Australian PHYSICS

January/February 2008 Volume 45 Number 1

A Publication of the Australian Institute of Physics

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Editorial

When teaching students about the properties of lasers, the concept of coherence is of fundamental importance. My choice of analogy revolved around contrasting laser light, and the light from an incandescent lamp, to the differences between the magnificent songs heard from a choir to the chaotic conversations overheard in a restaurant.

Around the restaurant you would hear many unique conversations, at multiple volumes, in different directions. For any observer, even one seated at a table, it is difficult to comprehend the intent behind any one voice among the many. It would be incoherent - analogous to the incoherent white light emitted from an incandescent lamp.

Conversely, imagine being seated in a quiet theatre where everyone is focused on a choir singing the same song, at the same volume, in the same direction - dozens of individual voices singing harmoniously, coherently. And just like the light from a laser, there is value in coherence. We need that coherence among the sciences.

In 2007, the ABC aired The Choir of Hard Knocks, following a group of disadvantaged people over a year while they became a rehearsed, talented and melodically successful choir. Although it certainly is not fair (or helpful to either group) to compare the different sciences to the disadvantaged, we can take comfort in knowing that disparate individuals can become united with effort. Admittedly, there are differences between the sciences with respect to particular syllabi, but not different enough when it comes to basic pedagogy, practice and the teaching of critical and analytical thinking. There is much that unites us.

Unless you have been living under a rock for the last year it is hard not to imagine 2007 as the year education took centre stage at the national level; however, taking to the stage and making something out of it are two completely different things. In this issue we have two more articles focused on educational matters. Dr. Mark Butler asks us to *Re-imagine Science Education*, while Mendez et al provide us with important data. Furthermore, the online site www.onlineopinion.com.au has devoted February to educational issues (including yours truly *http://www.onlineopinion.com.au/view.asp?article=6932*). If 2007 was the year education took to the stage, then, we must make every effort to ensure 2008 is the year (science) education sings in harmony.

Organisations like the Australian Academy of Science, AIP, and others, are very good at supporting bread and butter issues for education. Indeed, the AAS states that it "... advises governments on science education..." As does the AIP; but is that enough?

The Prime Minister's 1 000 strong love-in, though laudable, will amount to wonderfully philosophical feel-good direction, but little action. Like the consistent, powerful and focused light of a laser, the sciences and our representatives need to unite, speaking together with one coherent voice. We need to trump the Faculties of Education, the Departments of Education, and the bureaucrats by holding our own summit that will do more than "advise" but that will declare openly, and with a directed voice, that we will now advocate for science education regularly, consistently, strongly and with little regard to whose feet we tread on. It is no longer good enough to be by-standers, or stakeholders, we must be the leaders who set the agenda rather than follow it.

Like the singers in The Choir of Hard Knocks have shown, when there is a message to be heard there is strength in numbers and power in unity; but that common voice must be hard earned, argued over and practiced.

There has been a decade of decay in our educational system. Blame is irrelevant; eventually someone will call upon us to fix it, and 2008 appears to be the dawning of that call. Will we have one coherent voice in all of the sciences? In Physics?

By the time the invitation comes from government(s) it will already be too late.

Are we ready?

John Daicopoulos

Submission deadline for the March/April 2008 issue is March 22, 2008

President's Column: Generation Y

In one of the largest studies conducted on "Generation Y" (those born between 1980 and 1994) in Australia, McCrindle [1] found that 86% expect to be promoted within two years, 63% expect to stay less than two years with an employer, and over half (52%) think it's easy to find a new job. This information was gathered from a national survey of 3000 Australians combined with a series of in-depth focus groups, and paints a revealing picture of the emergence of a new type of employee, with very different attitudes and motivations than previous generations. With the proportion of Generation Y employees set to double from 20% to 40% of the Australian workforce in just five years, and "Baby Boomers" beginning to retire, more people will be leaving the workforce than entering it this year. Australia is currently experiencing the biggest generational shift in six decades.

So what does this mean for careers in physics? Is there really a difference between the four "generations" that make up the Australian physics community? Demographers split the population up into different generations as given in the table [2].

Description	Born	Age	Population ($x10^6$)	% of Population
Builders	Before 1946	62+	3.5	17%
Boomers	1946 – 1964	43 – 61	5.3	26%
Generation X	1965 – 1979	28 – 42	4.4	21.5%
Generation Y	1980 – 1994	12 – 27	4.2	20.5%
Generation Z	1995 – 2009	Under 12	3.1	15%

The "Builders", now over 62 years old, are the generation that created the modern economy and society of today. They established the structures and processes that we often take for granted. The formation of the AIP is a good example of the initiatives of this generation.

The "Baby Boomers" form the largest generation. They were rebellious in their youth and conservative in middle age. Over much of their careers, they have been optimistic, ambitious and loyal, and believed that employment was guaranteed. Status symbols have been important and they've worked hard and long hours, often to the exclusion of family life, to achieve. They have stayed in the same jobs or careers for most of their lives.

"Generation X" often grew up with both parents working. They are resourceful, individualistic, self-reliant and irreverent. In the workplace they focus on relationships, outcomes, their rights and building their skills. They are not as interested in long-term careers, loyalty or status symbols.

"Generation Y" has been brought up with modern information technology, and are optimistic and confident. They have very strong peer relationships, strong morals and a sense of civic duty. They expect high levels of workplace flexibility and think very differently to any other member of the work force. Generation Y is critical because it will form the bulk of the adult population within the next 20 years.

These generations can be assigned to different stages in scientific careers: Generation Y contains the students and Generation X the early- to mid-career scientists; the Baby Boomers are the mid- to late-career scientists and the Builders are our retirees.

Most mid- to late-career physicists have stayed in the same organisation for very many years. It is not uncommon for a physicist to retire with 30 to 40 years of service to one organisation. Furthermore, moving in and out of research remains difficult; if we track the careers of women that have taken maternity leave, we see the 30% of physics graduates that are women reduces to between 7 and 25% in the universities and government research laboratories and even less in industry.

This raises several issues relating to the way we employ physicists. On one level, physics could be seen as an ideal career for the members of Generation Y. Technology is always changing and developing. Research is a global activity, and the fact that similar research is performed in many laboratories around the world should make mobility easy. Physicists travel to use special facilities, attend conferences, and interact in collaborations and networks. Moreover, scientific research increasingly requires a broader range of cross-disciplinary skills.

However, the importance of track record and science metrics in assessing and granting rewards to physicists is also increasing. These requirements are better satisfied with a traditional career path; changing fields or taking a break from research make it harder to maintain a high rate of publication and citation. So is a career in physics able to accommodate the preferences and expectations of Generation Y?

Let's look at what is happening in universities, which are currently teaching Generation Y students. Full-time students are working more and spending less time on campus [3]. In 1994, full-time students spent, on average, 17.6 hours per week on campus. By 2004, this had fallen to 15.9 hours per week. In 1994, 42% of full-time students also worked; in 2004, 55% were working. Students have grown up with mobile phones, MSN, the web, email and a very rapid pace of life. Universities have also changed, with higher student-staff ratios and greater use of technology. Universities are making significant changes in the way they teach Generation Y, including increased use of CD-ROMs, initiatives such as "eLive" and "iLecture", web-based instruction and more flexible educational practices in general. There is the urban myth that standards are lower than in the "good old days". In fact, standardised testing of physics students at an Australian university shows that their ability has been constant over a large number of years. So universities, at least in their teaching methods, have already adapted with some success to accommodating the requirements of Generation Y.

continued on page 5

Australian Physics
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Cover image: The **PULSE@Parkes** project allows students to directly control the Australia Telescope National Facility's Parkes Radio Telescope via the Internet to target pulsars – small spinning stars that transmit periodic radio signals. For more on this News Item see page 11: **Students use "The Dish" to 'listen' to pulsars**.

Image credit: David McClenaghan, CSIRO

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Submission Guidelines

All articles for submission to Australian Physics should be sent in electronic format. Word or rich text format are preferred. Images should not be embedded in the document, but should be sent as high resolution separate attachments in jpeg or tiff.

Authors should also send a short bio of themselves and a recent photo.

The Editor reserves the right to edit articles based on length, space requirements and editorial content.

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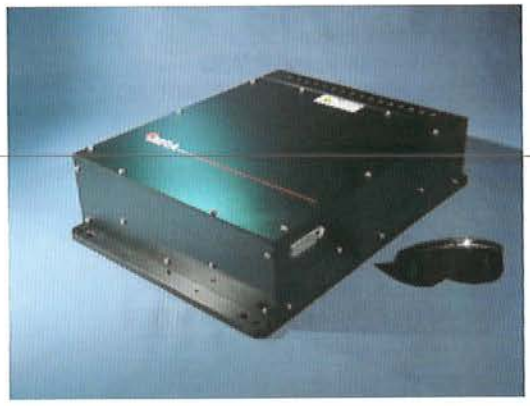

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President's column - continued from page 3

The typical member of Generation Y has very strong beliefs:

- Work–life balance is important, if work and life clash, life wins;
- The need for strong connectedness: *"You've got to enjoy the people you work with – it's a non-negotiable"* [1];
- Change and challenges are a way of life: *"Many young people leave their job not because there is a compelling reason to leave but because there is no compelling reason to stay"* [4];
- Leadership should be by consensus: Generation Y is much less likely to respond to the traditional command-and-control type of management still popular in much of today's workforce [5];
- Development opportunities by mentoring, in-house or external training are very important: 79% of those surveyed stated career development was very important to them and 90% agreed that if they received regular training from their employer it would motivate them to stay longer [1].

This suggests that the traditional physics career path will have to change if it is to attract and accommodate researchers from Generation Y. We will have to be open to greater mobility, more feedback to staff, changed management styles, and work practices that encourage and support life balance. There will have to be a greater understanding of how to assess broader experience and how to interpret science metrics for researchers with fragmented careers. The new work environment sought after by Generation Y will not only benefit them. Generation X and Baby Boomers will also benefit from a flexible workplace as they cope with aging parents, poorer health and, possibly, an expectation to work long past age 65. This new work order would better accommodate a diverse work force, especially women.

Science is not easily undertaken as a "9 to 5" job. The most innovative research usually comes from a period of focused work, with a level of commitment far removed from a balanced life. How this will fit with the preferences of Generation Y is difficult to predict!

So what is the AIP doing to provide services for the four generations of AIP members? Our diverse and fascinating membership, ranges from university students, to qualified professionals in all disciplines, to the interested and involved retired community. We have members working in academia, government and industry. The 2008 Council Meeting decided that the AIP should attempt to take on the expectations and needs of each generation. We plan to use the AIP website as a means of providing the services necessary to assist each member to have the best possible career. This will be undertaken in stages, beginning with the development of our website to deliver more member services. If you have ideas on services you would like the AIP to provide to assist you in your career then send me an email!

A final note: It is twelve months since I was elected as AIP President. I have been overwhelmed by the high regard in which our organisation is held by governments, the Academy of Science, university and government research organisation administrators, the media and the general public. These groups look to the AIP for leadership in how to deal with the important issues to which physicists can contribute; this in turn reflects the high repute in which our members and physicists in general are held. As a consequence, I have been enormously proud to represent the AIP as we strive to live up to the expectations of the wider community.

Notes:

[1] M. McCrindle (2007) New Generations, new trends: Snapshot of Australia's changing demographics, generations, & population shifts, *http://www.mccrindle.com.au/wp_pdf/BridgingTheGap_Employers.pdf*

[2] Australian Bureau of Statistics, *www.abs.gov.au*

[3] K. Krause, R. Hartley, R. James and C. McInnis, (2005) The first year experience in Australian universities: Findings from a decade of national studies, (2005) *http://www.dest.gov.au/NR/rdonlyres/1B0F1A03-E7BC-4BE4-B45C-735F95BC67CB/5885/FYEFinalReportforWebsiteMay06.pdf*

[4] J. Nicholson & A. Nairn, (2006) The making of the 21st Century: 2020 vision, Report by Boston Consulting Group for Innovation & Business Skills Australia (IBSA), Victoria: IBSA.

[5] C.W. Zust (2003) Baby boomer leaders face challenges communicating across generations, *http://www.zustco.com/christine/cz_articles/baby_boomer.pdf*

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Letters

Dear Sir,
The person wearing glasses who is standing between John Carver and S.E.Williams in the photograph on the cover of the November/December issue of Australian Physics is Arnold Reimann, Research Professor of Physics at the University of Queensland.

Reimann, of German extraction, was born in Adelaide. He worked for GEC in England in the 1930's and sometime around the middle of that decade came to the University of Queensland. While at GEC he had written a book on thermionic emission. He would be best described as a gentleman of the old school. He remained with the university until the early 1970's and died in Brisbane in, I think, the early 90's.

Ralph Parsons.
Formerly Professor of Physics,
University of Queensland.

* * *

Dear Sir,
A few comments on the Draft AIP Community policy, published in the December 2007 issue of Australian Physics:
1] Under the Environment section, item 2.2, the "Reason" given for pursuing policies that preserve the environment include "... and will present new business opportunities...". This is not a convincing argument to me.

2] Under Energy, section 3.1 refers to AIP support for a range of energy sources etc. I would be happy to support the implementation and development of any low-emission sources with the proviso that they be judged on the basis of an even-handed life-cycle analysis. The issue of life-cycle, that is, the scrutiny (as far as possible) of all components of a technology, not just its emissions in operation, is complex and often controversial. It is a non-trivial exercise and one where physicists could contribute some broad scientific understanding. Incidentally, I don't think it is necessary to list solar and wind. AIP Policy should not be a list of pet projects.

3] Section 3.4 is, in my opinion, entirely inappropriate. What mechanisms could or should be put in place for promoting the reduction of carbon emissions, whether these be direct taxes, the trading of carbon credits, caps, or whether they should be of regional or international scale, is a complicated matter. One that is being addressed by economists and politicians and many others. It is not an issue that is well served by a simplistic formula and I don't see it as one on which the AIP can give an expert opinion or should state a Policy.

