 1%. Focusing upon a domestic set of initiatives, though worthy, might prove pointless. All our steps should be directed to making a difference globally—climate change is a global phenomenon driven by the sum of all emissions. This inevitably requires agreement among the world's largest economies/emitters.

Six communities—the US, China, Japan, Russia, India and the European Union—account for 70% of the world's emissions. What they do collectively matters. The rest of us have parts to play, but they are meaningful only if they help drive sensible global initiatives.

Our priorities should be:

- Given that more than 70% of the world's electricity comes from coal (and will be for decades to come), and the importance of that product to our economy ($23 billion annual revenue), a national priority must be to make coal a cleaner fuel source. In particular, if research into geosequestration enables early implementation of carbon

Climate change and nuclear power in Australia

capture and storage, Australia should take the lead.

- To the extent that Australia can influence the major emitters to set upon a GHG reduction path, we should do so. Here our relationships with regional partners (especially China, Japan and Indonesia) and the US are especially relevant.
- Financial engineering in its positive sense is a national competence. The design of a carbon costing regime (such as an emissions trading framework) with a structure that allows for ready coupling to a global scheme plays to our strengths.
- Support the international expansion of nuclear power by opening up our uranium mining and export industry and continue to operate to the highest standards when supplying uranium to our customers. Today, Australian uranium and coal contribute roughly similar quantities of electricity worldwide. As that balance shifts to more nuclear power, so will the GHG challenge become more manageable.

Our domestic strategy needs to be one of adapting to a progressively warmer climate—indeed learning to thrive in it. Water availability is already a major national challenge, but unlike global warming, water management is a local issue under our control. Increasing numbers of bushfires and extreme weather events are expected—emergency service protocols need continuing improvement. Warmer temperatures require different building designs and codes. Some industries and their employees may need to relocate. There will be winners and losers over the decades as fossil fuels are displaced by cleaner alternatives. Energy costs will increase, perhaps substantially. Energy efficiency and conservation will become important. New business opportunities will appear and reward the inventive, farsighted and entrepreneurial.

Remaining issues and conclusions

Obviously many questions remain:

- What is the proper role for government? Is it to pick winners, to design even-handed incentive schemes or to set priorities? Is global warming the issue of our generation? What about poverty, malnutrition/famine, health/AIDS, illiteracy/education, terrorism, ethnic violence, drugs, pedophilia, crime etc.?
- Should we put more emphasis on renewables (solar, wind, geothermal, tidal, wave power) and demand more of our national R&D?
- Do we focus upon climate change, a global phenomenon, or climate adaptation, a local challenge? Or do we focus on both?
- Whether we invest 1% GDP each year (as recommended by the Stern report), and/or accept a few percent reduction in GDP from environmental initiatives and costs, this is a trillion dollar decision by 2050. Are we prepared to make it?

The Rio Earth Summit put climate change on the international agenda in 1992. Kyoto attempted to start the process of controlling emissions in 1996. But 2006 will be judged by history as when the alarm bells were heard globally. Importantly, 2007 is when Australians set their course to address the implications of global warming in our own backyard.

Factoids: Nuclear Power

- If Australia had the OECD level of 23% nuclear electricity, it would have 12 reactors today.
- The fissionable isotope U-235 represents 0.7% of natural uranium. It is enriched to between 3–5% for a power reactor, but more than 90% for weapons production.
- A typical reactor has a fuel load of 200 tonnes of enriched uranium in its core. About one third is replaced each year. This 70 tonnes annually of spent fuel rods (about the volume of a cube 2 metres each side) is stored on the reactor site until ready for long term storage in a deep repository.
- Over a typical 60 year lifetime of a nuclear reactor the volume of about 4200 tonnes of spent fuel rods produced would fit a cube 8 m each side—about the volume of a small single level suburban house.

Climate change and nuclear power in Australia

- One tonne of carbon dioxide has the same volume. Australia emits 560 million tonnes of GHG each year.
- The price of uranium has increased more than ten-fold in recent years to above $US130 per pound. Australia has 38% of the world's recoverable reserves. Some forecasts anticipate a uranium export industry approaching $10 billion per year by 2020, making uranium one of our top five export revenue earners. Coal contributes $23 billion per year today.
- In our region, the following countries are nuclear powered: China, Japan, India, Pakistan, South Korea and Taiwan. The next with plans to go nuclear are Indonesia and Vietnam.
- Approximately 20 countries are planning to introduce nuclear power in the next 15 years, while Germany, Sweden, Portugal and Belgium are planning to reduce their commitment to nuclear power. However, both Germany and Sweden are now reconsidering their positions.
- France produces more than 80% of its electricity from its 59 nuclear reactors. France has three times our population and economy, but has a slightly smaller absolute level of GHG emissions.
- Current projections see about 10 new reactors being built globally each year, meaning that during the 2050s the reactor population will be double today's 443. Even at this rate, nuclear power will barely keep up with the growth in global demand for electricity overall.
- Nuclear costs for electricity generation would be higher than for fossil fuel alternatives in Australia today by 20–50%. Generation costs represent one third of retail costs (the rest being in transmission, distribution and retailing). Even if nuclear was twice as expensive to generate (unlikely in a carbon costed world), and by 2050 a third of Australia's electricity was produced by 25 reactors, then the average household electricity bill could be 10% higher than might otherwise be the case. This increase would occur over more than 25 years at a rate of perhaps 0.5% per year, ie. about $1 extra every quarterly electricity bill.
- This calculation extends to all new forms of energy, including renewables. Early concerns with uncompetitive costs will be overtaken by the introduction of carbon costs for fossil fuels, the reducing costs of new technologies, higher community priorities for cleaner energy, and the social acceptance of slowly increasing energy bills in general.

Factoids: Climate Change

- The goal of greenhouse gas abatement is to stabilize global GHG concentrations to between 450–550 ppm by the middle of the century and to limit global warming to 2–3 degrees by the end of the century.
- The average temperature across Australian population centres (day and night, and all seasons) is about 15 degrees. While the average warming trend of 2–3 degrees over a century seems relatively benign (Melbourne's climate will be more like Adelaide, Sydney's like Brisbane), such increases may have dramatic impacts upon the global ecosystem. In 2005, the hottest year on record, 35,000 people died from heat related causes in Europe.
- GHG concentration is presently about 380 ppm and is expected to reach 480 ppm in 50 years. Of this increase in 100 ppm, Australia will be responsible for about 1 ppm.
- In the next 18 months, the US and China will emit more GHG than Australia will to 2050.
- Six communities—USA, China, Japan, Russia, India and the European Union—account for 70% of the world's emissions. Alignment of these major emitters regarding GHG reductions is critical to any global climate change strategy.
- One typical example of energy trends: electricity usage in south-east Queensland rose from 6.4 MW-hours per person in 1996 to 10.4 in 2006 (slightly above the OECD average). This 5% annual increase was driven by growth in access to air conditioning and household appliances (e.g. plasma TVs), an ongoing trend across the country.
- More GHG (11% of annual emissions) are produced by the nation's livestock (methane from belching by cattle and sheep, and decomposing manure) than by our 10 million passenger vehicles (8%), although the latter are growing more quickly.
- China and India account for 37% of the world's population, with about half their people living on less than $US1 per day. Access to electricity is an understandably higher priority for these countries than climate change. Each country continues to markedly increase its network of fossil fuel plants.

This edited version of the talk was prepared by Peter Robertson from RMIT University.

Life outside physics

by Ms Gaby Bright
gabrielle.bright@versi.edu.au
http://www.versi.edu.au

Although I did not intend to study physics at University it was no surprise to family and friends that I did end up becoming a physicist. I grew up helping my dad build and fix audio equipment at home – my going away present when I left home for university was a soldering iron. At Melbourne University I enrolled in a degree in construction management, which would have combined project and people management with technical knowledge, but after a summer away from study working on an apple orchard, I was suffering from maths withdrawal and changed degrees to study science. My experiences while growing up of fixing stereos and having the workings of a car explained to me lead me towards study in an experimental physics field. I completed honours in experimental particle physics in 2000, having been drawn to fundamental questions that particle physics attempts to answer: the systematic organisation of particles, the interactions between them, and the opportunity to have a hands on role in research.

Student Politics

During the third year of my undergraduate degree I got involved in activities in the Melbourne University Student Union. I enjoyed the process of making decisions about services that supported students and being part of an organisation that enhanced the lives of students during their time at university. It was during my honours year, when I was contemplating options for the future, that the opportunity to run for a position within the Student Union arose. I ran and was subsequently elected to a position that coordinated student services and spaces available in the building. It was great timing for me as it was a twelve-month fixed term position, allowing me the mental break from study whilst I remained on campus and continued tutoring and demonstrating undergraduate classes.

At the end of the year in the Student Union I was considering one of two paths: either postgraduate study in physics continuing on in experimental particle physics, or study in public policy. (This latter interest was shaped by my time in the Union.) I was offered a PhD place at Melbourne University, in the Experimental Particle Physics group.