George Dracoulis

Top of stairs going down: Alan Walsh, John Symonds, George Bell, John Carver, Arnold Reimann, SE Williams (UWA), ?
Around the table starting from the right: Stewart Dryden, Alan Harper and Fred Lehany. Sitting: Prof Huxley,

* * *

Dear Sir,
I read with interest the draft of the AIP Community Policy in the latest "Australian Physics". It is good to see that the Institute in engaging so strongly with environmental issues.

I do have some reservations about the draft as it stands. I will comment on 3.4 specifically (the carbon tax policy), although I have similar concerns about some of the other policies.

Firstly, I think we should not have policies unless we have actions to go with them. We are in no position to implement a carbon tax or even lobby for one (see below). It would be much better to have carbon-aware policies, such as minimizing air travel on AIP business, or videoconferencing the Congress, that we could actually carry out.

Secondly, we should not take up positions on matters where we are not clearly expert. How to set up and run a carbon taxation scheme is a technical and controversial matter amongst economists, and a debate where I do not believe the AIP can contribute authoritatively and factually.

We weaken our authority in matters where we *are* expert, by taking up positions on matters where we are not.

Dr Charles Jenkins
FAIP CSci CPhys FInstP
Senior Fellow & Deputy Australian ELT Project Scientist
Mount Stromlo Observatory

Branch News

NSW Branch
March/April Public Talk Series

Tuesday 25th March 2008 @ 5.30PM
"Attracting more Students to Physics"
Dr Mark Butler

This presentation will examine current issues in secondary physics education from the perspective of a practicing high school physics teacher. What physics is being taught in Australian Schools, who is teaching it and how it is being taught? Enrolment statistics, teacher qualifications and training, National Standards, the Australian Certificate of Education, and current small, and large scale initiatives to attract more students and teachers to physics will be discussed.

Dr Mark Butler is currently Head Teacher of Science at Gosford High School and the National Education Convener of the Australian Institute of Physics. He holds a PhD from Macquarie University in physics and has taught for over twenty years in private and public high schools in NSW.

Tuesday 25th March 2008 @ 7.00PM
"The Problem of Energy States on Metal Surfaces and How to Solve It"
Dr Marlene Read

Fundamental to understanding all electronic properties of surfaces is knowledge of the quantum electronic energy states. Present theoretical methods do not always predict all surface states and those predicted may deviate significantly in energy from measured features. A promising theoretical method that can potentially account for all surface states over their entire energy range is a scattering approach that builds up the metallic system by stacking a succession of atomic layers parallel to the surface.

Marlene Read has been associated with the School of Physics at the University of New South Wales continuously since 1965. Her research areas in theoretical condensed matter include bulk energy bands in solids, hydrogen in metals, low energy electron and positron diffraction from surfaces and surface energy states of metal systems.

Tuesday 22nd April 2008 @ 6.00PM
"Multiscale Brain Dynamics: Towards a First-Cut 'Working-Brain' Model"
Professor Peter Robinson

The electrical activity of the brain has been observed for over a century and is widely used to probe brain function and disorders, chiefly through the electroencephalogram (EEG) recorded by electrodes on the scalp.

Peter Robinson did his BSc and PhD in Theoretical Physics at the University of Sydney. He was appointed as a Senior Lecturer in Physics in 1994 and became a Professor in 2000. Since 2003 he has been an ARC Federation Fellow.

Note: All Lectures take place at the Slade Lecture Theatre, School of Physics, University of Sydney

Interested in helping the AIP improve its membership database and website?

The AIP Executive is seeking an AIP member volunteer to join the national Executive in 2008 as a special projects officer for the specific task of helping develop guidelines for improving our membership database and our website. An objective of the project is to make greater use of the website for the benefit of members. The person would be expected to seek relevant information, provide advice, attend 6 executive meetings during the year (held in various capital cities - travel expenses will be covered), and take part in occasional phone conferences. The project does not include implementing proposed changes, for which an IT professional would be engaged.

If you are interest, please contact the President, Dr Cathy Foley (cathy.foley@csiro.au)

Arp 87 Courtesy of NASA, ESA, and The Hubble Heritage Team (STScI/AURA).

Executive News

SUMMARY OF EXECUTIVE MEETING E272

Meeting held Tuesday December 11

Student and Staff IP Agreements

The executive will be reviewing student and staff intellectual property agreements with a view to developing recommendation or guidelines for what is reasonable.

Physics for Post Kyoto Australia

Development of information that provides science understanding of issues to meet the Kyoto protocol will be developed in collaboration with other international physical societies, IOP and APS in particular.

AIP Web Site

A review of the AIP web site with recommendations for development to provide better services to members is close to completion. The aim is to develop the web site to provide services and information to benefit the membership.

DSTO Scholarships

The applications for the DSTO scholarships were of the same high standard as in previous years. The winners were decided and their names would be forwarded to DSTO for approval. The winners are Emma Lawrance from Flinders University SA and Kimberley Heenan from ANU, ACT.

Science-Qualified Teachers

It was thought that the shortage of science-qualified teachers should be a high priority item for FASTS. FASTS will be approached and asked to place this on its agenda.

Accreditation

The accreditation process is continuing. The formal accrediting of courses has been useful for both universities and physics departments, and universities are taking a more proactive approach in seeking accreditation.

University Employment

It was noted that there had been considerable casualization of employment in the university sector, and this directly affects many members.

Database

Problems have been experienced with the database, partly because of problems involved with the transfer of data from the previous database. It will be necessary to work on upgrading the database to cope with the requirements placed on it. A specification of the data base is being developed with a view to creating a new data base which will be eventually accessible for updating via a secure web connection.

Australian Physics

John Daicopoulos has taken up the position of editor of Australian Physics. He is doing work on upgrading his skills for the preparation of the journal. It was thought that more prominence should be given to branches and branch activities. Branches will be asked to forward photographs of branch committee members.

Finance

The 2007 audit has been completed. There is considerable variation among the branches in the amount spent on student awards. This will be discussed with branches to investigate the development of a general policy that would provide more uniformity in the provision of awards by branches.

Membership

Membership is a matter of high priority, and there should be an executive portfolio for membership recruitment. Strategies for attracting new members were discussed. A new membership form and a streamlined method for handling new memberships were approved. A welcome kit will also be developed for new members.

Council Meeting

The Council meeting will be held in Melbourne on February 11/12. The AGM will be held on the Monday evening, to be followed by a talk to be given by Dr. Nanda Nandagopal.

Carrick Institute Project

The Carrick Institute has been working on projects on the teaching of science. The aspect of most interest to the AIP will be that of careers. The AIP will monitor progress on the project and will seek to give input on the development of career information.

Science Policy

The AIP science policy is under constant review. Proposals for policy development are always forwarded to branches for their comment. It was agreed that the AIP should develop a policy on greenhouse gases and global warming and this will be the next major topic for policy development.

2008 Congress

Work on the organization of the 2008 Congress is proceeding on schedule. Because of the substantial thrust in South Australia on space science, this could be an important stream in the Congress program.

Next meeting E273 will be held in April.
Ian Bailey,
Hon secretary.

Executive Minutes E270 Erratum

Under education: Cathy Foley visited the Director General of NSW Department of Education with Dr Mark Butler the AIP Education Convener. (Not the minister.) Cathy Foley also visited the Tasmanian Minister for Education's advisor to discuss the same issues.

Australian Institute of Physics 18th National Congress

aip
AUSTRALIAN INSTITUTE OF PHYSICS

Physics for 2008 the Future

30 November – 5 December 2008
Venue: The University of Adelaide, South Australia

www.aipc2008.com

The AIP 18th National Congress is Australia's pre-eminent meeting for physicists. The Congress brings together a broad range of physicists from around Australia working in a variety of fields covered by AIP Topical Groups and Cognate Societies. Held biennially in December, it attracts many of this country's finest physicists plus a number of prominent overseas attendees. It provides a forum for discussions within specialist physics topic areas, and opportunities for physicists from academia, government, and the commercial sector to keep up to date in areas outside their specialities.

The Congress has a tradition of attracting the very best international experts as plenary speakers, including several Nobel Laureates, and other notable speakers who have gone on to be awarded Nobel Prizes. In 2008, we anticipate a strong attendance of physicists, as well as a substantial number of trade and industry representatives from related fields.

There will be an industry session on future technologies for Industry and Defence, since South Australia regards itself as the 'Defence State'. There will also be an emphasis on Physics Education through a science outreach program with particular Congress content relevant and accessible to science teachers.

Integral with the Congress will be an associated Trade Exhibition which assists physicists to keep up to date with current products.

The Congress will continue to cover special topic areas of:

- Acoustics, Music and Ultrasonics
- Astronomy
- Atomic and Molecular Physics
- Biomedical Physics
- Complex Systems, Computational and Mathematical Physics
- Condensed Matter and Materials and Surface Physics
- Education
- Environmental Physics
- Geophysics
- Meteorology and Climate Change
- Nuclear and Particle Physics
- Optics, Photonics, and Laser Physics
- Plasma Science
- Quantum Information, Concepts and Coherence
- Relativity and Gravitation
- Renewable Energy
- Solar-Terrestrial and Space Physics
- Synchrotron Science
- Women in Physics

Details of relevant dates can be found on the Congress Web Page. The deadline for submission of abstracts is Monday 30 June 2008

The Congress will be held at the University of Adelaide which is located in the heart of the city of Adelaide.

We would like to invite and welcome you all to the 2008 AIP Congress in South Australia.

Hope to see you there.

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News

Independent ARC Advisory Council appointed

The Minister for Innovation, Industry, Science and Research, Senator the Hon Kim Carr, has delivered on the first stage of Federal Labor's election promise to restore independence to the Australian Research Council (ARC).

"I am pleased to announce the establishment of an ARC Advisory Council to provide advice to the Chief Executive Officer, Professor Margaret Sheil, on key research issues," Senator Carr said.

"Research is not a political plaything to be toyed with at the whim of the Government.

"Research is a matter of vital national importance, the outcomes of which have a significant impact on Australia's ongoing prosperity and standing in the world.

"It is our responsibility to seek and respect the views of those individuals most able to provide valuable insight into the issues faced by researchers and shape an environment that will deliver the best possible results for all Australians."

Senator Carr said that the Advisory Council, to be chaired by Professor Sheil, will provide her with non-binding strategic and policy advice on: strategic issues relating to the mission of the ARC; policy matters relating to innovation, research and research training; and matters relating to the evaluation of the quality and outcomes of research and research training in an international context.

In appointing the Advisory Council members, Senator Carr honoured a commitment to consult and obtain advice from people who reflect the breadth and diversity of Australia's research interests.

"The Rudd Labor Government is committed to improve the integrity of Australia's research funding system and one way of doing this is to ensure that the ARC has access to high quality advice from across the research sector," Senator Carr said.

The first ARC Advisory Council comprises individuals whose backgrounds encompass academia and/or industry and represent a broad cross-section of research disciplines.

The members of the Council, who have each been appointed for up to three years, are:

- Professor Terry Hughes, Director, ARC Centre of Excellence for Coral Reef Studies, James Cook University
- Dr Elizabeth Jazwinska, Johnson & Johnson Research Pty Ltd
- Professor Stuart Macintyre, Ernst Scott Professor of History, The University of Melbourne
- Professor John Ralston, Director, Ian Wark Research Institute, University of South Australia
- Professor Margaret Seares AO, Senior Deputy Vice-Chancellor, The University of Western Australia
- Professor Arun Sharma, Deputy Vice-Chancellor (Research/ Commercialisation), Queensland University of Technology

Senator Kim Carr
Minister for Innovation, Industry, Science and Research

NHMRC Award

School of Physics scientific photographer Steven Morton played an instrumental and creative roll in the production of the image (Figthat saw Brian Cooke of the Microbiology Department, receive the inaugural National Health and Medical Research Council (NHMRC) Award for "Science to Art". This award was for the outstanding image from health and medical research. The image shows the surface of a human red blood cell infected with a malaria parasite.

Detailed information on the awards, the image and the science behind the image may be found at:
http://www.monash.edu.au/news/dec07-nhmrc-awards.html

Monash University

Victoria Prize - Call for nominations

Nominations opened for the 2008 Victoria Prize for world-class excellence in science, technology or engineering on 9 February 2008.

Fig. 1 Human red blood cell infected with a malaria parasite.
Image Credit: Steve Morton, Monash University

Each year the Victorian Government awards the prestigious $50,000 Victoria Prize to an individual whose groundbreaking discovery or innovation has advanced knowledge and has produced or may produce a commercial outcome or other benefits to the community.

The Victoria Prize celebrates leadership, determination and creativity and highlights the many ways in which research and development of international significance is conducted locally.

The Anne & Eric Smorgon Memorial Award

The $100,000 Anne & Eric Smorgon Memorial Award is awarded by the Jack and Robert Smorgon Families Foundation to the research institute supporting the Victoria Prize recipient. Nominations close on 7 April 2008.

For nomination forms and more information visit:
www.business.vic.gov.au/vicprize

2008 Victoria Fellowships -Call for applications

Applications opened for overseas study grants for early career scientists, engineers and innovators on 9 February 2008.

Each year the Victorian Government awards up to six $18,000 Victoria Fellowships to enable early career researchers and innovators to travel overseas to pursue specialist training,

develop a commercial idea, expand international networks or gain recognition for their work.

Applications are open to early career researchers working in private enterprise or a research institution.

Winners of the Victoria Fellowships will be eligible to apply for $5000 AFAS FEAST-France Fellowships to undertake study missions to France. These Fellowships are offered by the Australian French Association for Science and Technology (Victoria) and the Embassy of France.

Applications close on 7 April 2008.

For application forms, details of information sessions and more information on the award program, visit: *www.business.vic.gov.au/vicfellows*

Editor's Note: Prizes and awards specific to physics are listed on pages 25 to 26 Summary of Awards.

Students use "The Dish" to 'listen' to pulsars

A CSIRO project designed to give students the chance to use "The Dish" Radio Telescope at Parkes, to listen and learn about pulsars, was launched 18 December 2007 in Canberra by the Minister for Innovation, Industry, Science and Research, Senator Kim Carr.

The PULSE@Parkes project allows students to directly control the Australia Telescope National Facility's Parkes Radio Telescope via the Internet to target pulsars – small spinning stars that transmit periodic radio signals.