Research

One of the appealing aspects of studying experimental particle physics is that my research allowed me to do a wide variety of activities. Through Australia's involvement in the ATLAS (A Toroidal Large hadron collider ApparatuS) collaboration at CERN, I participated in the construction and testing of the Semi-Conductor Tracker (SCT)—the detector is the innermost section of the massive ATLAS detector. The

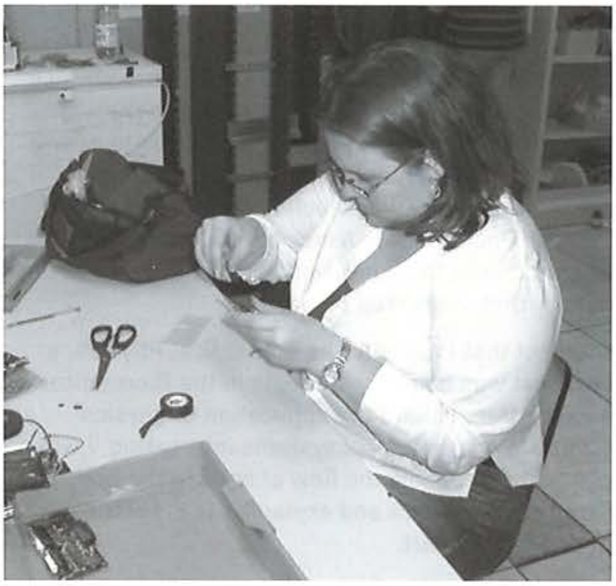


Fig 1. At CERN adjusting the cards that were an interface between the silicon detectors and the signal and power cables.

experiment, which will begin taking data in 2008, is a search for the Higgs Boson, the last Standard Particle to be discovered. The SCT will be responsible for the detection of particle tracks in a strong magnetic field, enabling the identification of charged particles. To provide the required accuracy the silicon detectors must be aligned with incredible precision; to within a tolerance of five microns, a tenth of the width of human hair. Addressing the engineering challenge was the first part of my research work.

All the components of the ATLAS detector must maintain their performance over the ten year life of the detector, in a radiation intense environment. The radiation damage to the detectors affects the speed of charge collection in the silicon and the applied bias enhances the collection. The settings of pre-irradiated detectors are finetuned, in testing, to simulate the radiation damage that could be expected over the ten year life of the experiment. The efficiency of the detectors was tested by using particles created by the Super Proton Synchrotron at CERN. (Fig 1)

The ATLAS experiment will not start for another nine months and in the years leading up to the experiment going online particle physicists simulate the creation, decay, and detection of particles. The capacity of the ATLAS detector as a whole, to detect rare decays, such as the lepton flavour violating decay $\tau \rightarrow \mu\gamma$, the decay I studied, helps finetune other settings. The data read out rate limits the particle events that can be recorded. Different event signatures aid physicists in determining which events will be recorded.

Life outside physics

Extra-curricular activities

Whilst undertaking my research in Australia and at CERN, I continued with my involvement in student representative activities and tutoring opportunities.

I had long been involved in the undergraduate physics student society and continued this involvement with the postgraduate physics society. In addition to acting as a student representative on Departmental and Faculty committees I was elected to the University of Melbourne Postgraduate Association Council. It was a great opportunity to be involved in other aspects of the University that supported research.

The subject that I tutored was Biomedical Physics, a subject that was taken by students in the Biomedical Science degree. I found the application of physics principles to our biological systems interesting. I was teaching students how the flow of salts in the body can be mapped as a circuit and explained the electrical response of the heart.

Like many physicists, I had not done any biology since high school and was much more interested in the field than the last time I had studied it ten years previously. I found myself looking for more relevant application of my research. The opportunity came about in the form of a job in the Victorian Public Service.

Science in the Public Service

I had for some time been distracted by my representative work and was no longer stimulated and motivated by the (physics) work I was doing. Whilst I will always be fascinated by particle physics, the reality for me was that I was no longer interested in the day to day work that is required. My supervisor and I agreed that I should convert my PhD to a Masters of Science and begin looking for jobs. What seemed like an ideal job for me was advertised; a position in the Radiation Safety Unit of the Victorian health department; and I was successful in my getting the role.

Radiation equipment and sources are regulated by each of the States, with dedicated teams of physicists required to understand the oftentimes publicly sensitive science that is involved. Whilst the physics itself was not complex the expression of it in policy documents and legislation required scientific communication skills.

The practical application of scientific knowledge was born out in the emergency management role that each of the State radiation regulators play. I was trained, alongside personnel from police, fire and ambulance services, to deal with radiation emergencies. In Victoria this training was of particular relevance during the running of the Commonwealth Games. The role of the physicists was to provide clear advice in often incredibly stressful circumstances.

I enjoyed the communication challenge posed and was able to explore the difficulties in science communication in a public awareness program I managed. The "Solaria: Fashion to Die For" campaign aimed to educate young women about the dangers of prolonged and frequent solarium use. The reality is that the health issues posed from the use of industrial and medical radiation sources are dwarfed by the effects of exposure to ultraviolet radiation from the sun. (Fig 2)

My move away from doing physics on a daily basis continued when I moved to my current role: Communications Manager for VeRSI, the Victorian eResearch Strategic Initiative.

eResearch

eResearch is the use of information and communication technology (ICT) in research. It is something that physicists have been doing for decades, perhaps best demonstrated by particle physicists using the web to share the vast amounts of experimental data they generate. The use of technology is not as prevalent in other scientific disciplines and even less so outside the sciences. Whilst VeRSI is an initiative to increase the adoption of eResearch by Victorian researchers generally, our particular focus is on those researchers

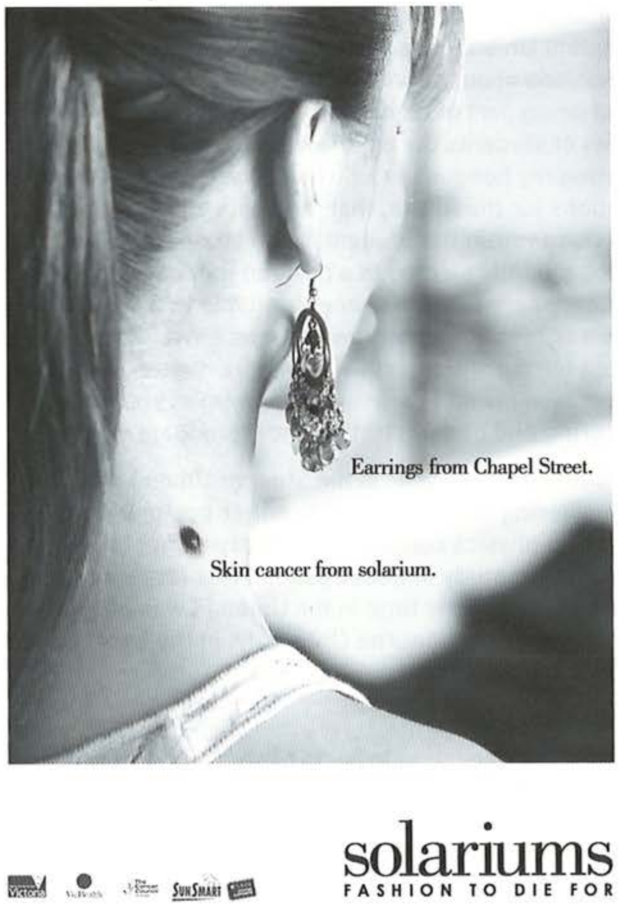


Fig 2. A poster from the solaria awareness campaign.

Life outside physics

Fig 3. Talking about eResearch at the national conference in Brisbane in June 2007.

working in the life sciences.

Australia has the good fortune to be home to world leading research, and researchers, in the life or biomedical sciences. There are two key reasons why eResearch can be of such great benefit to research in this field in Australia. One, our geographical location makes collaboration more difficult, and two, increasing the size of the inherently small collections of data provides greater scientific credibility and integrity. (The data sets are usually small in sample number only—medical imaging can produce very large data sets.) The challenges arise in the combination and handling of data and this is where eResearch can help.

As a particle physicist I am familiar with much of the computing jargon but additionally, and perhaps more importantly, understand the needs and ways of researchers in a way that ICT specialists may not. My role is to raise awareness of eResearch and, where necessary, act as a bridge between the sometimes disparate worlds of scientific research and information and communication technology. I provide training for researchers and represent VeRSI and our work in public fora. A big part of awareness raising is simply talking to people about it at every opportunity. (Fig 3)

The most recent opportunity to present the work of VeRSI was the launch to secondary school teachers of Young's double-slit experiment, located at the Australian Synchrotron. The unique feature of this particular experiment using visible light from the synchrotron, which has been designed for teachers of year 12 physics, is that it is completely remotely controllable via a website. Teachers can log in to move motors changing the slit width and the light source, then download data for further analysis. Neither the experiment, equipment nor technology is ground breaking, but it is the combination, in a practical manner that makes an otherwise remote experiment accessible to thousands of people.

(Further information: *http://vbl.synchrotron.vic.gov.au/BeamLineAccess/eVBL/*) (Fig 4)

In my job I love learning about the range of research that is occurring in Australia and in being part of the support of this research. I work with physiotherapists, biologists and, perhaps surprisingly, physicists. It should be no surprise though that physicists are taking their skills and applying them in other fields. Physicists are great problem solvers and are adaptable in the application of their skills. Particle physicists, and other 'flavours' of physicists are increasingly revealing themselves in the eResearch sphere. It is, perhaps, our role as the original eResearchers—physicists are user-builders and have, traditionally, developed the infrastructure needed to support our research.

My shift away from physics has been gradual and not particularly strategic. I had developed skills in communicating scientific and technical information through teaching, and the presentation of my work at various conferences and this combined with my interest in the diversified application of my other skills to take me to where I am now.

My training as a physicist is with me now and characterises much of how I do my work. I have had specialist web development and media training to supplement my research and technology experience and continue to learn how to develop communication strategies.

I still, proudly, refer to myself as a physicist, and imagine that I always will. It is something that stays with you forever.

Fig 4. Talking teachers of year 12 physics through the remote access to Young's double slit experiment.

l'Oreal For Women in Science Fellowship

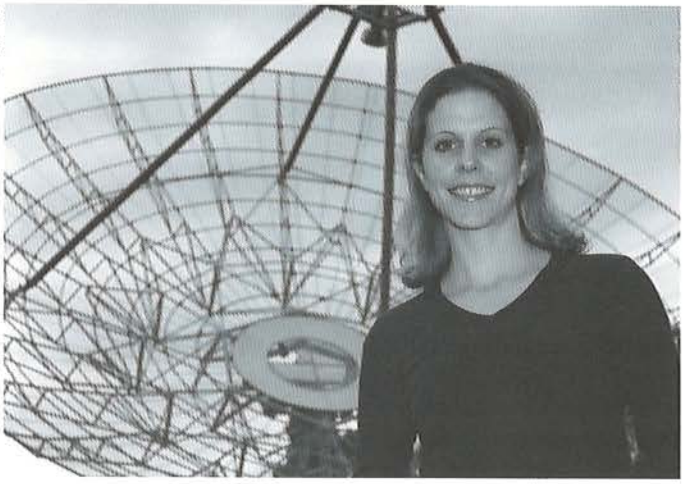


Photo credit: SDP Photo, Tim Morison

Black holes are some of the most bizarre objects in the universe. They can have as much mass as a billion stars combined. How did they form and how did they get so big?

"What are they doing to the galaxies in which they live?" asks Dr Ilana Feain of the CSIRO's Australia Telescope National Facility.

This is one of the biggest questions facing astronomers in the 21st Century. The 29-year-old astronomer will use her L'Oréal Australia For Women In Science Fellowship in her quest for an answer to this question.

And she is enlisting two Australian girls' schools to contribute to a 24/7 program to observe a 'nanoquasar' and its associated black hole some billion billion kilometres from Earth.

What role do black holes play in the creation of stars and galaxies? Stars form from collapsed clouds of interstellar gas. When black holes are nearby do they help concentrate that gas to make stars easier to form, or do they blow the clouds apart before the stars can get going?

"Black holes could play an important role in star formation and galaxy evolution," says Ilana. As a PhD student Ilana made a series of remarkable observations of black holes in the most distant galaxies in the cosmos.

"Ilana is intelligent, enthusiastic and has a very probing style," says Ron Ekers, Federation Fellow at the CSIRO's Australia Telescope National Facility.

"She digs into the fundamentals and develops a clear understanding of both the instruments she is using and the objects she is studying."

Ilana has travelled to major observatories in the USA and Chile to make her observations, and she has attended a number of prestigious meetings and workshops overseas.

While this sort of international travel is a necessity for scientists these days, she has her sights firmly set on a career based in this country. Australia is one of two possible sites for what will be the largest radio telescope in the world - the Square Kilometre Array.

Ilana is keen to get her hands on it to extend her work. "The galaxies and black holes I'm studying are basically the most distant objects in the universe—they existed when the universe was less than a tenth of its present age—and we have no idea how these bodies could have formed so quickly after the Big Bang," says Ilana.

Ilana's other passion is public outreach: talking to school students and adult groups to convey the excitement of the work she and other astronomers are doing.

"I feel rewarded when I go into schools to give them a 'this is astronomy' talk and they ask questions," she says. Ilana actually dropped out of school after year 10, but soon changed her mind and went back to finish Year 12.

"I was never inspired when I was a student. I didn't enjoy school, but here I am now a physicist!" she says with a wry laugh. This is part of why she is so passionately committed to spreading the word about the excitement and wonder of scientific research and why she has already taken part in many outreach activities.

"I'm very committed to my work in astrophysics, but I also want to spend a lot of my time taking science to the public through various outreach activities," she says.

"I think it's important to encourage students and let them know how exciting science is, and how much opportunity is out there."

This is one reason why she is now involved with an ambitious project enlisting high school students to contribute to cutting-edge astronomical research.

Global Jet Watch—an initiative being led by Dr Katherine Blundell at Oxford University in the UK—is establishing small observatories at five girls' boarding schools around the world, Tara in Sydney, and one in India, South Africa and Chile.

A second Australian site is proposed for Perth. The students will make real scientific measurements of the behaviour of a famous black hole system called SS433.

"This exotic phenomenon fires jets of hydrogen from near its black hole at speeds of over a quarter of the speed of light in two directions. These sweep out along an axis every six months, producing a corkscrew pattern. As visible astronomy can only be done at night, keeping a constant watch on SS433 is impossible for a single dedicated observatory and yet is essential for us to understand the physics of nanoquasars, and by analogy of quasars and radio galaxies," says Ilana.

The data will be combined and processed by Global Jet Watch scientists and, it is hoped, will lead to a better understanding of these bizarre cosmic beasts.

Ilana was approached to be the Australian scientist for the project, and will divide her time between training and encouraging the students and analysing the data they generate.

The L'Oréal For Women in Science Fellowship will greatly facilitate this work. It promises to be an exciting and rewarding endeavour—and the perfect outlet for Ilana's talents and interests.

Supporting tomorrow's physicists

Over the last two years the Defence Science and Technology Organisation (DSTO) and the Australian Institute of Physics (AIP) have jointly supported an honours scholarship for two of the best eligible candidates studying physics in Australian universities.

Four have now been chosen. This year the recipients were Tom Griffin from the University of Sydney, and Paul Altin from ANU. In 2006 the recipients were Yakov Kulik from UNSW and Jolyon Bloomfield from ANU.

Tom Griffin

Tom Griffin formed an interest in science at an early age. "The underlying logic and careful reasoning of scientific thought greatly appealed to me," he says. "To be able to uncover and explain the fundamental laws of nature through mathematics and reasoning is an ideal that has mesmerized me."

His interest has led him to study physics at the University of Sydney, where he is now undertaking his Honours year, supported by a DSTO-AIP Honours scholarship.

Last year, he undertook one semester of study at the University of California Berkeley where he had the chance to interact with some of the world's leading physicists, further strengthening his passion for this field.

During his studies at Sydney, Tom has also conducted research that has resulted in original, publishable work, to the great delight of his supervisors.

Once he completes Honours, he intends to pursue research in quantum field theory and string theory...both major areas of physics that promise to revolutionise mankind's understanding of nature and the cosmos.

Paul Altin

"I was attracted to physics because of my desire to learn about the natural world," says Paul Altin. "I'm fascinated not only by what is known in this fundamental science, but also by what is still to be discovered."

Paul has been doing a research-focused Bachelor of Philosophy degree at the ANU since 2004, and this year is undertaking Honours in physics, thanks partly to a DSTO-AIP Honours scholarship.

His research interests so far have been wide-ranging, including isotope production, relativistic optics (he helped produced a DVD on relativity that is used in schools and universities around the world), biophysics, laser physics, cosmology and astrophysics, electrodynamics and condensed matter physics.

In his Honours year he is now concentrating on atom optics, specifically research into Bose-Einstein condensation. This is a dynamic new field at the forefront of modern physics.

"I feel that I can contribute to the outstanding research currently being performed in this field here at the ANU," he says.

Jolyon Bloomfield

Jolyon Bloomfield has been passionate about physics since he was a kid.

"I have a deep desire to understand how this universe works, and a fascination for the amazing phenomena and relationships between fields and matter," he says.

He topped his year in 2006 at the ANU in honours in physics, attaining a mark of 96/100 and 97% for his thesis. Upon graduation he was awarded the University Medal in Theoretical Physics. Jolyon's work was supported by a DSTO-AIP scholarship.

While at the ANU, amongst other things he studied low-temperature gases in one dimension. "Our world is three dimensional, but that often creates issues with finding exact solutions," he says. "One dimension simplifies the maths significantly, and in special situations, can be replicated experimentally."

He also worked with Dr Craig Savage to investigate quantum cryptography methods using satellites. However he had to cut short this work when he learned that he had been accepted to begin a PhD in physics at Cornell University in New York State. That's where he is now, and he's eager as ever to get stuck in.

"I look forward to finding out what people are researching over here, and diving into the world of physics," he says. "Through a better understanding of this universe, I hope to contribute to the betterment of society."

Yakov Kulik

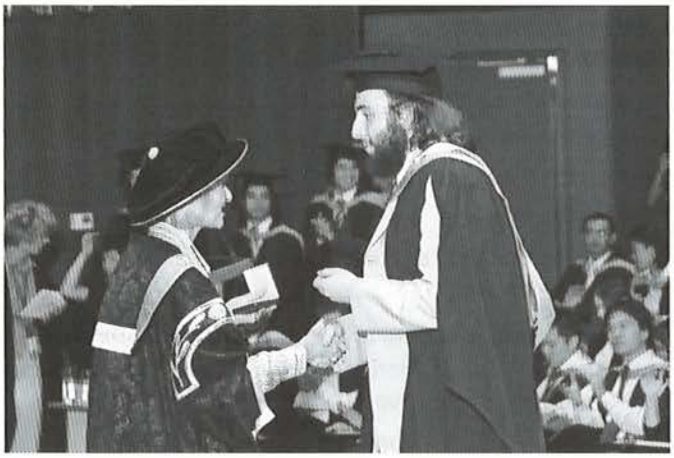
From the depths of the ocean to the blackness of outer space, Yakov Kulik is aiming to make major contributions to energy technologies of the future.

He completed his Honours year in physics in 2006 at the University of NSW, achieving a final mark of 96, with First Class Honours and the University Medal. Yakov's work was supported by the award of a DSTO-AIP scholarship.

For his Honours year Yakov wrote two theses, one of which, in the words of one of the assessors, was a "magnum opus" that can be compared in style and rigour to the work of legendary Nobel Prize- winner Lev Landau. He discovered eight fundamentally new non-linear effects in relation to the conversion of oscillatory energy to translational energy.