Under supervision, students will use the ATNF's 'remote observing' capabilities to move the telescope and record data.

They then analyse the data and share the results with students from other schools and professional astronomers.

On 4 December 10 students from Kingswood High School in Sydney – 365km from The Dish – successfully tested the project systems' capabilities at the ATNF's headquarters in Marsfield, Sydney.

While lightning at the telescope caused a few spurious 'spikes' in the data – giving the students a taste of the frustrations of doing 'real science' – they recorded good results that were used to estimate the distance to two out of six observed pulsars.

That and future data gathered under the auspices of the project will be archived and made freely available online to allow students to compare their observations.

It will also be used as additional information to aid in the ongoing search for gravitational waves in space.

The PULSE@Parkes project paves the way for students to use the Australian SKA Pathfinder (ASKAP) telescope, which will be built by CSIRO and partner institutions in Western Australia by 2012.

CSIRO

Pawsey Medal for Nano-Fabrication Pioneer

Associate Professor Kostya Ostrikov, a pioneer in the field of plasma nano-science at the University of Sydney, has been awarded the 2008 Pawsey Medal by the Australian Academy of Science.

Associate Professor Ostrikov earned the medal, awarded to early career scientists for outstanding physics research, for both theoretical and experimental work, which, in the words of one of his colleagues, Professor Iver Cairns "has created the field of deterministic plasma nano-fabrication, which was inconceivable just a few years ago".

While most manufacturing of nano-scale devices involves painstaking methods that build structures atom by atom, plasmas – ionized gases – have the ability to deposit atoms in a highly controlled fashion by the millions in just millionths of a second. Until recently it was thought that the inherent randomness of plasma would limit any attempts at high-precision control of the deposition process. However the research of Associate Professor Ostrikov and his colleagues has developed methods of controlling the plasma's characteristics, such as pressure, temperature or voltage, in such a way that the plasma organizes itself, forming intricate nano-structures such as cylinders or pyramids - a very different result to the deposition by neutral gases.

As well as developing mathematical models for the formation of these self-organised complex systems and the surfaces to which they attach, Associate Professor Ostrikov is a leader in a team which has developed innovative plasma sources that can create the nano-structures predicted by his models.

Understandably the ability to create such precisely controlled nanostructures in such fast timeframes has many industries pricking up their ears, with the prospect of applications in nano-electronics, nano-optics and biomedicine looming large, as well as more exotic applications such as quantum dots for nano-lasers, ultra-thin solar cells or quantum computing.

Beyond the lab, Associate Professor Ostrikov has looked at nano-fabrication in nature: in his soon-to-be-published book "Plasma Nanoscience: From Nature's Mastery to Deterministic Nanofabrication" he also looks at nano-particles around red-giant stars, and discusses the creation of the first building blocks of life on primordial earth.

Associate Professor Ostrikov was educated in the Ukraine, and was awarded a Doctor of Science by Kharkov University at age 29, at the time the youngest ever recipient of the prestigious award. He also won the Best Young Scientist of Ukraine Award of the Academy of Sciences of Ukraine. He currently holds a QEII research fellowship at the University of Sydney's School of Physics.

University of Sydney

Ice clouds

Many hours of LIDAR (LIght Detection And Ranging) operation at Davis resulted in the first ground-space coincident observation of 'Noctilucent clouds – when viewed from the ground' or 'Polar Mesospheric Clouds – when viewed from space' over Antarctica.

These very thin ice clouds indicate temperatures lower that -130°C

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where they form near 83 km altitude. Increasing occurrence of noctilucent clouds is expected from the cooling effect of increasing carbon dioxide at high altitudes.

A unique polar mesospheric cloud captured on the lidar on New Years Eve/Day persisted for 22 hours and almost jumped off the brightness scale. Atmospheric radar also recorded related intense 'blobs' or to the Ice, Ocean, Atmosphere and Climate scientists 'Polar Mesosphere Summer Echoes'.

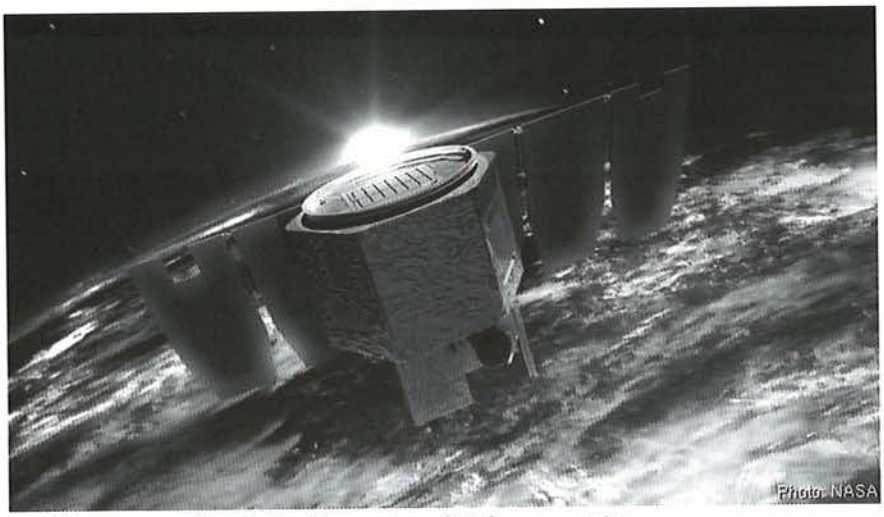

Fig. 2 Aeronomy of Ice in the Mesosphere (AIM)' spacecraft
Image Credit: NASA

Amazingly, orbiting Davis at this time was the 'Aeronomy of Ice in the Mesosphere (AIM)' spacecraft – which recorded its brightest and thickest PMC layer to date (Fig. 2).

The study of these ice layers that form at the edge of space in the altitude range of 80 to 94 km using the Davis lidar and radars, and the NASA AIM spacecraft instruments - is focussed on determining whether their increasing brightness and latitude coverage are an indicator of climate change.

This research is part of the Ice, Ocean, Atmosphere and Climate program contribution to the International Polar Year science objectives.

Australian Antarctic Division

UN makes 2009 International Year of Astronomy
The United Nations 62nd General Assembly proclaimed 2009 as the International Year of Astronomy (IYA). IYA2009 will be a year-long, community-based celebration of the science, history and cultural impact of astronomy for people throughout the world, and will draw attention to the night sky as the heritage of all humanity.

"2009 will be the 400th anniversary of the Italian scientist Galileo Galilei turning a telescope to the sky," said Professor Matthew Colless, Chair of Australia's National Committee for Astronomy.

"That act started modern astronomy. It led to the extraordinary knowledge we now have of our own solar system, planets around other stars, galaxies beyond the Milky Way, and the history and fate of the Universe."

Ninety-nine countries have signed up to take part. In Australia, planning for the Year is being carried out under the auspices of the National Committee for Astronomy, which is a committee of the Australian Academy of Science.

Events will include school activities, public "star parties", exhibitions, tours and live shows. "Astronomy is one of the most accessible ways to engage with the natural world, and it's a great gateway into science for young people," said Professor Colless.

IYA2009 is an initiative of the International Astronomical Union, which represents the world's professional astronomers, and UNESCO.

IAU statement, including text of UN Resolution: *http://www.iau.org/iau0702.486.0.html*
International IYA website: www.astronomy2009.org

AAO

Flinders Medal and Lecture (2009)
Professor Bruce McKellar
Professor of Theoretical Physics, University of Melbourne

Bruce McKellar has consistently provided leading edge research in physics, influencing a number of fields of particle physics including important work on weak interactions in the nucleus, which led to the development of the 'Tucson-Melbourne Potential' with his collaborators. He has devoted much of his energy to the scientific community, through teaching, training of students and post-doctoral fellows, and through his service to the University of Melbourne and scientific institutions.

Australian Academy of Science

Nuclear reactor start-up: safety submission lodged
ANSTO lodged an application with the independent safety regulator (ARPANSA) seeking approval to modify the reactor fuel design and to use the modified fuel design to restart operation of the nuclear research reactor OPAL.

OPAL has been shut down since late July when, during a routine monthly shutdown, some fuel plates contained within some fuel assemblies were found to have been displaced.

To address the problem, the design of the nuclear fuel has been changed to incorporate a stopper to prevent fuel plate movement.

The proposed design has been thoroughly tested and evaluated, including tests that exceeded conditions that would be experienced in the reactor.

To ensure the safety of the design modification, ANSTO has undertaken detailed risk assessments and technical analyses, in collaboration with the reactor designer, INVAP and drawing upon the advice of independent international experts.

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If approval is given, operation of OPAL would recommence using a 'start-up' core specially manufactured to the new design. This fuel has been manufactured overseas and will be available in early January.

ANSTO places a high priority on nuclear safety, which has necessitated time-consuming but thorough examination, analysis and testing. During the removal of the fuel assemblies from the core, regulatory approvals also had to be obtained.

The shutdown has also enabled ANSTO to successfully complete repairs to the reflector vessel. The very small leaks between the heavy water in the vessel that surrounds the reactor core and the normal water in the reactor pool would gradually have affected the efficiency of neutron production over several years if not resolved.

The public can be reassured that there are no abnormal safety or radiation issues. The reactor design is sound, and it operated successfully for a year prior to the shutdown. ANSTO has kept the community and customers regularly updated on progress over the past five months.

The reactor cannot recommence operation until regulatory approval is granted by ARPANSA.

ANSTO

UNSW Vice-Chancellor's Fellowships
The School of Physics scoops two of UNSW's eight highly prized Vice-Chancellor's Fellowships. The fellowships are for three years, and are highly competitive. Congratulations go to Dr Julian Berengut, who is coming from the USA to work on Theoretical Physics with Prof. Victor Flambaum, and Dr. Peter Reece, who is coming from the University of St Andrews (Scotland's oldest university) to work with Prof. Mike Gal on Optoelectronics in the Condensed Matter Physics Department.

UNSW

IUPAC Election
AIP Honorary Registrar, Bob Loss, has been elected Vice President and incoming President of the International Union of Pure and Applied Chemistry (IUPAC) Division of Inorganic Chemistry for the period covering 2008 - 2012. Bob has served on IUPAC since 1993 under the Commission on Isotopic Abundances and Atomic Weights and as a Divisional member since 2005.

The Division is involved with a number of activities in association with IUPAP such as the naming of elements with Atomic numbers of 112 and above and in evaluation of the half lives of long half life isotopes as used by geo and cosmo chronologists.

Curtin University/AIP

Physicists make plea to halt research council delivery plan
Physics and astronomy in the UK is under threat and could face serious damage if the Science and Technology Facilities Council (STFC)'s Delivery Plan is not put on ice until the Wakeham Review has had to time to report, according to the chief executive of the Institute of Physics (IOP).

The £80 million shortfall in STFC's budget has resulted in a delivery plan that will lead to job losses at universities and three leading research laboratories; a 25 per cent cut in university grants; and withdrawal from a number of high-profile programmes such as the International Linear Collider.

Dr. Robert Kirby-Harris, chief executive of IOP, said, "Funds must be provided to prevent damage being done before the Review has had time to report. A moratorium to put the cuts on hold must be established or we risk doing damage before the UK's scientific priorities are properly considered. We should not press ahead with a delivery plan that was produced in such a short timescale."

Because STFC has to meet a number of fixed financial commitments, such as international subscriptions, cuts have had to be concentrated in other budget areas. Consequently, the shortfall in funding has had a more serious effect on these areas, which include research grants to universities.

It has been calculated that some university physics departments across the UK will lose up to £750,000 in income, resulting in job losses and threatening the health of physics.

The government has asked Professor Bill Wakeham to undertake a review into the health of physics. IOP strongly welcomes the Wakeham Review but, as it is not due to report until mid-summer 2008, there is fear that serious damage may already have been done.

IOP will be providing oral evidence to the Innovation, Universities and Skills Select Committee's Inquiry into the Science Budget Allocation on January 21.

1. For further information please contact IOP Press Officer, Joe Winters at: joseph.winters@iop.org

2. The Institute of Physics is a scientific membership organisation devoted to increasing the understanding and application of physics. It has an extensive worldwide membership (currently around 34 000) and is a leading communicator of physics with all audiences from specialists through government to the general public. Its publishing company, IOP Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

Institute of Physics

The AIP Executive is in contact with the IOP to see how we may best assist them.

The equivalence principle as a stepping stone from special to general relativity: A Socratic dialog

Sam Drake

This is a reprint, with some minor modifications, of Am. J. Phys. 74 (1), January 2006

We show how students can be led to an understanding of the connection between special relativity and general relativity by considering the time dilation effect of clocks placed on the surface of the Earth. This paper is written as a Socratic dialog between a lecturer and a student.

I. SETTING THE SCENE

Sam is in the office and has just finished reading Plato's Meno [Ref. 1] in which Socrates uses a self-discovery technique to teach a boy Pythagoras' theorem. Sam is inspired by this dialog and is pondering its applicability to lecturing undergraduate physics when a tap on the door breaks that chain of thought.

Kim enters the room looking bleary eyed and pale. "Been out celebrating the last lecture of the year" Sam surmises, little knowing that other things have kept Kim awake.

II. THE DIALOG

Kim: Your lectures on special relativity fascinated me, and when I got home I wondered if I could construct a simple experiment to prove or disprove time dilation, the aspect of special relativity that interests me the most. While lying in bed before dozing off, I realized that a clock placed at the equator should run slower than a clock placed at the pole. So I did a little calculation and found that special relativity predicts that a clock on the equator runs slower by about 100 ns per day with respect to a clock at the pole. Although this effect is not large, it is certainly measurable with modern atomic clocks. So I went onto the internet to see if I could find any reference to such an experiment and to my surprise I couldn't.

I was starting to get so frustrated that I couldn't sleep. I glanced at the clock (3 am). I thought to myself "How accurate is my clock?" I should check it against internet time. Then it occurred to me that the world timing standard organizations must mention a latitude effect on local clock accuracies.

So I went onto the internet again and checked The Bureau International des Poids et Mesures [Ref. 2] because the Bureau calculates the international atomic time from atomic clocks located in more than 30 countries around the world. I was sure that I must find something about the latitude effect on their web site. After spending hours trawling their site and then other sites on the web, I came up with nothing. There was a discussion of the relativistic effect of placing clocks at high altitudes, but nothing about latitude. In my despair I gave up and collapsed into a fitful sleep.

I came to see you today in the hope that you could cure my insomnia.

Sam: You are in good company in thinking that clocks at the equator and the pole should tick at different rates. Einstein himself predicted as much in his famous 1905 paper on the special theory of relativity [Ref. 3]. Luckily for physics the effect was not measurable with the instruments of the day because
Einstein's prediction would have failed to match experiment.

Let us return to your findings:

1) According to the special theory of relativity a clock located at the equator should run slower than one at the pole and

2) Empirically, all clocks located at sea-level on the Earth's surface tick at the same rate, regardless of latitude.

To help you understand how both apparently contradictory statements can be true I will ask you a question. If the Earth were a rotating perfect fluid and we could ignore the gravitational effects of the Sun and the Moon, what shape would the Earth be?

Kim: Well, I don't see how this question is relevant, but I would answer your question by drawing a free-body diagram. Can I use your blackboard?

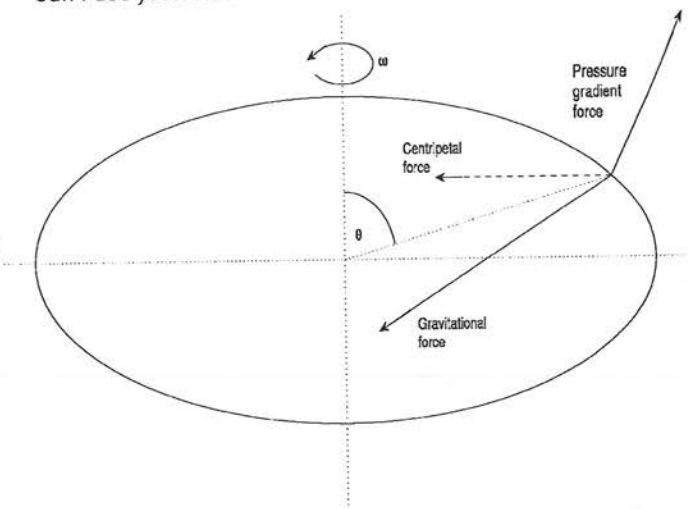


Figure 1: Free body diagram for a mass placed on the surface of the Earth as seen from space.

Now let me see ... consider a test mass placed on the surface of the Earth (see Fig. 1). We know that the forces acting on the test mass are the outward force due to the difference in pressure and the inward force due to gravity. If the test mass is in hydrostatic equilibrium, then the pressure gradient force must be perpendicular to the surface and the sum of the gravitational and pressure gradient forces is the centripetal force, which is perpendicular to the axis of rotation[Ref. 4].

Hmmm ... you would have a complicated integral equation to solve because the direction of the gravitational force vector would depend on the distribution of mass. Furthermore, the pressure gradient would be perpendicular to the surface we are trying to calculate. It seems to be a complicated problem and, to be honest, I am not sure that I could solve it.

Sam: It is a difficult problem whose solutions involve

The equivalence principle as a stepping stone from special to general relativity: A Socratic dialog

hyperbolic and elliptic functions. Chandrasekhar has devoted a whole book to the subject [Ref. 5]. Before we travel that arduous mathematical road, let us see if we can use some physics to help us. Taking our model of Earth as a rotating perfect fluid, is the Earth an equipotential surface?

Kim: Thinks ... Yes.

Sam: Why?

Kim: Because if it wasn't, the sea water would feel a force $\vec{F} = -m\nabla\Phi$ and would move until $\nabla\Phi = 0$ everywhere on the surface.

Sam: So if I told you what the Earth's gravitational field is, could you tell me the shape of the Earth?

Kim: Yes, I think I could.

Sam: How?

Kim: If you told me that the Earth's gravitational potential is $\Phi_g(r,\theta)$, where r is the distance from the centre and θ is the colatitude,1 then I could calculate the effective potential felt by an observer co-rotating with the Earth by including the centrifugal force

$$\Phi_{eff} = \Phi_g(r,\theta) - \frac{1}{2}\omega^2 r^2 \sin^2\theta \qquad (1)$$

where $\theta \in [0,\pi]$, $\theta = 0$ at the north pole, $\pi/2$ at the equator, and π at the south pole; ω is the Earth's rotation rate; and r is the distance from the centre to the Earth's surface. The second term on the right-hand side of Eq. is the "centrifugal potential." Now we have already argued that a co-rotating observer on the surface of the Earth feels no change in the effective potential regardless of his/her latitude, that is, Φ_{eff} is constant. Furthermore, you have told me that we know the Earth's gravitational potential is $\Phi_g(r,\theta)$, so all I need to do is rearrange Eq. 1 and, voilà; we have an expression for the shape of the Earth's surface. Mind you, because $\Phi_g(r,\theta)$ may be a complicated function, I am not sure that I can find an analytic expression for r anyway.

All this is very interesting, but I don't see how it answers my question about why clocks tick at the same rate on the Earth's surface.

Sam: Patience, we are coming to that. First let us investigate the discovery you have made, namely the shape of the Earth. Let me see, I know I have it in here somewhere...

Sam flicks through some notes in the filing cabinet.

Ah here it is. Despite the Earth's complicated shape with mountains and valleys, its gravitational field can be modelled to a fractional accuracy of 10^{-14} by [Ref. 6]

$$\Phi_g(r,\theta) = \frac{-GM_e}{r} - \frac{J_2 GM_e a^2(1-3\cos^2\theta)}{2r^3} \qquad (2)$$

where $GM_e = 3.986\,004\,42\times10^{14}\ m^3\ s^{-2}$ is the product of the gravitational constant and the mass of the Earth [Ref. 2], $J_2 = 1.082\,636\times10^{-3}$ is a measure of the Earth's equatorial bulge and is related to the Legendre polynomials [Ref. 7], and $a = 637\,813\,7\ m$ is the Earth's equatorial radius [Ref. 7].

To evaluate your equation for the Earth's surface (which incidentally is called the Geoid), you will need an accurate value of the Earth's rotation rate.

Sam shuffles through some files ... Yes here it is [Ref. 9]

$$\omega = 7.292\,116\times10^{-5}\ rad/s \qquad (3)$$

Now your Geoid equation is going to be a bit tricky to solve analytically so instead of doing that let us see if we are on the right track. The easiest thing for us to do is to check that your equation for the Earth's effective potential Φ_{eff} is the same at the equator and the pole.

Φ_{eff} at the pole: The Earth's mean polar radius is

$\bar{b} = 6356.76 \pm 0.07\text{km}$ [Ref. 9] and

$$\Phi_{eff}(r=\bar{b},\theta=0) = \frac{-GM_e}{\bar{b}} + \frac{J_2 GM_e a^2}{\bar{b}^3} = -6.2637\times10^7\ m^2\ s^{-2} \qquad (4)$$

Φ_{eff} At the equator: The Earth's mean equatorial radius is $\bar{a} = 6378.1 \pm 0.2\text{km}$ [Ref. 9] and

$$\Phi_{eff}(r=\bar{a},\theta=\pi/2) = \frac{GM_e}{\bar{a}} - \frac{J_2 GM_e a^2}{2\bar{a}^3} - \frac{1}{2}\omega^2\bar{a}^2 = -6.2637\times10^7\ m^2\ s^{-2} \qquad (5)$$

Look the two values for Φ_{eff} are the same! What have you shown?

Kim: We have shown that the Earth is indeed an equipotential surface with respect to an observer sitting on the surface. But Sam, this calculation has nothing to do with the question I originally asked you!

Sam: Doesn't it? What did you ask me again?

Kim: I asked you why all clocks tick at the same rate on the surface of the Earth when special relativity predicts that they should run slower at the equator than at the pole.

Sam: Kim do you remember how we derived Einstein's famous formula $E=mc^2$?

The equivalence principle as a stepping stone from special to general relativity: A Socratic dialog

Kim: Yes and to be honest I was a little disappointed with it. Once we learned that a constant speed of light lead to the Lorentz transformations, the rest was just algebra.

Sam: Remind me of the algebra.

Kim: We got to the point where we realized that the proper time interval, $d\tau$ must be defined as

$$c^2 d\tau^2 = c^2 dt^2 - d\vec{x}^2, \qquad (6)$$

Where dt and $d\vec{x}$ the coordinate time and space interval, respectively. Then we multiplied Eq. by $m^2c^2 / d\tau^2$ to obtain

$$m^2c^4 = m^2c^4 \left(\frac{dt}{d\tau}\right)^2 - m^2\vec{u}^2c^2 \qquad (7)$$

Where we have equated $\vec{u}$ with $d\vec{x} / d\tau$. The right hand side of Eq. then becomes $m^2c^4\gamma^2 - \vec{p}^2c^2$ as $\gamma = dt / d\tau$ and $\vec{p} = m\vec{u}$. Finally we denote the relativistic kinetic energy by $E = m\gamma$ so that Eq. 7 becomes

$$m^2c^4 = E^2 - \vec{p}^2c^2 \qquad (8)$$

So if $\vec{p} = 0$ then $E = mc^2$. Like I said, just algebra.

Sam: Hmm, yes indeed. Suppose you are floating in a room with no windows or doors. All of a sudden, you feel a force that throws you against the wall. If there were two possible forces, gravitational and centrifugal, are you able to determine which force you are feeling?

Kim: I don't see how.

Sam: And what would you (sitting in this closed room) say your time dilation was with respect to an observer who was not feeling the centrifugal or gravitation force?

Kim: I think I see what you are getting at. I can't say whether the force is gravitational or centrifugal, so I must treat their effects as the same. If I knew the force was centrifugal, I would say that my time dilation with respect to a stationary observer depends only on my velocity $\vec{v}$, that is, $\gamma = 1/\sqrt{1 - v^2/c^2}$. Because I don't know where the energy to thrust me against the wall has come from, to be consistent I must say that the time dilation depends only on the effective potential, which is the sum of the gravitational and centrifugal potentials.

Sam: Excellent! The idea that you can't know if the force is a uniform gravitational force or a combination of uniform forces, is called the equivalence principle [10]. What does it tell you about clocks on the surface of the Earth?

Kim: Yes, yes, of course. According to somebody standing anywhere on the surface of the Earth, all their energy is effective potential energy Φ_{eff} . The rate at which their clock ticks depends only on this effective potential. We already showed that the effective potential over the surface of the Earth is constant. So all clocks on the surface of the Earth tick at the same rate. Eureka, I can sleep again!

Sam: Yes, you can sleep well indeed because you have just discovered one of the fundamental arguments that led to the development of the general theory of relativity. Before you go, let me clarify one point. To determine the time dilation, you used the effective potential which came from Newtonian arguments about gravitational and centrifugal forces. According to general relativity the Newtonian effective potential is an approximation to the relativistic effective potential. This difference does not change our conclusion in any way, the effective potential is still constant, it just means that in general relativity we have a slightly different version of Φ_{eff} . Having said that, you should note that for the Earth, the Newtonian and relativistic effective potentials are almost identical. To learn precisely what the difference is, you will have to take my general relativity course, unless you continue to derive general relativity by yourself!

After exchanging pleasantries, Kim leaves for the long cycle home. While cycling home Kim reflects on the fact that the thought experiment involving a person in a windowless room who didn't know if the force she/he felt was gravitational or centrifugal was very similar to the arguments about absolute and relative motion that they had learned in their special relativity course.

III REFERENCES

1. "Meno by Plato translated with an introduction by Benjamin Jowett", The University of Adelaide Library Electronic Texts Collection, March 2, 2003 , *http://etext.library.adelaide.edu.au/p/plato/p71mo/*
2. The Bureau International des Poids et Mesures, *http://www.bipm.org/*
3. Alex Harvey and Engelbert Schucking, "A small puzzle from 1905," Phys. Today 58 (3), 34–36, 2005.
4. William K. Rose, Astrophysics (Holt, Rinehart and Winston, New York, 1973).
5. Subrahmanyan Chandrasekhar, Ellipsoidal Figures of Equilibrium, 2nd ed. (Dover, New York, 1987).
6. Claude Audoin and Bernard Guinot, The Measurement of Time (Cambridge University Press, Cambridge, 2001).
7. Guy Bomford, Geodesy, 5th ed. (Oxford University Press, Oxford, 1986).
8. Pratap Misra and Per Enge Global Positioning System: Signals, Measurements, and Performance 2nd Edition (Ganga-Jamuna Press, Lincoln, MA, 2006).
9. David Lide, CRC Handbook of Chemistry and Physics (CRC Press, New York, 1997).
10. Bernard F. Schutz, A First Course in General Relativity (Cambridge University Press, Cambridge, 1985).