"I've wanted to be a physicist ever since I was a child, in order to understand the hidden secrets of the universe

Supporting tomorrow's physicists



Yakov receiving the University Medal from UNSW Pro-Chancellor Ms Jillian Segal.

and its creation," he says. "And I have always liked the elegance of the language which is used to describe the physical world—mathematics."

For his future work, Yakov wants to apply the methods of statistical mechanics to solve the problems of plasma confinement, the main obstacle to thermonuclear fusion power generation, with. His research has applications also in to significantly increasing the efficiency of fuel cell technologies (used to generate electricity in spacecraft), making strategic submarines quieter, and vastly improving the extraction of oil from below the ground, amongst other things.

Yakov is currently undertaking PhD studies at the University of New South Wales.

About the scholarships

The winners were selected from across Australia based on their academic record and their motivation to study physics.

The scholarship scheme runs for three years with two scholarships awarded each year each to the value of $15,000. DSTO funds the scholarships while the AIP is responsible for the administration and competitive selection of scholarship candidates.

Nominations for the 2008 scholarships are now open and close 26th October 2007. Details at www.aip.org.au

Focus on physics at DSTO

(Reprinted from "Connections", the internal journal of DSTO)

DSTO is one of the largest employers of physicists in the country. DSTO physicists not only do their profession proud but many of them – like Olivia Samardzic (EWRD - Electronic Warfare and Radar Division) and Pina Dall'Armi-Stoks (EWRD) – actively work to promote and popularise physics to a wider audience. Below are profiles of some of DSTO's many physicists who make a significant contribution to Australian defence science.

Kerry Mudge (ISRD - Intelligence, Surveillance and Reconnaissance Division), one of our newer recruits, joined DSTO in 2000 and is currently working as a Research Scientist in the Secure Communications Branch of ISRD. "My research involves investigations into the operation and potential applications of novel electro-optic devices including modulators and detectors for optical signal processing, free space optical communications systems and optical remote sensing. A background in physics has enabled me to carry out research in a wide variety of different fields and technologies. Currently, we are investigating the applicability of optical signals for signal processing and free space communications; applications traditionally in the domain of the electrical or RF engineer. A physics degree provides the freedom to look at existing problems in a new way with new technologies thus enabling an enhancement of performance or an increase in the application of the technology."

Shayne Bennetts (EWRD) is a physics graduate from ANU, now working on high power slab lasers as well as pulsed fibre lasers and amplifiers. He is doing a part time PhD project on "Phased array fibre lasers" jointly with the Centre of Expertise in Photonics at Adelaide University. To describe the importance of physics in his day to day work he talked about a few of the elements of their laser program. "When I joined DSTO just three and a half years ago our slab lasers were suffering beam quality problems above 10W, damaging with pulse energies above 1mJ and our imaging laser radar travelled in a small shipping container. Now our Long Range Research task has milestones which aim to produce 1J pulses, demonstrate beam combination of an array of fibre lasers which can be scaled to many kilowatts and LADAR lasers the size of a telephone handset/box of tissues/thick novel, for as little as a few thousand dollars. New physics and new ways of thinking about lasers is at the heart of this progress. We are using fibre lasers which achieve up to twice quantum efficiency, diode coupling operating at the fundamental diffraction limit, our passively Q switched fibre lasers are based on nonlinear optics we are still trying to fully understand and model, and high pulse energy lasers are based on a new hybrid laser architecture. All of this is cutting edge physics you read about in journals."

Julian Vrbancich (MOD - Maritime Operations Division, Pyrmont) is pioneering the use of airborne electromagnetic (AEM) methods traditionally used in geophysical exploration of mineral deposits for surveying shallow seawater to determine water depth and resistivity of sediments. This technique will be very useful in water affected by turbidity because laser airborne depth sounding methods rely on water clarity and sediment type to obtain sufficient transmission at optical wavelengths through the seawater and reflection from the seafloor respectively. "Airborne bathymetric mapping has a greater rate of coverage than sonar systems that are deployed from a surface vessel, and AEM can survey waters that are navigationally treacherous." said Julian.

Kelly Tsoi (AVD - Air Vehicles Division) began at DSTO as a professional officer and started working on a project that involved the use of tritium to detect cracks and defects in aircraft structures. DSTO sponsored Kelly for further study for her PhD which involved embedding shape memory alloys into composite structures and investigating the thermomechanical behaviour of the new materials. Kelly won the prestigious Zonta International Amelia Earhart fellowship, which is awarded to women who are pursuing graduate degrees in the field of aerospace-related sciences and engineering. "All of the projects that I have worked on in DSTO have had a strong physics basis and the ability to do autonomous research, obtained through my undergraduate physics and PhD degrees, has enabled me to learn, understand and quickly adapt to new and developing areas of science and technology." Kelly says. "The majority of my current work involves research into the use of advanced thermographic techniques for non-destructive evaluation of defects in structures. Effective structural management of ageing aircraft is an ongoing requirement and the early detection of damage and degradation in these structures provides a strong impetus for improved NDE techniques."

Lloyd Hammond (MPD - Maritime Platforms Division) joined DSTO in 1989, applying x-ray diffraction, x-ray fluorescence and electron microscopy techniques for materials science applications, including Zn-Ni electroplates and ceramic coatings. Lloyd transferred to MPD in 1994, where he undertook research to develop experimental and numerical modelling procedures for predicting the structural responses of naval vessels to underwater explosions. He completed a part-time PhD in this area in 2001. Lloyd now works on the Reduced Cost of Ownership (RCOO) Task which aims to demonstrate cost savings to ADF operations through the analysis of cost drivers/resource consumption, development of models and decision

systems and identification of technology solutions. Lloyd is working on the latter component. The focus of Lloyd's technology solutions program includes undertaking Reliability-Centred Maintenance (RCM) analysis on critical ANZAC and COLLINS systems, particularly propulsion systems. Lloyd is currently working with a small team to develop a Condition-Based Maintenance (CBM) program for the ANZAC Frigate's Propulsion Diesel Engine. As part of this program, online sensors as well as offline analysis technologies will be identified and trialled to facilitate implementation of reliability and condition based maintenance for this and similar systems.

John Thornton (AVD) tells us that his research is

Fig 1. Shayne Bennetts (see text) on the left and Alex Hemming on the right. Both are Physicists and currently doing their PhD in Physics.

involved in improving flight safety and achieving cost savings by improving the durability of propulsion systems - particularly the hot parts (gas temperature 1400°C). "One of the key drivers to my work is thermal barrier coatings. These are ceramic coatings to thermally insulate the hot parts of gas turbine engines and thereby make the parts last longer. To assess how long the ceramic coatings themselves will last at high temperatures we make use of high energy synchrotron radiation to measure the residual strains that eventually break up the coatings. This helps us understand how to design durable coatings and how to estimate how long the coatings will last." The second key driver leads to investigations into how X-ray and neutron radiography can be improved. This involves working with the School of Physics at Melbourne University. Most of the joint work has focused on gaining extra contrast by ultilising the differences in refractive index of materials - conventional radiography only utilises the differences in absorption. "Furthermore, conventional radiography also requires access to the front and rear of the object of interest - the radiation source sits at the front and then the film has to be at the back to collect the shadow of the object. Sometimes the object is too thick or complex for the shadow technique to work. I am developing techniques for backscatter radiography to circumvent the need for access to both sides of the object and allow one-sided radiography to be performed." All of the work described benefits from access to synchrotron and neutron sources.

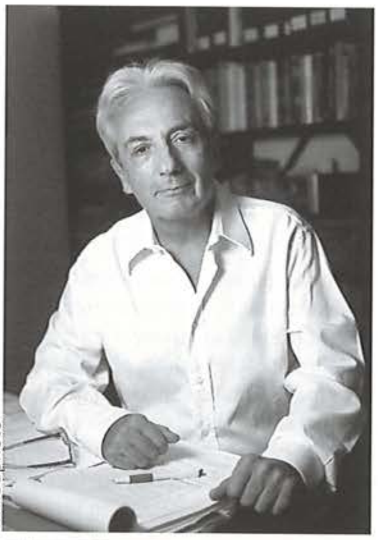
Darryl McMahon (MOD Stirling) is Head of the Submarine Sonar Group. He talks about a physical phenomenon that was not previously considered important to submarine sonar until some work was done by his group. "Some years ago MOD staff Stephen Hoefs, Warren Smith and Paul Clarke recorded hull sonar data which was able to avoid the confusion of overlapping signals arriving along different paths. In subsequently analysing the data, Derek Bertilone, Damien Killeen and Chaoying Bao discovered unexpected behaviour in the outputs of sensors from the cylindrical array (CA)," said Darryl. The CA lies under the dome of the Collins Class submarine, and comprises an array of sensors around a metal cylinder. The sensors are offset from the cylinder to reduce coupling of vibrations into the sensors, and to improve coupling to the water. "It was discovered that the unusual behaviour could be explained by applying scattering theory to the cylinder, and was caused by interference between incident and scattered waves. The scattering was shown to have a significant impact on sonar performance at high frequencies," Darryl explained. The group is also interested in how a towed array changes its position and shape behind a manoeuvring submarine. Detailed knowledge of the shape can greatly improve performance. This is an application of the physics of hydromechanics. Alec Duncan at Curtin University is developing a towed array model, while Darryl McMahon is contributing an empirical model of submarine manoeuvres. The hydrodynamics of long thin cylinders remains an active area of physics research that is relevant to a new generation of towed arrays that may only be a few millimetres in diameter.

Matthew Legg (MOD Stirling) is undertaking PhD research at Curtin University to improve underwater communications using sound. This is a difficult physics problem when the same signal arrives at different times on many different paths, the background noise level is high and contains impulsive sounds from snapping shrimps.