The equivalence principle as a stepping stone from special to general relativity: A Socratic dialog

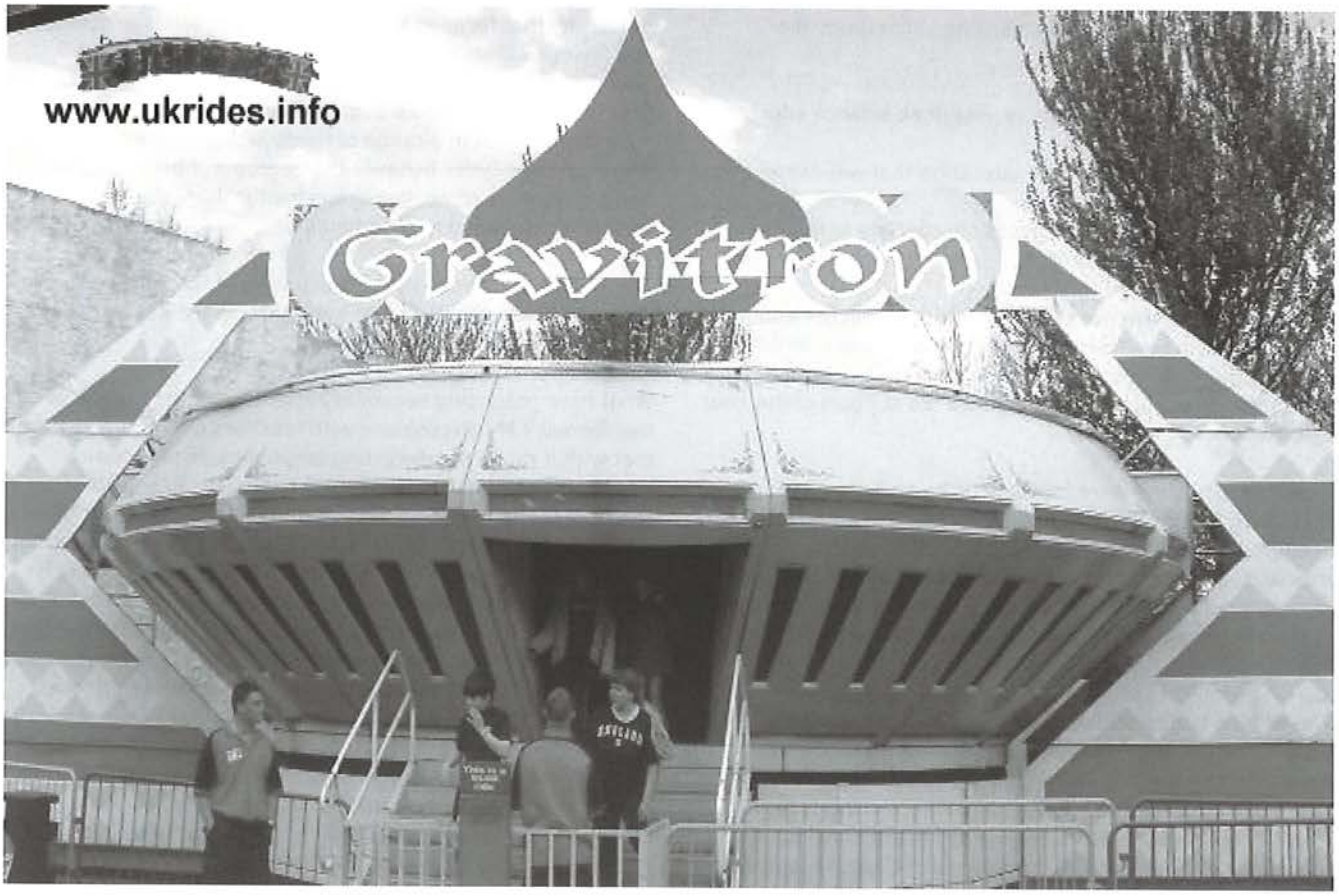
(Footnotes)

1 Colatitude is $\pi/2$ minus latitude. It is the coordinate of choice for most references on planetary gravitational potentials.

2 This is the total mass of the Earth including the atmosphere. Because we are calculating the gravitational potential at sea level, we should subtract the mass of the atmosphere, but we do not need to do this subtraction as the mass of the atmosphere is roughly one millionth of the total mass of the Earth.

3 This value of a is defined to fit the ellipsoidal Earth model WGS84, for more details see [Ref. 8].

Sam Drake is a senior research scientist with the Australian Public Service holding a Bachelor of Science with Honours degree from the University of Melbourne and a PhD from the University of Adelaide on general relativity. The University of Adelaide has kindly given Sam the position of adjunct associate lecturer so that he might write publications of the sort presented here.



Has the time come to Re-imagine Science Education?

Dr. Mark Butler Like most counties in the developed world, Australia has been adversely affected over the past two decades by an increasingly serious 'crisis' in science and technology. Decreasing interest and participation by students in the enabling science has been well documented and Australia has for many years only managed to stave off a serious skills shortage by importing trained workers from overseas. Some commentators have suggested that negative attitudes to science have their origins in our schools and that the current shortage of teachers in the enabling sciences will only exacerbate the problem.

In response to this perceived 'crisis' in science education, the Australian Council for Educational Research (ACER) organised a National Conference in 2006 entitled 'Boosting Science Learning – What will it take?' At the end of the Conference there was general agreement among the delegates that the purpose and nature of science had changed significantly over the past thirty years but that science education had not kept pace with this change. There was a need therefore to 're-imagine' science education to ensure it would continue to be valuable and relevant to our young people.

The Conference concluded with a plenary session from which the following propositions emerged:

Proposition 1: We need to re-imagine science education, accepting a shift that is occurring and must occur in the way we think of its nature and purposes. The implication of this [shift] is that any moves towards a national agenda for science education need to be premised on this re-imagining rather than refinement of the existing curriculum and assessment.

Proposition 2: To achieve this re-imagined science education we need to develop:
- a new metaphor for science education that will capture its nature; and,
- rigorous assessment processes appropriate to this re-imagined science education.

Proposition 3: There needs to be a national teacher education agenda focusing on re-imagining the role of the science teacher and developing teachers' capabilities (knowledge, pedagogy, disposition) which enables the support of the new directions.

These propositions were followed up by an Australian Education Review (AER51) in 2007 entitled: 'Re-imagining science education – Engaging students in science for Australia's future'[1]. In this Review, Professor Russell Tytler (a science education academic from Deakin University) attempts to show what a re-imagined science education might look like.

The Review begins with a glowing forward from Australia's Chief Scientist Jim Peacock about the importance and relevance of the work. This is followed by a brief examination of the 'crisis in science'. Tytler believes the crisis is an imperative for educational change but that it should not be taken as a 'reference point' for change. He argues that the drift away from science in developed countries might well have deep societal roots rather than be a consequence of school curricula alone. Tytler instead bases his argument for change on a number of studies that link traditional high school science curricula with the decline in interest in science.

Tytler states throughout the Review that science is often taught using a narrow range of pedagogies to deliver outdated, discipline-bound, canonical content to students who are then assessed largely by declarative means. He asserts that science content is seldom taught within an appropriate context and that teaching abstract concepts to enable students to solve standard problems is no longer an acceptable way to teach modern science. The report does concede however, that science is not taught this way in all Australian classrooms and that there are pockets of creativity and innovation across the Nation.

The multitude of science education initiatives aimed at modernising curricula and pedagogy that have been introduced around the world over the past 20 years are largely dismissed by Tytler as well meaning but ineffective. He sheets the failure of many of these initiatives down to the difficulty of changing teachers' ingrained attitudes about what science is and how it should be taught.

The Review uses selected science education literature to support specific changes in content and pedagogy that Tytler believes will enrich science education and engage the science learner more effectively. The Review strongly supports the new BSc/B.Teach(Sci) degree recently introduced at Deakin University that focuses on contemporary practice in science and includes units on; Science Communication, Being a Science Learner, Working with Science and Community Science Project. The new degree enables graduates to gain employment in a range of fields including education and Professor Tytler believes the degree will better equip graduates to work in science education, science communication and related fields.

The Report concludes with a discussion of teacher led reform and a table (See Table 1) that summarises the key strands of a 're-imagined science curriculum'.

What have practising secondary science teachers made of this Review? My discussions with teachers about AER51 have met with a range of interesting responses. Many science teachers were concerned about the danger of contextual teaching diminishing conceptual understanding and/or that they might end up teaching 'science appreciation' rather than science. They were also concerned that while the approach advocated in the report might suit some students it would not suit all students. In particular, talented students who love the abstract conceptual nature of the subject were mentioned and concrete thinking students who loathe ill defined rich tasks were brought up.

Some experienced teachers were incensed about being 'blamed' for the failure of earlier initiatives, which they believed were caused by lack of resources, poor training and/or poor long term support. Some teachers were

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Table 1 Strands in a re-imagined science curriculum.

Strand	Comment
Conceptual content and context	It is clear that the curriculum needs to seriously cater for student interest and be set within contexts that will be meaningful to all students. The content of science needs to be set within these contexts, and introduced on a need-to-know basis but structured so that major ideas are covered. The amount of content coverage needs to be reduced. Content should be chosen to represent contemporary practice, and with a view to its usefulness in students' current and future lives as citizens. Content should not be restrictive but needs to allow room for initiatives built around local conditions.
Pedagogy	Teaching strategies in science need to be more varied, with greater agency accorded to students to pursue ideas and have input into discussion. Ideas should be treated as tools to be used flexibly, rather than simply recalled and recounted, and a premium should be put on the having and testing of ideas. Explicit attention needs to be paid to: (a) the literacies of science and the role of representation in learning; (b) reasoning in science; and (c) aesthetics and narrative elements in science learning.
The way science works	Greater attention needs to be paid to the workings of science in contemporary society, including sociological and epistemic aspects. That is to say, the curriculum should strongly represent the way science interacts with society and technology and include concepts such as risk and questions of value and ethics. It should strongly represent the way knowledge is established in science, the nature of scientific evidence, and the processes of science investigation, via rich representations.
Investigative Science	Science investigations need to be more varied, with explicit attention paid to investigative principles. Investigative design should encompass a wide range of methods and principles of evidence including sampling, modelling, field-based methods, and the use of evidence in socio-scientific issues. Investigations should frequently flow from students' own questions. Investigations should exemplify the way ideas and evidence interact in science.
Capabilities relating to science	The curriculum needs to explicitly aim to widen the capabilities currently associated with school science to include understandings of the nature of science and the way it works both in a research and a societal sense, the capacity to investigate and reason, dispositional capabilities such as interest and curiosity and appreciation of the workings and methods of science, and more broadly generic capabilities such as thinking analytically, communicating and working in teams, and creativity and imagination. In so far as these are part of generic sets of capabilities included in some states' science curricula, more work needs to be done on conceptualising what they look like and how they can be developed and assessed in science.
The setting of school science	School science should be linked more often and more closely with local and wider communities, and science should be studied in community settings that represent contemporary science practices and concerns. Ways need to be found to embed school–community initiatives into the curriculum in sustainable ways.
Assessment	Assessment approaches need to be developed that support the wider range of curriculum emphases advocated by this review. This includes assessment of investigative capabilities, the capacity to explore science in social and ethical contexts, reasoning and imagination, and understandings of the nature of science. Ways need to be found to embed authentic, learning-based assessment practices in mainstream practice, alongside more imaginatively conceived test-based items.

delighted with the Review and felt that change was long overdue. Many experienced teachers expressed the view that the key strands of a re-imagined curriculum were not particularly new or revolutionary. Indeed these teachers felt many of these innovations have gradually been filtering into classrooms over the past twenty years and that modern curricula and teaching has for some time been evolving towards the re-imagined science education proposed by the Review. Some teachers believed that the crisis in science was not due to, nor could it be solved by, changes in teaching practice or curricula. These teachers talked about; limited employment opportunities in science, poor salaries and conditions, lack of employment security, poor promotion prospects, and the low status of scientists, science teachers and engineers.

In my own school over the past decade the emphasis has clearly shifted towards more contextual teaching and towards the use of more varied, student-centred pedagogies. There is also a greater emphasis now on the nature, uses, social implications, history, and practice of science. The changes to the NSW Science Syllabuses in 2000 accelerated this evolution, but I have no doubt that science education in NSW was moving in this direction anyway. Changes in the practice

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of science and the findings of science education research take time to filter down to schools but, in spite of this Report's inference to the contrary, they do filter down and content and practice does change.

One of our most successful school based innovations, in terms of encouraging more students to study science in the senior school was to introduce one-term units in Physics, Chemistry and Biology in year ten. Exciting, contextual, ten week units taught by enthusiastic, specialist teachers in each subject area opened the students eyes to what each discipline is about, how it can be applied and what career opportunities it might open up.

We have seen many students who were uninterested in science in years 8 and 9, suddenly become excited about science in year 10 and pursue science in the senior school and beyond. This type of specialist subject/teacher based initiative goes against the multidisciplinary approach advocated by Tytler's Review, but there is no doubt it significantly increased senior science numbers at our school. The students also like it. When surveyed, 98% of students preferred doing separate units with different teachers in year 10 and 92% of year 11 physics students said the yr10 course influenced their decision to study physics in the senior school.

Content and pedagogy can influence student motivation, but a much more important influence is the quality of the teacher. The report fails to address this key requirement of a re-imagined science education adequately. My views on the importance of the teacher have been expressed elsewhere[2]. Suffice it to say that 'great teachers' are passionate about their subject and about teaching others about it. They are also have an expert knowledge of their subject and have the ability to make a connection with each of their students. Students enjoy their classes and want to learn what the teacher has to teach. The low entry scores of science teaching degrees at many Australian universities, the low status of teachers and poor teaching salaries and conditions were not discussed. Perhaps as well as re-imagining content and teaching methods we should also be trying to work out how we can put more 'great teachers' in front of our children.

Science education in schools today may not be perfect, but it is not a total failure either. Many students develop a genuine passion for science in our schools and there is a risk that radically changing the emphasis of what we teach and how we teach it might turn as many students off science as it switches onto science. There have been a multitude of similar innovative science education programs implemented throughout the world and surely if any of these programs succeeded with all students they would have been replicated in schools around the globe. The report suggests there is currently a mood for change among science teachers. I suspect this is true, but I believe most teachers would prefer to develop best practice through individual 'bottom up' school based trials and initiatives, rather than have a single model of best practice thrust upon them from above.

The new federal Labor government's announcement, that all Australian students will be studying a single national curriculum in English, History, mathematics and science by 2011 could well force the issue. It would seem that AER51 has been released at on opportune time to influence the science educators, academics and teachers that will be involved in designing the new national science curriculum. Most teachers will be hoping that the new national curriculum will mirror the best practice that has evolved in schools and that it will be flexible enough to facilitate continuous school based innovation.

1. Tytler, R. Re-imagining Science Education. Australian Education Review 51. ACER press Vic. 2007

2. Butler, M. and Collins, R. Great Teaching. ATSE Focus No.138 October 2005

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Aussie girls beat US young physicists.

Tess Livingstone, of The Australian, reported that *AMID serious concerns about falling education standards, three 16-year-olds from Brisbane have taken on the best in the US in physics - and won hands down."*

Brisbane Girls Grammar Year 12 students Samantha Luck, Sarah Thang and Kathryn Zealand were the only Australian team invited to the US National Young Physicists Tournament, held at the North Carolina School of Mathematics and Science.
The only all-girls team in the competition, they took on the best eight teams from US schools. In the final, the girls defeated the all-boys Woodberry Forest School, Virginia, the defending champions, by 344 points to 277.