Focus on physics at DSTO

Stuart Anderson (ISRD) is a veteran DSTO physicist. After more than 30 years as a researcher in the field of over-the-horizon radar, he is firmly of the opinion that exploring the underlying physics "in more depth than seems necessary at the time" has been the key to developing new and ever more remarkable capabilities from this technology. "Who would have thought that plasma instabilities at a distance of ten earth radii would be responsible for phase fluctuations observed in terrestrial HF radar signals, which we have had to learn to correct by special signal processing? How unlikely it seemed at the time that we would need to resort to perturbation theoretical techniques developed originally by Richard Feynman in the context of quantum electrodynamics to obtain bounds on radar signal dispersion and Doppler spread arising from multiple scattering processes. Given the success of linearised hydrodynamics as a basis for most of physical oceanography, how fascinating that subtle radar signatures of weak hydrodynamic nonlinearities should turn out to be amongst the richest sources of oceanographic remote sensing information. We became fixated with the idea that High Frequency necessarily meant large antennas, severe constraints on radar absorbers and so on – then along came metamaterials. And in the age of stealthy targets, how chastening to be obliged to adopt holistic approaches to detection by searching not just for the targets themselves but for the correlated disturbances they create in their environment. As Obi-Wan Kenobi said in *Star Wars*, 'I feel a great disturbance in the Force'."

2007 Nobel Prize for Physics



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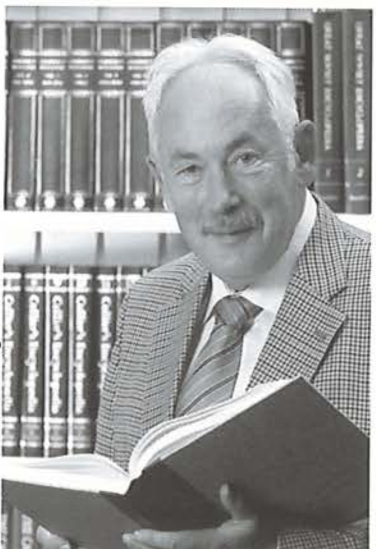

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Albert Fert (top) and Peter Grünberg have been jointly awarded the 2007 Nobel Prize for Physics

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Physics for 2007 jointly to Albert Fert Unité Mixte de Physique CNRS/THALES, Université Paris-Sud, Orsay, France, and Peter Grünberg Forschungszentrum Jülich, Germany, "for the discovery of Giant Magnetoresistance".

Nanotechnology gives sensitive read-out heads for compact hard disks

This year's physics prize is awarded for the technology that is used to read data on hard disks. It is thanks to this technology that it has been possible to miniaturize hard disks so radically in recent years. Sensitive read-out heads are needed to be able to read data from the compact hard disks used in laptops and some music players, for instance.

In 1988 the Frenchman Albert Fert and the German Peter Grünberg each independently discovered a totally new physical effect – Giant Magnetoresistance or GMR. Very weak magnetic changes give rise to major differences in electrical resistance in a GMR system. A system of this kind is the perfect tool for reading data from hard disks when information registered magnetically has to be converted to electric current. Soon researchers and engineers began work to enable use of the effect in read-out heads. In 1997 the first read-out head based on the GMR effect was launched and this soon became the standard technology. Even the most recent read-out techniques of today are further developments of GMR.

A hard disk stores information, such as music, in the form of microscopically small areas magnetized in different directions. The information is retrieved by a read-out head that scans the disk and registers the magnetic changes. The smaller and more compact the hard disk, the smaller and weaker the individual magnetic areas. More sensitive read-out heads are therefore required if information has to be packed more densely on a hard disk. A read-out head based on the GMR effect can convert very small magnetic changes into differences in electrical resistance and there-fore into changes in the current emitted by the read-out head. The current is the signal from the read-out head and its different strengths represent ones and zeros.

The GMR effect was discovered thanks to new techniques developed during the 1970s to produce very thin layers of different materials. If GMR is to work, structures consisting of layers that are only a few atoms thick have to be produced. For this reason GMR can also be considered one of the first real applications of the promising field of nanotechnology.

Extract from the Nobel Prize Committee Press Release. October 9 2007

Samplings

New statistical analysis confirms human role in climate change

http://physicsworld.com/cws/article/news/30711

The idea that global warming is caused by changes in solar output rather than human activity has been dealt a further blow by a new analysis of temperature, volcanic and solar-radiation data by a physicist in Germany. The research, carried out by Pablo Verdes from the Heidelberg Academy of Sciences in Germany, does not rely on climate models, which cannot account for all global-warming mechanisms. Instead, the work reveals a strong statistical link between rising temperatures and greenhouse gas emissions (*Phys. Rev. Lett.* 99 048501).

The results add weight to the consensus of the Intergovernmental Panel on Climate Change, which came to the conclusion earlier this year that humans are to blame for rising temperatures. Verdes thinks that his statistical approach should "enrich the continuing debate on the future of our climate."

Labyrinths appear in bead mixtures

http://physicsworld.com/cws/article/news/30704

Physicists in Norway have created beautiful maze-like patterns by simply allowing a mixture of tiny glass beads, water and glycerol to dry out slowly. Computer simulations suggest that the labyrinthine patterns are formed when "fingers" of air invade the solid-liquid mixture and push the beads apart. The researchers believe that the characteristic shapes of the patterns result from a balance between the forces of friction and surface tension in the mixture (*Phys. Rev. Lett.* 99 038001).

Labyrinthine patterns can emerge spontaneously in a number of physical systems including magnetic fluids and reaction-diffusion systems of chemicals. Physicists believe that such patterns arise because the systems are driven from equilibrium, where competing forces cause fingers of one phase of the system to invade another phase. Bjornar Sandnes and colleagues at the University of Oslo created such patterns by combining glass beads (50-100 µm diameter) with water and glycerol and injecting the mixture into the narrow gap between two circular plates.

Perfect lens could reverse Casimir force

http://physicsworld.com/cws/article/news/30670

The normally attractive Casimir force between two surfaces can be made repulsive if a "perfect" lens with a negative index of refraction is sandwiched between the surfaces, according to calculations done by physicists in the UK. Ulf Leonhardt and Thomas Philbin of the University of St Andrews reckon that the repulsive force may even be strong enough to levitate a tiny mirror. The repulsive effect - which has yet to be observed experimentally - could also help minimize the friction in micrometre-sized machines caused by the Casimir force (*New Journal of Physics* to be published).

Microscope unravels the intricacies of protein folding

http://physicsworld.com/cws/article/news/30658

A new way of using an atomic force microscope to unfold proteins could give us a better understanding of certain fatal diseases, say physicists in the US. Unlike previous techniques, it can map the intermediate energy states of proteins as they are unfolded -- crucial for scientists hoping to find out why proteins misfold in conditions such as Alzheimer's, Parkinson's and CJD (*Phys. Rev. Lett.* to be published).

Proteins – the building blocks of life – consist of a long chain of molecules called amino acids folded into a 3D shape. An atomic force microscope (AFM) can be used to study this folding by attaching one end of a protein to a substrate and the other end to the AFM's cantilever. As the protein is stretched, the cantilever is oscillated and the force restoring the protein and cantilever back into equilibrium is measured.

Laser flips magnetic bit without any help

http://physicsworld.com/cws/article/news/30762

Physicists in the Netherlands and Japan are the first to flip the value of a magnetic memory bit by firing a very short pulse of circularly-polarized laser light at it. Unlike other magneto-optic data storage systems, no external magnetic field was required to flip the bit, which meant that its value could be changed about 50 thousand times faster than the fastest conventional memory. The laser pulse was circularly polarized, which means that it creates an intense but highly localized magnetic field within the material. The pulse was switched between two polarization states, which flips the direction of the field. The result could lead to the development of low-cost and ultrafast all-optical magnetic hard disk drives (*Phys. Rev. Lett.* 99 , 047601).

Physicists minimize 'sticky' friction in tiny machines

http://physicsworld.com/cws/article/news/30811

Physicists in the US claim to have found how undesirable sticky friction or "stiction" could be minimised in microscale machines. By measuring the adhesive forces of silicon wafer, Deli Liu and Nancy Burnham of the Worcester Polytechnic Institute, in collaboration with semiconductor-device manufacturer Analog Devices, have discovered that - perhaps surprisingly - stiction is lowest when the surfaces are not smooth but when they have a certain roughness (*Appl. Phys. Lett.* 91, 043107).

Stiction is a problem in nano- and micro-electromechanical systems (NEMS and MEMS) whereby the tiny components stick together, often greatly reducing the reliability and long-term durability of these devices. It occurs when capillary, van der Waals and electrostatic forces between surfaces overpower the built-in restoring forces of the overall structure. In smaller systems the effect is more pronounced because of a larger surface-area-to-volume ratio. Liu and co-workers have performed experiments that demonstrate a correlation between surface roughness and stiction, in which there is an optimum roughness for which adhesion is minimized - a result that they hope could be used to minimize stiction in MEMS, and possibly NEMS, components.

Beyond batteries: Storing power in a sheet of paper

http://www.eurekalert.org/pub_releases/2007-08/rpi-bbs080907.php

Researchers at Rensselaer Polytechnic Institute have developed a new energy storage device that easily could be mistaken for a simple sheet of black paper. The nanoengineered battery is lightweight, ultra thin, completely flexible, and geared toward meeting

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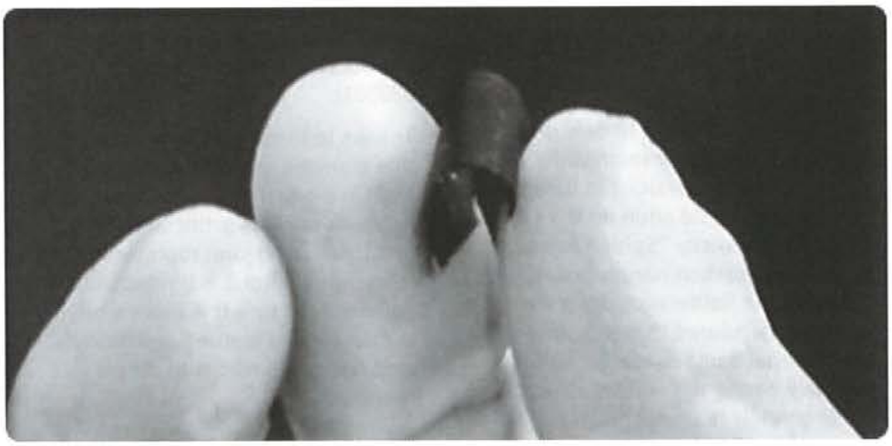

sample of the new nanocomposite paper developed by researchers at Rensselaer Polytechnic Institute. Infused with carbon nanotubes, the paper can be used to create ultra-thin, flexible batteries and energy storage devices for next-generation electronics and implantable medical equipment.

Photo Credit: Rensselaer/Victor Pushparaj

the trickiest design and energy requirements of tomorrow's gadgets, implantable medical equipment, and transportation vehicles.

Along with its ability to function in temperatures up to 300 degrees Fahrenheit and down to 100 below zero, the device is completely integrated and can be printed like paper. The device is also unique in that it can function as both a high-energy battery and a high-power supercapacitor, which are generally separate components in most electrical systems. Another key feature is the capability to use human blood or sweat to help power the battery.

The semblance to paper is no accident: more than 90 percent of the device is made up of cellulose, the same plant cells used in newsprint, loose leaf, lunch bags, and nearly every other type of paper. Rensselaer researchers infused this paper with aligned carbon nanotubes, which give the device its black color. The nanotubes act as electrodes and allow the storage devices to conduct electricity. The device, engineered to function as both a lithium-ion battery and a supercapacitor, can provide the long, steady power output comparable to a conventional battery, as well as a supercapacitor's quick burst of high energy.

Nanotubes guide phonons with ease
http://physicsworld.com/cws/article/news/30825

Tiny nanotubes made of carbon or boron nitride can act as phonon waveguides and retain their excellent heat transmission properties even when they are severely distorted, report physicists in the US. The researchers believe that the discovery could lead to the development of communications systems that use phonons to transmit information along nanotubes - in much the same way as light is used to carry data through optical fibres. (*Phys. Rev. Lett.* 99, 045901).

Heat can be transported through a solid by phonons, which are quantized sound waves. Some physicists believe that phonons could be used to transmit information along a fibre if a suitable material could be found. However, any fibre capable of carrying phonons would have to be just tens of nanometres in diameter. While it is very difficult to make such fibres from most materials, carbon and boron nitride nanotubes can be made at such thicknesses. Now, Alex Zettl and colleagues at the University of California at Berkeley have shown that such nanotubes are exceptionally good at transporting phonons – even when the nanotubes are severely deformed.

Interferometry images living cells in 3D
http://physicsworld.com/cws/article/news/30822

Researchers in the US have invented a new interferometry technique that has produced the first 3D images of a living cell without having to alter the cell beforehand. Created by physicist Michael Feld and colleagues at the Massachusetts Institute of Technology, the technique involves shining a laser beam through a biological sample at different angles to record a 3D image with sub-micrometre resolution (Nature Methods advance online publication).

Tiny biological samples must normally be prepared before they can be viewed in 3D. Cells, for example, often have their inner components highlighted with fluorescent dyes. But such modifications can disrupt a cell's normal functions, limiting the possibilities for analysis. Feld and colleagues have done away with such preparations, and instead use the optical properties of the cell in its natural state to generate a 3D image.

Physicists hit the rippled road
http://physicsworld.com/cws/article/news/30885

Experiments by physicists in the UK, France and Canada have shed new light on the unwanted ripples that appear spontaneously on the surface of unpaved roads. The team has discovered that the size and spacing of the ripples - which can damage vehicles and even cause accidents - are simple functions of the speed and weight of vehicles using the road. The findings suggest that the ripples arise because flat unpaved roads are inherently unstable, which could explain why the troublesome ridges are so difficult to prevent (*Phys. Rev. Lett.* 99 068003).

Team claims first silicon spinFET
http://physicsworld.com/cws/article/news/30935

Researchers in the US have built the first silicon spin field-effect transistor (spinFET), which uses an applied voltage to control a current of spin-polarized electrons. Although this is not the first spinFET - a device was built two years ago using a carbon nanotube - it is the first to be made of silicon. The component is an an important step towards the first commercial "spintronic" devices, which could use the spin - as well as the charge - of electrons to store and process information more quickly and efficiently than conventional transistors (*Appl. Phys. Lett.* 91 072501).

The spinFET was made by Biqin Huang and Ian Appelbaum of the University of

Samplings

Delaware, along with Douwe Monsma of Cambridge Nanotech in Massachusetts, who earlier this year worked out a way to transport a spin-polarized current of electrons 10 µm through a piece of silicon. Their new device builds on this work, taking advantage of the fact that the direction of the spin-polarization can be rotated as the electrons move through the silicon by applying a magnetic field.

Polaron melting heralds colossal resistance
http://physicsworld.com/cws/article/news/30977

Researchers in Germany and the US have made a breakthrough in understanding colossal resistance – the dramatic drop in electrical resistance that occurs when some solids are placed in an electric or magnetic field. They found that the effect is due to quasiparticles called "polarons" transforming from a solid to a liquid. A better understanding of colossal resistance could lead to the effect being used to improve sensors that detect magnetic fields or boost the density of computer memories (PNAS 104 13597).

Superlens avoids absorption
http://physicsworld.com/cws/article/news/31018

Physicists in the US and Germany have proposed a new type of material that could get around the absorption problems that have prevented the creation of practical "superlenses" for visible light. The material - which has not yet been made - uses "electromagnetically induced chirality" (a variation on an established technique called electromagnetically induced transparency (EIT)) to be transparent to light while having a low enough density to be made practically (*Phys. Rev. Lett.* 99 073602).

Spiderman suit modelled
http://physicsworld.com/cws/article/news/30993

Geckos, spiders and the comic-book hero Spiderman seem to defy gravity by scurrying along smooth walls and ceilings. Now, a physicist in Italy claims that humans could soon do the same by donning a sticky "Spiderman suit" woven from carbon nanotubes. Nicola Pugno of the Politecnico di Torino in Italy has calculated that - assuming the material could actually be made - a person wearing the suit would be able to cling safely to smooth surfaces such as the side of a skyscraper (*J. Phys.: Condens. Matter* 19 395001).

The stickiness of geckos and spiders comes from thousands of tiny fibres on their feet that grab hold using a combination of three effects – capillary forces arising from a thin layer of liquid water between the fibres and the surface; van der Waals attraction between the fibres' molecules and those on the surface; and Velcro-like interlocking of the fibres with tiny structures on the surface. Unlike glue, these effects still allow the feet to easily detach from the surface and thus allow the creatures to walk, and they also seem to prevent the feet from accumulating dirt.

Warm ice could improve medical implants
http://physicsworld.com/cws/article/news/31004

Ice melts at 0°C, right? Not necessarily, according to Alexander Wissner-Gross and Efthimios Kaxiras at Harvard University in the US. The pair used computer simulations to show that diamond surfaces implanted with sodium atoms can sustain very thin layers of ice at temperatures up to 37°C. The frosty covering could help to make artificial medical implants more compatible inside the human body, say the researchers (*Phys. Rev.* E 76 020501).

Thanks to their resistance to wear, thin diamond coatings are being used in a growing number of medical implants such as artificial heart valves, prosthetics and joint replacements. However, diamond is limited in its potential because it is more likely to cause blood clotting and tissue abrasion compared with other materials.

Wissner-Gross and Kaxiras think these problems could be solved if a layer of sodium atoms were covalently bonded to the surface carbon atoms in diamond beforehand. By encouraging dipole interactions with the surface, this sodium layer would allow a layer of water over 2 nm thick to stay frozen on the surface, thus providing a biologically-compatible shield from the diamond beneath. Although experiments have produced nanoscale ice at room temperature before, this theoretical result shows that it could have a practical application.

Items for Samplings have been provided by Don Price, CSIRO

Product News

Lastek P/L

Nanofilm introduces the S-sens® K5 Biosensor System

The S-sens® K5 system is an innovative new biosensor system that enables marker-free affinity measurements and the detection of molecular interaction kinetics. The chip-based system applies the technology of surface acoustic waves (SAW). It allows measurements with extremely high sensitivity to molecule association to and dissociation from the sensor surface. The system affords the time-resolved detection of mass loading and/or viscosity alteration processes. Due to the highly sensitive SAW measurement mode, a limit of detection above 0.8 pg/mm^2 is achieved.

The S-sens® K5 may even be regarded as a more sensitive form of the popular QCM (Quartz Crystal Microgravimetry). The reactions are monitored through the resulting mass changes or by means of changes of the electric properties at the active sensor surface. SAWs, as the name suggests, are confined to a guiding layer at the top of the sensor surface, imparting a localisation of the energy density, which yields an extremely high sensitivity to mass loading. Mass loading alters the wave propagation, which is detected as an alteration of the wave's amplitude and/or phase, yielding quantitative information regarding association/ dissociation of mass and alteration of the density-viscosity product.

The compact table top unit combines an entirely computerised data acquisition and liquid handling with a most user-friendly system-control software. This guarantees easy system handling, and permits the conduct of fully automated experiments.