Kathryn, who is planning a career in quantum physics said the girls were amazed to find only one other girl in the entire competition. Samantha and Sarah said excitement about physics was a given at their school.

Sarah said the best part of the experience was taking on opposing teams in "physics fights" where the girls had to defend their solutions and find the flaws in their opponents' solutions.

They were invited because of the school's high profile in international physics. Brisbane Girls Grammar hosted the International Young Physicists Tournament in 2004."

Readers of Australian Physics will remember Kathryn Zealand from our article (Australia wins the International Young Physicists' Tournament) in the September/October 2007 issue.

Parts of this report are from an edited news item. The complete story can be found at The Australian: *http://www.theaustralian.news.com.au/story/0,25197,23205445-30417,00.html*

Australian Physics Bachelors and Honours Graduates in Industry: Where are they? How well prepared are they?

A. Mendez (Sydney), J. Pollard (Adelaide), M. D. Sharma (Sydney), D. R. Mills (Monash), S. J. Gribble (Curtin), Sue Hagon (UNSW), L. Kirkup (UTS), M. Livett (Melbourne), D. Low (UNSW@ADFA), A. Merchant (RMIT), J. O'Byrne (Sydney), A. Rayner (Queensland), G. Swan (ECU), M. Zadnik (Curtin), W. Zealey (Wollongong)

Who employs 3-year and 4-year (Honours) physics graduates?
What are the experiences of these graduates when studying physics?
What are graduates' perceptions of the value or usefulness of their physics education in relation to their employment?
What graduate attributes are developed in undergraduate physics?
What are the employers' experiences with such physics graduates?
Are the graduates readily trainable in the workplace?

Introduction

The study of physics graduate employment in Australia was part of the two-year project on tertiary physics learning and teaching conducted in 2004-2005[1]. In order to assess how effectively undergraduate physics studies prepare students for the workplace, the project team attempted to locate and interview recent physics graduates, and employers of these graduates. The study was limited to graduates who majored in physics with a 3-year (Bachelors) or 4-year (Honours) degree, who did no further or concurrent (double degree) studies, who were employed, and who graduated within the last five years. From a sample of eleven physics departments, it was soon recognised that there were relatively few such graduates. Interviews with a small sample of the graduates and employers confirm that physics graduates have particular strengths in problem solving and adaptability, and identified some areas for improvement. There are important implications for Australian tertiary physics education in the situation now evolving.

Employment of Physics Bachelors and Honours Graduates

Australia-wide, there were 747 students in third year physics in 2004 (rising steadily each year from 488 in 2001 to 870 in 2005), and 174 in fourth year in 2004 (a slow upward trend since 2001)[3]. Many physics majors are in double degree programmes: the project team chose not to include graduates from such programmes due to the difficulty of separating the capabilities acquired from their undergraduate physics from those arising from the other degree program (e.g. engineering). Most Australian physics students also study mathematics to at least second if not third year, hence no attempt was made to disentangle the contribution made by mathematics. The study did not look at the relatively small number of new graduates going into teaching, since this involves either further study or a double degree arrangement, although we acknowledge that this is an area of critical importance. Figure 1 shows the types of degree and employment of those graduates who were included in this study.

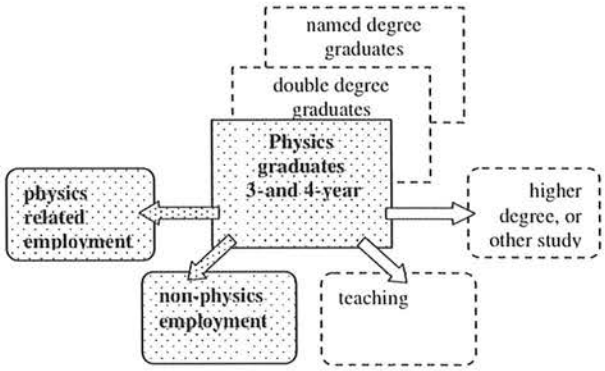

Figure 1. The options available to students after completing a physics undergraduate degree. This study only considers the categories which are shaded.

The eleven departments who participated in the search for potential interviewees are spread across five states and the ACT, and included large Go8 research departments, medium sized departments with an applied physics emphasis, and small departments mainly teaching service subjects. The third year enrolment numbers in these eleven departments account for 46% of the total third year physics enrolments in Australia in 2004. Only five departments were able to find and interview graduates fitting the criteria. These five departments account for 26% of the total third year enrolment. Since the graduates identified in this study come from a small number of departments, the project team does not claim that the observations presented here can be generalised to all departments. Nevertheless, they give some indication of the general situation.

Whilst it is common knowledge that a large fraction of physics graduates continue with further studies, it is nevertheless surprising how few physics graduates enter the workforce with only a pass or honours degree. For example, the University of Sydney quoted 2 from the 2002 cohort of 66 third year students. (Interestingly even as far back as 1980[4], only about 20% of third year physics students looked for immediate employment with another 46% proceeding onto Honours or higher degrees and a further 31% undertaking further undergraduate or diploma studies.)

Two recent trends in the employment of physics graduates provide the background to this study.

Outcomes of this work in an international context has been published as
"What does a physics undergraduate education give you? A perspective from Australian physics," in the European Journal of Physics.[2]

This project is on-going as part of the Carrick Institute for Learning and Teaching in Higher Education funded project titled Forging new directions in physics education in Australian universities.

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1. First, physics employment opportunities in Australia have changed over recent years. The number of physics related job positions advertised in the press for which a bachelors or honours qualification is sufficient, has declined, particularly in 2003[5]. This was in part due to several large companies (such as Kodak) closing down their research sections which formerly employed honours graduates as a consequence of new technologies and globalisation, and few openings in government institutions such as CSIRO and DSTO.

2. Second, there is a strong and rising demand to fill postgraduate positions. The number of physics postgraduates in Australian universities has increased steadily in recent years, rising from 743 in 2001 to 913 in 2005. To sustain this latter number would require about 200 new postgraduate students each year – a figure well in excess of the annual number of Australian physics honours graduates. Departments are keen to grow or at least maintain their research strengths and hence recruit many of their fourth year graduates into research. The implications of "departments needing students" versus "students wanting physics" are discussed below.

Interviews with Graduates and Employers

Some of the interview questions are quoted in the box at the beginning of this article. The questions were open-ended in order to obtain unprompted answers. The interviews were analysed both by comparing the responses for each question across the interviewees and by considering each interview as a whole, in order to identify key categories and features.

The data comprises six graduate interviews (three females and three males) and seven employer interviews. (Most, but not all, of the graduates and employers "match up".) Five graduates had done an honours degree and the sixth had work experience in research. Whilst these are small samples, there is value in the information gleaned as case-study material and in establishing issues raised for future investigation.

Who employs 3-year and 4-year (Honours) physics graduates (with no other qualifications)?

Six of the seven employers interviewed are from a scientific or educational institution; employing physicists in the areas of medical physics, computer programming, data analysis and research. The one exception is a financial institution employing a physicist as an account manager. Two of the graduates interviewed are employed as physicists and another works as a geophysicist; all three identify themselves as physicists. Of the remaining three, one is employed as a research assistant in the educational field, one as an actuarial analyst and one as an account manager. Other destinations reported by the departments surveyed included DSTO, ANSTO, the Australian Synchrotron and medical physics. Collectively these destinations are broadly comparable with Prescott's 2003 survey[5] of advertisements.

The positive news is that physics graduates are getting satisfying jobs which use their education; while one of the six graduates acknowledges being overqualified for the job, all others indicated a degree of challenge in their work. Three of the group however, had other experience or training which may have advantaged them in gaining employment: two of the graduates interviewed had substantial industrial experience, one had prior actuarial studies.

What were the experiences of these graduates when studying physics?

In the interview, graduates were asked what features of their undergraduate physics studies were most beneficial to their learning. This question was designed to complement the information gained largely from academics about effective learning and teaching.

The first feature was that all but one graduate mentioned laboratories as the feature where a substantial amount of valuable learning took place – where theory can be applied, hands-on experience is acquired and skills such as planning, experimental design and documentation are developed. The one graduate who did not mention laboratory is a special case, having come from mathematics to do physics honours, and had little exposure to undergraduate physics laboratories.

A second feature apparent in the responses is the importance of the tutorial experience, identified by four of these graduates. They not only appreciated tutorials as a vehicle in which to develop their problem solving skills but also thought it very beneficial to work in groups and have access to tutors. Their comments indicated that tutorials were quite interactive. In one instance a graduate lamented the fact that tutorials had not continued beyond the first year of the physics degree.

Teamwork was also mentioned in four interviews, in situations ranging from year-long projects to seminars and small group discussions. Half of the graduates indicated that they appreciated the provision of good lecture notes and worked examples.

"Tutorials were extremely helpful ... having someone go through examples at a pace you could follow, and being able to ask questions, helped to consolidate the ideas."

What aspects of their physics education were most helpful for their career?

All graduates interviewed were positive about how their physics degree had prepared them for the workplace. In answering the open-ended question about the aspects which had helped most, graduates gave three to five main points (some added several further sub-points). Overall, the most important were problem solving (5 graduates), analytical thinking (4 graduates), and seeing the bigger picture (4 graduates).

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"Doing physics has given me the confidence to tackle difficult problems and to look at the bigger picture before moving into the details."

What are graduates' perceptions of the advantage of having done physics?

All the graduates saw significant advantages in having done physics over other disciplines. Two specific advantages were repeatedly mentioned:
- physics gives a bigger picture and greater depth of understanding than obtained from other disciplines (5 graduates), and
- it provides the ability to tackle difficult problems from a variety of angles (all 6 graduates).

Only the person working in educational research did not specifically mention the first factor, which is understandable given the different field of work. Significantly, the graduates working in non-science fields believed that they were readily able to make up for their lack of career-specific training, and had the advantage of analytical skills. Those in the science workplaces felt that they would seek a deeper understanding of the situation than would say an engineer or geologist.

"Physics gives you a broader knowledge base ... allows you to work in other disciplines more easily."

What graduate attributes are developed in undergraduate physics?

At the end of the interview, graduates and employers alike were given a list of 11 graduate attributes and asked to rank the extent to which each skill was developed in their undergraduate physics or seen in their physics-graduate employees.

Nearly all of the graduates believe that they have acquired 'some' or 'a lot' of skills in relation to problem solving, laboratory and experimental design. They are least sure about possessing skills in project planning, oral communication and social and ethical issues. In their responses to open-ended questions about the most valuable skills and knowledge gained from their studies, practical and problem solving skills were frequently included while other generic skills were rarely mentioned. These perceptions closely mirror those of current physics students in focus groups in 2004[1].

Employers concur with graduates that problem solving is highly developed. However their perceptions differ in relation to experimental design: four graduates thought that experimental design was a well-developed attribute, but of the four employers in science industries, only one gave the highest ranking ("a lot") to this attribute. Two employers stated that whilst physics graduates are generally competent at carrying out tasks or experimental work when the procedure is given, they found that they do less well when forced to start from scratch. The related areas of project planning and research methodology were also ranked noticeably lower by employers.

"More confidence in "lashing up" experimental setup from scratch is needed ... these attributes need to be at least addressed by university if not fully developed."

Are physics graduates readily trainable in the workplace?

All seven employers interviewed said that physics graduates are able to adapt well and quickly upon entering the workplace, with four of the six giving very positive comments, and another noting that the graduate developed positively with supervision. Half said that physics graduates are better equipped than other graduates when it comes to tackling problems outside their field of expertise (a further two employers were obviously positive in other comments but felt they should not compare on the basis of only one physics graduate). All agreed that physics graduates bring a broad range of skills and are open minded about the way problems may be approached.

The employers' ranking of computational skills is mixed. One employer required strong computing skills and recognised that their physics-trained graduate was less well equipped than a computer science graduate (the employer was satisfied in all other areas). Two employers explicitly reported that they chose to employ physics graduates and bring them up to speed in computing or IT rather than employ computing-IT specialists.

Interpersonal, business and management skills were important to employers in people-related industries such as medical physics or business and to others in government scientific organisations. Professional courses (whether in health or engineering) provide specific training to address such needs, so now expectations are higher in the workplace.

Taken as a whole, the employers interviewed had high expectations of graduates across a wide range of abilities, including technical expertise, modelling, problem solving, teamwork, and being able to participate in a constant process of improvement. It is encouraging that physics graduates do well in most areas.

"The learning is continued in the workplace but the habits are formed within the education system."

Conclusions

The main conclusion this study has reached is that few 3- and 4-year graduates are entering the workforce. One likely reason is a common demand for physics postgraduate students to carry out research, in spite of considerable diversity in the make-up of the 3- and 4-year graduate cohorts across departments. Another is that fewer students are doing a single degree because of the popularity of combined degrees.

Interviews with employers and graduates however have given a positive perspective on employment experiences for this small subset of graduates. The study has confirmed that they have a range of important skills valued by employees

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and are readily trainable upon employment. Employers across a spread of industries continue to value the strengths traditionally associated with a physics degree. It has shown weaknesses in some graduate attributes particularly for those wishing to work in non-science sectors.

Individual departments are best placed to evaluate their own course and graduates and how they will adapt for a rapidly changing world. Areas such as experimental design, project planning, management and interpersonal skills may well be in need of attention. The current risk is for departments and individual students alike to be laissez-faire about employability since most graduates continue into higher degree research, and those wanting to enter the workforce are still getting jobs. It is clear that if more physics graduates were to enter the workforce it would become even more vital that they have excellent generic skills in addition to the advantages of a physics education.

There is a particular need to have physics graduates in the workplace where their physics skills and knowledge are acknowledged and valued. If physics withdraws into itself and does not strive to have 3- and 4-year physics graduates in the workplace, it could potentially see a spiral-down effect in which suitable work is done by graduates of other disciplines, with even fewer opportunities for physics graduates in the future. A healthier future is promised by more students inspired by physics in their early years, becoming better equipped graduates for the workplace and moving out beyond traditional opportunities into multidisciplinary areas and into teaching.

The next phase of the project is designed to collect more information about destinations for physics graduates, including higher degree and combined degree graduates. If you are interested in assisting in the project please contact
Dr John O'Byrne at the
School of Physics, University of Sydney
j.obyrne@physics.usyd.edu.au.