Applications:
Marker free detection of molecular interactions
Liquid based biochemical binding events
Real-time kinetic analysis
Mass loading, and visco-elastic properties

Specifications:
- limit of detection: 80 pg/mm^2
- 4 ml chamber volume per channel
- 5 sensor channels per chip (re-usable ~50x)
- Active sensor surface (Au standard, others optional)

Nanofilm: Develops and manufactures imaging ellipsometer and other surface analysis instrumentation & accessories for analysis of surfaces in materials research, biochips, flat panel displays, Langmuir-Blodgett films and several other fields. Nanofilm have consistently expanded their line of novel instrumentation to various unique ellipsometers; now ellipsometry is our expertise. For over 16 years, internationally renowned firms and institutes world-wide have been using ellipsometer and other instrumentation from Nanofilm.

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New XLP12 μW Low Power Thermopile from Gentec-EO

Gentec-EO introduces the new thermopile-based eXtreme Low Power detector, the XLP12 for low power measurements in both the uW and mW regimes with very low thermal drift. This power detector has been carefully designed to extend the performance of thermopile detectors

into the photodiode typical power range. The low power thermopile draws on the advantages of both measurement technologies.

The XLP12 offers the flat spectral response and the low spatial dependence of the thermopile detectors, while retaining the high sensitivity and the compactness of the photodiodes. It is the best device to measure from 1 μW to 1 W in broadband applications. Contrary to photodiodes, the XLP12 handles nicely any pulsed laser, even slower ones. Users working with lasers in the mW range will appreciate its lower thermal drift compared to the standard thermopile detectors. The XLP12 is ideally suited for measuring any pulsed or CW low power laser.

Features:
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- Minimal Thermal Drift
- Flat Spectral Response
- High Sensitivity

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Product Description:
This ergonomically designed imager houses the complete uncooled microbolometer-based camera core together with a long life Li-ion battery pack. For ease of use the image is displayed on a large 3½" color LCD with LED backlight. Images can be captured using an MMC or SD card for recall and further analysis. Images can also be downloaded to a PC from the memory card for analysis, report generation and printing.

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Please note that a US export license approval will be required for the 85770, please contact Lastek for details.

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Conferences

2007

October 8 - 12
Advanced Infrared Technology and Applications 2007 Giorgio Ronchi 9th International Workshop (AITA 2007)
CIO, Leon, Guanajuato, Mexico
ronchi.iei.pi.cnr.it/AITA2005

October 9 - 13
SPERA 2006 - 9th South Pacific Environmental Radioactivity Conference
Royal Society Victoria, Melbourne
www.arpansa.gov.au/spera/index.cfm

Oct 14 - 18
Engineering and Physical Sciences in Medicine and The Australian Biomedical Engineering Conference 2007
Fremantle, WA
www.keynotewa.com/epsm-abec-2007/

Oct 25 - 27
5th conference on Physics Teaching in Engineering Education
Delft, Netherlands
www.tnw.tudelft.nl

Nov 19 - 22
19th International Geophysical Conference and Exhibition 2007
Perth, Australia
www.promaco.com.au/2007/aseg

November 21 - 23
15th AINSE Nuclear and Complementary Techniques of Analysis
Melbourne University, Melbourne, Australia
www.ansto.gov.au/ainse/events/conferences.html

Nov 28 – Dec 1
International Student Summer School on Quantum-Atom Optics
Kioloa, NSW
www.acqao.org

Dec 3 – 6
OSA Topical Meeting on Quantum-Atom Optics Downunder
Wollongong, NSW
www.osa.org/qao

Dec 11 – Dec 16
International Conference on Magnetic Materials (ICMM-2007)
Kolkata, West Bengal, India
www.saha.ac.in/cmp/icmm.2007/

Dec 12 - 14
MULTIPHYSICS 2007
Manchester, United Kingdom
www.multiphysics.org/

2008

Jan 7 – 9
Ninth Frontiers of Fundamental Physics
Udine and Trieste, Italy
ffp9.fisica.uniud.it/

Jan 29 – Feb 1
32nd Annual Condensed Matter & Materials Meeting
Charles Sturt University, Wagga Wagga, NSW

Feb 16 - 21
POLYCHAR 16 : World Forum for Advanced Materials
Lucknow, India
www.polychar16.com

Feb 19 – 23
3rd Environmental Physics Conference
Aswan, Egypt
www.geocities.com/Athens/Library/7348/EPC_08.html

Feb 25 – 29
ICONN 2008
Melbourne, Victoria
www.ausnano.net/iconn2008/

Mar 10 - 16
Solid State and Materials Chemistry
Mexico, Cancun
www.zingconferences.com/solidstate

April 14 – 19
15th Young Scientists' Conference on Astronomy and Space
Kyiv, Ukraine
ysc.kiev.ua/index.php?text=about

April 14 – 18
International Conference on Optical Fibre Sensors OFS-19
Perth, Western Australia
obel.ee.uwa.edu.au/OFS-19/

May 1 - 6
38th Annual Scientific Meeting of the Australian and New Zealand Society of Nuclear Medicine
Gold Coast, Australia
www.anzsnm2008.com

May 28 – June 1
8th World Biomaterials Congress
Amsterdam, the Netherlands
www.wbc2008.com

Jun 8 - 10
2nd INTERNATIONAL CONFERENCE ON SCIENCE AND TECHNOLOGY (ICSTIE'07/'08)
Penang / Kedah, MALAYSIA
www.penang.uitm.edu.my

June 13 – 15
Third International Conference on the Nature and Ontology of Spacetime
Montreal, Quebec, Canada
www.spacetimesociety.org/conferences/2008/

Jun 15 - 19
17th World Hydrogen Energy Conference
Brisbane Convention and Exhibition Centre
www.whec2008.com

June 27 – July 5
International School "Frontiers in Numerical Gravitational Astrophysics"
Erice, Sicily, Italy
astro1.phys.uniroma1.it/ericeschool/index.html

July 7 – 10
21st Congress of the International Commission for Optics
www.iceaustralia.com/ICO2008

July 8 – 10
OECC/ACOFT
www.iceaustralia.com/OECC_ACOFT2008

Prompt Critical Reviews

Spacecraft Dancing Lesson

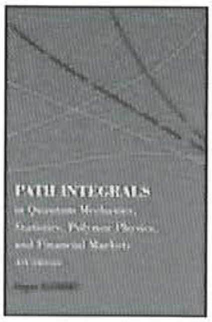
Here is a wonderfully informative book from the Princeton University Press. Its title is Fly Me to the Moon, but that is only part of the story. More to the point is the book's subtitle An Insider's Guide to the New Science of Space Travel. But that is not the whole story either because it deals with a new approach to spacecraft trajectories that was ridiculed until recently when some spectacular successes were achieved.

The new methodology, presented by its principal originator Edward Belbruno, applies chaos theory to orbital mechanics, bypassing the notoriously unsolved three and four body problems. Belbruno presents the essential ideas without mathematics, at a level about that of a Scientific American article. He shows how it is possible to travel to the moon, or a planet, by using only a fraction of the fuel required for a normal trajectory provided there is enough time to carry out a series of delicate maneuvers.

Belbruno's first success was the rescue of Hiten a Japanese relay satellite whose lunar probe Hagoromo was lost. With no signals to relay, the mission could be saved if Hiten's small amount of leftover fuel could propel it to the moon, which it did. Other triumphs followed and the doubting voices were stilled. For manned missions direct high-speed trajectories are essential but for cargo the longer times needed for low-fuel trips are less important.

For anyone with an interest in this remarkable development in spaceflight the book is a must at US$ 19.95 in hardcover. It has a 53-item bibliography and a short but useful index. Order it through its ISBN-13: 978-0-691-12822-1.

Colin Keay
Reviews Editor



Path Integrals in Quantum Mechanics, Statistics, Polymer Physics, and Financial Markets (4th ed.)

H Kleinert
World Scientific Publishing, Singapore
2006
xliii + 1547 pp.,
US$38.00 (paperback)
ISBN: 981-270-009-9

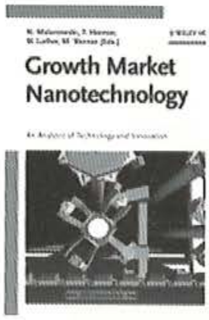
With a frequency of possibly less than once in a generation, an absolute bible of a book comes out that is the definitive authoritative monograph on its subject matter. Kleinert's book on Path Integrals is precisely such a book. It belongs on a special shelf alongside books like Misner, Thorne and Wheeler's Gravitation, or Courant's classics on Differential and Integral Calculus. If you get a copy of Kleinert's book you will know that you have the best single book on the subject: the depth of knowledge and exposition is representative of a true master scholar.

If you have a background in path integrals, and possibly use them already in your teaching or research, and this book is not already on your shelf, then it should be. Even more widely this is one of those books that every graduate student in theoretical physics should have.

This 4th edition includes a new chapter devoted to path integrals and financial markets. That chapter alone makes a significant contribution, in this case to the field of econophysics, and it is one of the finest examples of writing that I have come across that ports a proven technology to a new discipline area.

This is a book well worth having, even if it was at some of the monster prices that some book companies charge these days, but at less than US$40, and with an excellent job on the typesetting and layout by World Scientific, this book is not only a genuine classic, it is a true bargain.

B I Henry
Department of Applied Mathematics
University of New South Wales



Growth Market Nanotechnology: An Analysis of Technology and Innovation

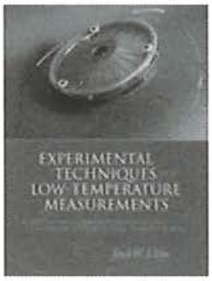
N Malanowski, T Heimer, W Luther and M Werner (eds)
Wiley-VCH, Weinheim
2006
xxiv + 270pp, € 99.00 (hardcover)
ISBN 3-527-31457-1

While there are now a myriad of books on the nascent field of nanotechnology, there are very few that detail the economic potential of nanotechnology. This book attempts to fulfil this need by summarising global activities in nanotechnology, discussing nanotech-based markets and endeavouring to predict future directions that may unfold, through the perspectives of specialists in nanotechnology, marketing and finance. There is a rather comprehensive coverage of current trends in nanotech-oriented research activities and the need for changes to various scientific fields and standards (and where appropriate, a lack thereof). There also is extensive analysis of patent data in the fields of chemistry, optics, car manufacture, medicine and life sciences.

It is unfortunate that this book is highly oriented toward commercial markets and companies in Europe and Germany in particular (with three full chapters on these) and contains little by way of underlying science beyond the summary of activities. Hopefully its appearance will initiate several more likeminded books from across the globe.

Jamie Quinton
School of Physics
Flinders University

Reviews



Experimental Techniques for Low-Temperature Measurements
Jack W Ekin
Oxford University Press, New York, 2006
xxviii + 673 pp., UK pounds 49.95 (hardcover)
ISBN 0-19-857054-6

As the subtitle states, this book is concerned with...'cryostat, material properties, and superconducting critical current testing'... and therefore complements other works on low–temperature techniques which are more concerned with liquefaction and storage of cryogens, ultra-low temperatures and how properties change as T approaches zero. The author was grounded in cryogenics at Cornell University, measuring resistivity of potassium. He then moved to Boulder (NIST), to test superconductors, both low- and high- Tc.

Part I deals briefly with cryogenic fluids, cryocoolers, measurement cryostats, heat transfer, with a detailed description of cryostat construction and suitable materials. Ekin also touches on the nitty-gritty of soldering and welding various components.

Part II covers methods of electrical transport measurement, sample holders, contact techniques particularly those related to superconductors in bulk and in thin films.

Part III deals with Ekin's favoured area of expertise: the measurement and analysis of critical currents in superconductors...two chapters designed for the specialist in this important area of applied superconductivity.

Finally the 130-page Appendix contains an extensive collection of physical data on materials (including suppliers) ranging from 24 different stainless steels to resins, glues and varnishes; a 40-page index is also impressive. Interestingly Jack planned this book far back in 1993 while a visiting scientist at CSIRO/NML, with some time to ponder!

Guy White

Bellerive, Tasmania.

Laser Physics and Applications
Landolt-Bornstein, Vol 8
Springer Verlag, Berlin 2006
xvi + 307 pp., EUR 3,490 (hardcover)
ISBN 978-3-540-28824-4

This book falls under "Advanced Materials and Technologies" — the 8th group in a series of books on "Numerical Data and Functional Relationships in Science and Technology" — an ambitious project covering everything from fundamental constants to geophysics.

In the 8th group the book is part 2 of subvolume A which covers Quantum Optics, Coherence and Superradiance, Optical Components, Optical Resonators and Interferometry — a broad and eclectic range of topics. The announced net price is 3,490 Euros — surely not just for this book, but at least you would hope for the 8th group if not the entire series!

Having criticised the broad ambitious and costly nature of the undertaking, nevertheless the material itself is very well organised and presented. It takes an interesting historical perpective, so that new students will be able to appreciate the distant origins of the concept and the way that the field developed. The book is well referenced, and provides an excellent starting point to delve further into the field.

The theoretical chapters (such as quantum optics and superradiance) are well explained with a sufficient but not overabundant use of equations, and is readable as a narrative rather than as a definitive work on the topic. Good use is made of tabulating the key experimental results in the area, and important experimental data are used to illustrate the text.

The experimental chapters (such as optical components) are well illustrated. They provide the important equations to describe the behaviour of the devices themselves, list key materials properties and again give a brief tour of the componentry to set the reader in the right direction for further investigation.

Given the wide ranging topic areas in this 300-page volume, the amount of information is densely packed and well selected. The indexing is comprehensive, and a CD ROM is provided with linked sections and references that makes for easy onscreen reading. Unfortunately the indexing system did not work on my computer/software which is aimed at PCs rather than a Macintosh.

All told a useful reference to add to the series, provided you can afford the hefty price tag!

Ken Baldwin
Laser Physics
Australian National University

Aspects of Basic Physics for Dental Students
John Patterson
Author, 23 Boundy Road, Highbury 5089
96 A4 pp., A$33.00 (paperback)
ISBN 978-0-646-47099-3

This book is the accompanying text to a series of lectures to undergraduate dental students given by the author. It consists of eight chapters, each a lecture covering the following: 1) Forces and Stress, Strength of Materials and Heat; 2) Optics and Imaging; 3) Optical Instruments; Colour and the Eye; 4) Electricity and its Effect on the Human Body; 5) X-rays, Properties, Spectra, X-ray tubes; 6) X-ray Imaging and Other Modalities; 7) Health Physics, Radiation Safety and Protection; and 8) Gasses and Liquids. The text has associated exercises with each chapter.

The stated aim is to "know and explain appropriate laws and physical principles" and "understand the basic principles of optics and imaging".

The approach is disappointing in that extensive physical principles are condensed into 8 lectures. For students with high school physics the book is of limited value whereas those with only junior high school exposure it does not provide the foundation required.

Considering Chapter 1, Forces, these are briefly described with minimal supporting diagrams. Emphasis placed upon levers because of the critical role of the mandible to dentistry. A schematic diagram to define a torque and how critical this is to virtually all loading of structures in the oral cavity would have helped. Similarly linking stress-strain and E modulus, to interatomic forces would provide an insight for the basis of strength

of materials as well as thermal and electrical behaviour.

The best chapters relate to Health Physics although whether dental students need to know about oncology radiation is questionable.

M Swain
Dentistry and Biomaterials
University of Sydney

In the shadow of the bomb

S S Schweber
Princeton University Press, Princeton 2007
xviii + 260 pp., US$18.95 (paperback)
ISBN 0-691-12785-9

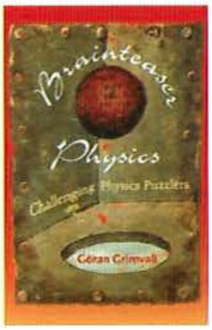
The author of this book studied physics with J. Robert Oppenheimer and Hans Bethe, who were two very talented physicists and major contributors to the success of the famous Manhattan Project to develop an atomic weapon in the 1940s. The author is Professor Emeritus of Physics and Professor in the History of Ideas at Brandeis University and an Associate in Harvard's Department of the History of Science. There is no doubt that he is well qualified to write about the two key figures of "Oppenheimer and Bethe and the moral responsibility of the scientist" which is the sub-title.

Having said the above, this reviewer did not find this an easy book to read. In fact, if he had not been asked to review the book, he would have put it down as indigestible after reading the preface and the first two chapters plus one of the eight sets of notes at the end of the book. The reviewer was not pleased to find the author used seven and a half pages to explain why he was well entitled to write the book because of his long association with Oppenheimer and Bethe. The reviewer objected strongly to the author's insertion of German words into the text at regular intervals without translating them, as very few readers of science today are familiar with German as they almost certainly were 50 years ago. The reviewer also objected strongly to the author providing long lists of notes to almost every chapter, eg. 102 for the Introduction alone, 171 for chapter 2 and 97 for Chapter 3. In addition there were 16 pages of formal references at the end. The reviewer blames the editor as much as the author for not editing the text to remove or give translations for these German words, as well as the excessive use of notes and the author's style of using five sentences when one or two would suffice.

However, your reviewer persevered and learned much from the two "bibliographic chapters", Chapter 2 on the life of Oppenheimer and Chapter 3 on the life of Bethe. As for the other chapters, they appear to be more a dissertation in psychological analysis of these two physicists based on extensive research of their speeches on many occasions and how they interacted with their colleagues and the "government" over a long period of time. So, if you want to learn a lot about the lives of these two great physicists, then buy this book at its relatively low price and read the Introduction and Chapters 2 and 3 and speed read or skip the rest.

Clarence J Hardy
Australian Nuclear Association
Pacific Nuclear Council

Brainteaser Physics: Challenging Physics Puzzles



Goran Grimvall
Johns Hopkins University Press, Baltimore MD 2007
vi + 162 pp., US$23 (paperback)
ISBN 0-8018-8512-4

I found it hard to put down Goran Grimvall's new book. Was it because it boasted lavish full-colour photographs? No. The book abounds with helpful sketches, diagrams, tables, graphs and equations (no photographs) but they are all in black and white. Perhaps it was the compelling prose that captivated me. No. Although the book is very well-written, there are many more equations than anecdotes. It must have been the unique logic puzzles that caught my attention. Again, no. I had seen many of the puzzles before and most of them could not be solved by the application of logic alone; some knowledge of physics was required as well.

So what was it that I enjoyed so much about the book? I appreciated the fact that the book required thought. It is not a book for passive browsing. Sections titled "Outlook", "Does it matter?", "Any caveat?", "Additional Challenge" and "How Physicists think" further challenged readers.

I found that I would read a puzzle, contemplate it, perhaps re-read it, predict a solution, check my answer, and read the proof. This was such an enjoyable experience that I found myself thinking. "I'll do one more, I'll just do one more..."

This book would be a useful resource for Physics teachers and lecturers. The puzzles are interesting, and the explanations and mathematics very clear (calculus is not used). The book concludes with a commendably detailed index. Go ahead, take up the challenge...

T.W.Burns
School of Mathematical and Physical Sciences
University of Newcastle

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