Acknowledgments

The authors wish to thank the employers and physics graduates who gave their time and thoughts in the interviews, and Professor John Prescott (Adelaide) who provided advice. The project has been funded by the Australian Universities Teaching Committee and the Carrick Institute for Learning and Teaching in Higher Education. Institute of Physics Publishing has permitted the use of material earlier published in the European Journal of Physics.

References

1. M. D. Sharma, D. Mills, A. Mendez and J. Pollard, Eds, 2005, Learning Outcomes and Curriculum Development in Physics [Monash University, ISBN: 0-7326-2063-5]. Downloadable from *http://www.physics.usyd.edu.au/super/AUTC/*

2. M. D. Sharma, J. Pollard, A. Mendez, D. R. Mills, J. O'Byrne, S. Hagan, S. J. Gribble, L. Kirkup, M. Livett, D. Low, A. Merchant, A. Rayner, G. Swan, M. Zadnik, W. Zealey, 2008, What does a physics undergraduate education give you? A perspective from Australian physics, [European Journal of Physics, 29,59-72]

3. J. de Laeter, P. Jennings and G. Putt, 2005, Physics Enrolments in Australian and New Zealand Universities 2000-2005, [Australian Physics, 42, 115-123]

4. P. J. Jennings and M. G. Zadnik, 1980, Career Aspirations and Employment Experience of Physics Students, [The Australian Science Teacher's Journal, 26, 31-38]

5. J. Prescott, 2004, Jobs in Physics 2003, [Australian Physicist 41, 44-49]

Australian Institute of Physics

Summary of Awards

Walter Boas Medal

Brief Description: The aims of the award are to promote excellence in research in Physics in Australia and to perpetuate the name of Walter Boas.

Eligibility/Procedure: The award consists of a medal and is open to competition in any year among persons resident in Australia for at least five out of the seven years preceding the closing date of the entry for the award. The award shall be given for original research making, in the opinion of the examiners, the most important contribution to physics. This will be judged in papers published during the four years immediately preceding the date on which entries for the award close, supported where appropriate by unpublished papers or reports on work carried out during that period.

If a candidate considers that knowledge of work carried out prior to the four year period is necessary for the correct evaluation of the record of work submitted for the award, reference may be made to the work where published, or an unpublished account of such previous work may be submitted. The Medal shall not be awarded more than once to the same person.

Web site: *http://www.aip.org.au/content/boas*
Closing date for nominations: 1st August 2008
Awarding Organisation: Australian Institute of Physics (Victorian Branch)

Harry Massey Medal

Brief Description: The prize is awarded every two years for contributions to physics or its applications made by an Australian physicist working anywhere in the world, or by a non Australian resident in, and for work carried out in, Australia.

Eligibility/Procedure: The recipient must be a member of the Australian Institute of Physics or the Institute of Physics (England) and an Australian physicist working anywhere in the world, or by a non Australian resident in, and for work carried out in, Australia. A lecture on the work for which the Medal is awarded is presented at Congress in the year of the award, and an article published in Australian Physics.

Web site: *http://www.aip.org.au/content/massey*
Closing date for nominations: 31st April 2008
Awarding Organisation: Institute of Physics (UK)

Award for Outstanding Service to Physics in Australia

Brief Description: The Australian Institute of Physics has several awards for excellence in some aspect of Physics. They are usually based on the research contributions of the individual or group concerned.

Eligibility/Procedure: The Award will be open to members of the AIP. Nominations may be made by a Branch Committee or by three members of the AIP. There will be no more than three awards nationwide in any one year and the Selection Committee, which will be appointed by the Executive, will reserve the right to make no awards in any one year.

The AIP Award for Outstanding Service to Physics will recognise an exceptional contribution on the part of an individual. Nominations should be accompanied by a clear one or two page citation describing the outstanding service given by the nominee.

Web site: *http://www.aip.org.au/content/serviceaward*
Closing date for nominations: 1st August 2008
Awarding Organisation: Australian Institute of Physics

Gold Bragg Medal

Brief Description: The Bragg gold medal for the best PhD thesis by a student from an Australian University was established in 1992 as an initiative of the South Australian Branch, to commemorate Sir Laurence Bragg (in front on the medal) and his father Sir William Bragg.

Eligibility/Procedure: The medal is awarded annually to the student who is judged to have completed the most outstanding PhD thesis in Physics under the auspices of an Australian university, whose degree has been approved but not necessarily conferred in the previous thirteen months. No candidate may be nominated more than once.

The medal will be presented to the chosen candidate at Congress in even numbered years, and in uneven numbered years at a function to be arranged by the AIP Branch of the state of the candidate's university. The medal will not be awarded in absentia; the candidate must be present for the presentation at a time that is mutually convenient. Only one medal shall be awarded; there is no possibility of a dual award. If the selection committee considers that none of the theses submitted reaches an appropriate standard, no award will be made.

The nomination made to the Secretary of the local State Branch should include a citation describing the significance of the work, markers' reports if available and a justification of the nomination.

Web site: *http://aip.org.au/content/bragg*
Closing date for nominations: Nominations from the universities should reach the secretary of the local State Branch by 1st July 2008.

The selected nominations from the State Branches, accompanied by three copies of the thesis, the citation and referees' reports, should reach the Honorary Secretary Friday 1st September 2008.

Awarding Organisation: Australian Institute of Physics

Australian Institute of Physics

Summary of Awards

Alan Walsh Medal

Brief Description: This award, an initiative of the NSW Branch of the AIP, recognises significant contributions by a practicing physicist to industry in Australia. It commemorates the late Sir Alan Walsh, Kt, FAA, FTS, FRS, one of Australia's most eminent and distinguished scientists, who was the originator and developer of Atomic Absorption Spectrophotometry (AAS) and pioneered its application as a tool in chemical analysis.

Eligibility/Procedure: The award consists of a medal and is open for competition among persons resident in Australia for at least 5 of the 7 years preceding the closing date for applications. The award will be given for physics research and/or development that has led to patents, processes or inventions which, in the opinion of the judging panel, have led to significant industrial and/or commercial outcomes, such as devices that are being manufactured or have influenced a major industrial process. The Alan Walsh medal will be presented at the biennial AIP Congress, following which the medallist will present a lecture on the subject of the award.

Web site: *http://www.aip.org.au/content/walsh*
Closing date for nominations: 31st August 2008
Awarding Organisation: Australian Institute of Physics

Education Medal

Brief Description: The purpose of the prize is to recognize an outstanding contribution to physics education in Australia.

Eligibility: The prize is awarded to any member of the AIP who is judged to have made a significant contribution to physics education in Australia. In determining the recipient of the award, the quality of the work, the significance to physics education, and the creativity displayed will be taken into account.

Web site: *http://www.aip.org.au/content/educationmedal*
Closing date for nominations: 30th June 2008
Awarding Organisation: Australian Institute of Physics

Women in Physics Lecturer

Brief Description: The Australian Institute of Physics International Women in Physics Lecture Series was instituted to celebrate the contribution of women to advances in physics.

Eligibility: Under this scheme, a woman who has made a significant contribution in a field of physics will give (at least) one lecture in a venue arranged by each participating branch of the AIP.

Web site: *http://www.aip.org.au/content/wiplecturer*
Closing date for nominations: TBD by WIP group
Awarding Organisation: Women in Physics and Australian Institute of Physics

DSTO-AIP Physics Scholarship

Brief Description: DSTO and the Australian Institute of Physics offer two scholarships for final year honours students studying physics in Australian universities. The scholarships, worth $15,000 each, are offered to students who have completed three years of undergraduate studies in physics and have been identified as being suitable to undertake an honours year.

Eligibility/Procedure: Candidates for the scholarships will only be eligible to be awarded a scholarship by AIP where they are:
i) enrolled in the final year of a degree with a physics major (AIP accredited)
ii) undertaking an honours year of study in the year following the award of the scholarship.
iii) able to demonstrate excellence and commitment to physics
iv) enrolled in full time study for the year they hold the scholarship.

Web site: *http://www.aip.org.au/news/98*
Closing date for nominations: 1st October 2008
Awarding Organisation: Defence Science and Technology Organisation

In addition to these AIP sponsored prizes and awards there are an array of other National and International awards that many of our members may be eligible for. These will be featured in the next edition of Australian Physics so keep an eye out for them.

Samplings

High-Tc superconductors plug 'terahertz gap'
http://physicsworld.com/cws/article/news/31957

Electromagnetic radiation in the terahertz range has a host of potential applications, from detecting explosives to diagnosing cancer. But sandwiched between microwaves and the infrared, terahertz radiation is not easy to generate — its frequencies are too high to be produced by semiconductor devices, yet too low to be produced by solid-state lasers. Researchers from the US, Turkey and Japan, however, have shown that this "terahertz gap" could be filled by exploiting the in-built Josephson junctions present in high-temperature superconductors.

Josephson junctions, which comprise two superconductors separated by a thin insulator, are well known for displaying odd quantum effects. In particular, applying a fixed voltage across a junction sets up an oscillating supercurrent, causing the junction to emit photons at a frequency matching the superconductor's energy gap. In other words, Josephson junctions can produce electromagnetic radiation.

Unlike conventional superconductors, high-temperature superconductors do not need to be made into Josephson junctions because they naturally contain them throughout a unique layered structure. They also have comparatively large energy gaps that lend to producing radiation well into the terahertz range.

Ulrich Welp at Argonne National Laboratory and colleagues have discovered a simple way to synchronize the phase of these "intrinsic" Josephson junctions in high-temperature superconductors to emit milliwatts of power (Science 318 1291). "A wide variety of sensing and imaging applications can be envisioned for terahertz radiation in this power range," said Welp.

Protein calms the waters
http://physicsworld.com/cws/article/news/31838

Biophysicists in the US have discovered that a protein called myoglobin can coordinate the motion of surrounding water molecules, slowing them down significantly – perhaps to allow certain interactions to occur (PNAS 104 18461).

The team has also shown that the motion of these water molecules can be associated with the shape and function of the protein – information that could improve computer simulations of protein dynamics and lead to a better understanding of diseases like Alzheimer's and Parkinson's, which involve drastic protein shape changes.

It has long been suspected that the interactions between proteins and surrounding water molecules – a process called protein hydration – play important roles in protein folding and function. However, these interactions had been very difficult to study because they are so fleeting – sometimes lasting less than a billionth of a second.

[Courtesy: Ohio State University]

Artist's impression of myoglobin: Dongping Zhong and colleagues have shown that this protein controls the motion of nearby water molecules.

Over the past few years Dongping Zhong and colleagues at the Ohio State University have developed a way to study protein hydration using ultrashort pulses of laser light. Their technique involves the amino acid tryptophan, which occurs naturally in proteins. When tryptophan is excited by a laser pulse, it emits light with properties that depend on how the tryptophan is interacting with nearby water molecules.

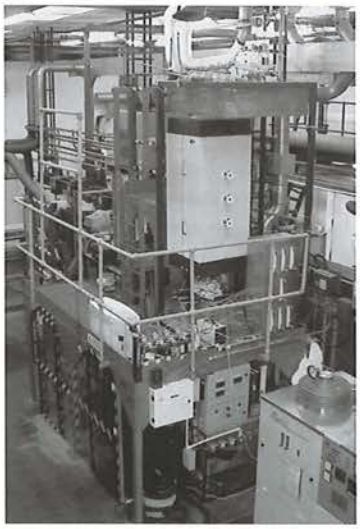
Venus flytrap inspires adaptive optics
http://physicsworld.com/cws/article/news/32071

It may be best known for ensnaring flies, but now the Venus flytrap has also captured the attention of some materials physicists in the US. Alfred Crosby and colleagues at the University of Massachusetts at Amherst have been inspired by the carnivorous plant's unusual jaw structure to create a new material that can rapidly change its shape when stimulated by pressure, heat or electrical current. The team claims that the material could be used to create surfaces that change their reflectivity or lenses that switch between focal lengths.

The movement of the Venus flytrap relies on a "snap-buckling instability", a common phenomenon that can be demonstrated for any rubbery hemisphere. Crosby's group sought to create a structure that could exhibit this behaviour on small scales throughout (Adv. Mater. 19 3589).

Nanotube fibres toughen up
http://physicsworld.com/cws/article/news/31812

Physicists in the UK are the first to make fibres from carbon nanotubes in a simple one-step process that could be adapted for commercial production.



[Courtesy: K Koziol]

Photograph of the carbon nanotube fibre rig at the Department of Materials Science at Cambridge University.

The fibres, which are just a few micrometres across, are claimed to be stronger than any known material and consist of hundreds of thousands of nanotubes bound together. According to its inventors at the University of Cambridge, the new material could find use in a host of applications from bullet-proof vests to flat-panel displays.

Samplings

Despite having walls only a few atoms thick, carbon nanotubes are remarkably strong, yet lightweight, strands that could someday be made into fibres that could be woven into extremely durable fabrics. While several techniques have been developed to spin nanotubes into larger fibres, these are all multistep processes that "are not viable on an industrial scale."

'Nanosoldering' makes a clean contact
http://physicsworld.com/cws/article/news/31814

Physicists in the US have developed a technique for soldering nano-sized objects without contaminating them.

The technique could be used to make clean electrical contacts between advanced structures such as graphene in the making of tiny transistors and nanomachines. Alex Zettl and Caglar Girit at the University of California at Berkeley have come up with a cheap, quick "nanosoldering" technique that overcomes these problems associated with the use of contaminating resists and solvents in electron beam lithography.

Uranium gives opal its shine
http://physicsworld.com/cws/article/news/31941

The beautiful optical properties of the gemstone opal are the result of tiny amounts of uranium present when the stones were formed, according to Brian Senior and physicist Lewis Chadderton, from the ANU in Canberra. They claim that their work could lead to the production of artificial opal and have already shown that the gamma rays given off by the uranium and its radioactive daughters can lead geologists to new underground deposits of the gem.

Opal carvings by the artist Daniela L'Abbate: The play of colour of the precious stones can be seen in the carvings.(Courtesy: OTRAD Pty Ltd. S Tranter-Brown and D Sanders)

Nanowires convert heat to electricity
http://physicsworld.com/cws/article/news/32446
http://www.nature.com/nature/journal/v451/n7175/full/451132a.html

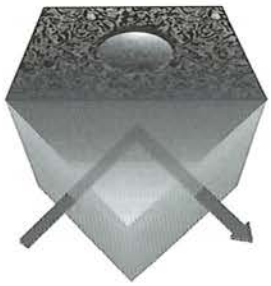
Silicon could soon be used to make low-cost devices that convert waste heat to electricity. That is the bold future outlined by two independent teams of scientists in the US, who have shown that arrays of silicon nanowires have extremely good thermoelectric properties. The findings could lead to the development of cheap thermoelectric materials that boost the efficiency of existing electricity generators and generate electricity from other sources of waste heat.

Unfortunately, today's thermoelectric materials are synthetic nanostructures that are very expensive to make and are nowhere near efficient enough to be used commercially. Some researchers believe that silicon-based thermoelectric materials could overcome these limitations because silicon is easy and inexpensive to work with and has the right electrical properties to be a thermoelectric material. However, silicon is also a good conductor of heat, which makes it a very inefficient thermoelectric material. Now, two independent teams in California have worked out a way to boost the thermoelectric efficiency of silicon by as much as a factor of 100, by using arrays of silicon nanowires.

Casimir effect goes classical: the force of fluctuations
http://physicsworld.com/cws/article/news/32380

Researchers in Germany have made the first direct measurements of the "critical Casimir effect", a classical analogue of the strange quantum effect that draws two conducting surfaces together in a vacuum. They also say that the classical effect can be easily tuned to repel rather than attract for reducing undesirable friction in nanomachines.

The quantum Casimir effect comes about because a vacuum always contains fluctuating electromagnetic fields. The critical Casimir effect has the same underlying principle, but is a classical phenomenon that arises in a mixed liquid close to its critical point — the point, defined by a threshold temperature and pressure, beyond which the gas and liquid phases are indistinguishable. A mixed liquid taken towards its critical point gradually begins to separate into regions of its constituent substances, the size and shape of which fluctuate like the quantum fields in a vacuum. And, like the quantum Casimir effect, two close surfaces in such a liquid set boundary conditions, this time by preferring to be in contact with one of the substances over the other. To fulfil these conditions, the surfaces attempt to surround a single region of the preferred substance by drawing together.



(Credit: Ingrid Schofron)

Researchers from the University of Stuttgart in Germany make use of "total internal reflection microscopy" to measure the critical Casimir effect.

The discovery is not a surprise: Michael Fisher and Pierre-Gilles de Gennes had predicted the existence of the force in 1978, and indirect evidence for it had already been found. Yet this new, strong evidence is extremely impressive — not least because of the weakness of the force that the researchers have uncovered.

Conduction seen in DNA backbone
http://physicsworld.com/cws/article/news/32224

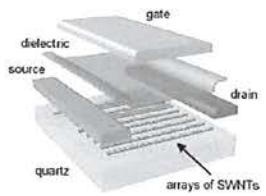
Tetsuhiro Sekiguchi of the Japan Atomic Energy Agency and Hiromi Ikeura-Sekiguchi at the AIST research centre in Japan are the first to measure how electrons move through the DNA backbone using a technique called resonant Auger spectroscopy (Phys. Rev Lett. 99 228102). They have gained important new insights into how DNA might behave as an electrical conductor. Their discovery could help provide a better understanding of the role that conduction plays in the way living cells detect and repair damaged DNA and could ultimately lead to strands of DNA being used in molecular electronics technologies of the future.

Samplings

Biophysicists are keen to understand how electrons are conducted in DNA because conduction is thought to be an important mechanism by which enzymes recognize damaged DNA that, if not repaired, could lead to cancer. A better understanding of conduction could also lead to the engineering of new forms of DNA with properties more suited to electronic applications. DNA is an attractive building block for tiny electronic circuits because of its ability to assemble into complex interconnected patterns that would be required for assembling circuit components.

Nanotube radio goes large
http://physicsworld.com/cws/article/news/32704

The first practical transistor radio made entirely of carbon-nanotube based electronics has been unveiled by researchers in the US. Unlike previous nanotube radios, which produced very weak signals that needed further amplification, the team were able to listen to a local broadcast on headphones connected directly to a nanotube transistor.



Courtesy: PNAS

Schematic exploded view of a radio-frequency (RF) transistor that uses parallel, aligned arrays of single walled carbon nanotubes (SWNTs) for the semiconductor.

To make the radio, John Rogers of the University of Illinois and colleagues worked out a way to align thousands of the nanometre-diameter tubes in sheets in order to create electronic devices that can handle sufficiently large currents to be of practical use (pnas.0709734105). The team claim that their technique is reliable and compatible with commercial electronics fabrication processes.

Light could trap and release bacteria
http://physicsworld.com/cws/article/news/32591

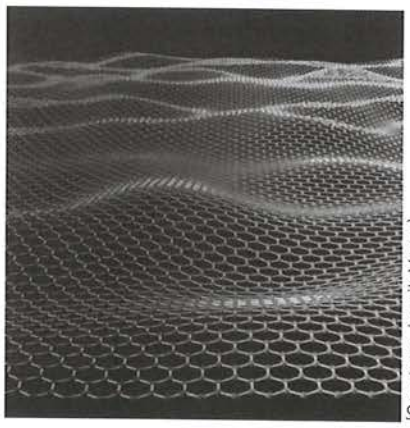
Sensors that use light to trap, analyse and then release tiny objects such as bacteria or DNA are one step closer thanks to new computer simulations done by researchers at Cornell University in the US (Nanotechnology 19 045704). The team modelled the optofluidic interactions that occur when a liquid flows through a tiny channel next to an optical waveguide. The work could lead to new lab-on-a-chip sensors that could be used in a wide range of areas including medicine and security.

In such optofluidics sensors, the tiny objects of interest would be mixed with a fluid that would flow through tiny channels next to solid waveguides. When light is passed through the waveguides, it would create a short-range evanescent electric field in the channel that would trap tiny particles. While being held the objects could be studied using analytical probes, before being released.

Graphene breaks speed record
http://physicsworld.com/cws/article/news/32539

An international team has discovered that electrons move much more easily through graphene than any other known material. Their findings strengthen the belief that graphene — which is a 2D sheet of carbon just one atom thick and a semiconductor — might be the best material for making electronic devices.

Intrinsic electron mobility is a measure of how easily electrons move in a substance, and boosting mobility is one way of making semiconductor devices smaller and run faster. Now, André Geim of Manchester University and colleagues in Russia, the Netherlands and the US have found that the intrinsic mobility of graphene was around 200,000 cm^2/Vs (Phys. Rev. Lett. 100 016602). This value is more than 100 times higher than that of silicon and over 20 times higher than gallium arsenide (1500 and 8500 cm^2/Vs respectively).



(Courtesy: Jannik Meyer).

Artist impression of a corrugated graphene sheet.

Samplings by Don Price CSIRO

Are you a physicist working in an industrial/commercial environment?

We would like to publish more articles about physics and physicists in industry or commerce. If you would like to write an article for Australian Physics on your area and activities to inform the Australian Physics community please contact editor-in-chief A/Prof Brian James (B.James@physics.usyd.edu.au).

Product News

Warsash Scientific

New super range aberration corrected spectrometer

Warsash Scientific is pleased to announce the release of StellarNet's new super range aberration corrected, fibre-coupled concave grating spectrometer. The EPP2000C UV-VIS-NIR spectrometer features improved wavelength sensitivity range from 200 to 1100 nm with better than 1 nm resolution and utilises a 40 mm diameter concave grating with aberration correction to provide superb imaging. This concave grating significantly improves spectral shapes by eliminating comma and astigmatism often encountered in plane grating spectrometers. The flat field spectrometer architecture does not utilize mirrors, and therefore provides the lowest possible stray light in the UV.

The spectrometer is USB interfaced and features no moving parts or detector sockets making it suitable for fieldwork and process stream applications such as remote sensing. This high performance, low cost spectrometer is an ideal OEM component for application specific analytical instrumentation used in process control or QC monitoring.
Features/Benefits
- The flat field grating delivers a uniform focus on the detector, providing ~ 1 nm resolution.
- 2048-element CCD detector.
- Up to eight units can be daisy-chained via USB-2 hubs for dual- and multi-beam process applications.
- Optical input is via fibre optic cable with an SMA-905 termination.
- A choice of 14-, 25-, 50-, 100- and 200-µm slits available.
- The spectrometer is available in two models: the C-SR for 200 to 1080 nm, and the CXR-SR for 220 to 1100 nm.
- SpectraWiz ™ operating software and LabView programs are included.

EPP2000C Super Range Concave Spectrometer

For further information on this and other spectrometer instrumentation:
Warsash Scientific Pty Ltd
Tel: +61 2 9319 0122
Fax: +61 2 9318 2192
sales@warsash.com.au
www.warsash.com.au

New 515 nm DPSS laser for laser fluorescence applications

Cobolt AB continues to expand their portfolio of compact, visible lasers by announcing the release of the Fandango™, the first compact diode pumped solid state (DPSS) solution for 515 nm, now available from Warsash Scientific.

The Cobolt Fandango™ is a continuous-wave solid-state laser with an output wavelength of 515nm and 25mW of power. Built on Cobolt's high-quality, hermetically sealed package, the Fandango™ is a single longitudinal mode laser which features very low noise, narrow spectral line width and exceptionally high beam quality.

With the release of the 515 nm Fandango™, Cobolt now offers a complete suite of compact, all solid state lasers ideal for the replacement of gas (krypton and argon ion) lasers used in fluorescence applications. The Fandango™ is well suited to the excitation of YFP, Alex 514 and Oregon Green. Wavelengths of 491 nm, 515nm, 532 nm and 561 nm are currently available with output powers ranging from 10 to 150 mW.

The Fandango™ laser controller is available in both a CDRH version, intended for stand-alone use in a laboratory environment, and as an ultra-compact remote controlled model for OEM integration. Applications include confocal microscopy, laser scanning microscopy, medical diagnosis and spectroscopy. It is also ideal for use in pharmaceutical labs and clinics requiring an ultra-high brightness light source to induce fluorescence for bioanalysis.
Features & Benefits
- Compact diode-pumped solid state laser
- CW output power up to 25 mW at 515 nm
- Single longitudinal mode
- Narrow spectral bandwidth
- High quality laser beam, TEM00
- Low noise <0.3% rms

For further information on this and other Cobolt DPSS laser systems:
Warsash Scientific Pty Ltd
Tel: +61 2 9319 0122
Fax: +61 2 9318 2192
sales@warsash.com.au
www.warsash.com.au

Fandango 515 nm DPSS Laser

Warsash Scientific Represents IMRA

Warsash Scientific are pleased to announce they have been chosen to exclusively represent IMRA America, Inc. in Australia and New Zealand.

IMRA America, Inc. is a globally active company dedicated to the development of leading edge, ultra-fast femtosecond-pulsed fibre laser technology for commercial and research applications.

Their turnkey fibre lasers combine state-of-the-art design with ultra-compact packaging, high stability, and maintenance-free operation. They are designed for use in material research and processing, semiconductor inspection and repair, multiphoton applications, telecommunication, test and measurement, instrumentation, and medical diagnostics and therapy.

Further information on these and other laser systems is available from
Warsash Scientific Pty Ltd
Tel: +61 2 9319 0122
Fax: +61 2 9318 2192
sales@warsash.com.au
www.warsash.com.au

µJewel Yb-fiber oscillator/amplifier system

Product News

Hiden Analytical

Hiden Analytical Announce Innovative SIMS-on-a-Flange

Hiden Analytical announce the introduction of a complete, compact SIMS facility conveniently mounted on a single UHV Conflat-type flange. The new system, aptly named SIMS-on-a-Flange, allows users to quickly install a complete SIMS resource on existing vacuum and process chambers with no major reconstruction or alignment issues.

SIMS (Secondary Ion Mass Spectrometry) is a high sensitivity surface analysis technique for the determination of surface composition, for contaminant analysis, and for depth profiling in the uppermost surface layers of a sample. Applied to analyses extending from a few Angstroms up to a micron in depth, surfaces are analysed by species and by abundance, layer by atomic layer.

The system comprises the analytical-grade quadrupole mass spectrometer with integral energy filter, the fine-focus oxygen gas-sourced ion gun, and all necessary software and hardware for system operation, for ion beam raster scanning, for data presentation and for surface mapping.

Mass range options enable operation from 1 amu to 1000 amu, with ion counting detection of both positively and negatively charged ions. Standard mounting flanges are DN-150-CF (6-inch port size) and DN-200-CF (8-inch port size) dependent on options.

For further information on this or other Hidenproducts please contact Hiden Analytical ay: *info@hiden.co.uk* or visit the main website at: *www.HidenAnalytical.com.*

A complete SIMS facility mounted on a single conflat flange

Lastek

Lastek appointed the new SensL Australian/NZ Distributor

SensL are manufacturers of advanced new High Gain Silicone APD technology for all Low Light Sensing applications. In fact they now offer the first real solid state alternative to PMT's

SensL's vision is to become the brand and partner of choice for users of low light detectors and imaging systems. They will enable customers to radically improve system performance by providing a unique and disruptive technology that frees them from the limitations of existing Photomultiplier Tube (PMT) based detectors, thereby creating a range of new applications.

This breakthrough in low light detection solutions has been achieved by leveraging their core Geiger Mode Photodiode technology to create three distinct low light detector platforms. SensL's Photon Counting, Silicon Photomultiplier and Low Light Imager products enable the development of new systems for applications such as Bio-diagnostics, Medical Imaging, LIDAR, Environmental Monitoring and High Energy Physics.

Solid state detectors are the future in low light sensing. The performance of SensL's solid-state Silicon Photomultiplier (SPM), and Photon Counting detectors surpasses the current standard detector - the photomultiplier tube (PMT) - and the avalanche photodiode (APD) and PIN photodiode in many applications. SensL's broad range of detector technologies in analog SPM and digital Photon Counting are designed to suit the current and emerging market for low light sensors. At the core of every SensL detector is a low light sensing silicon photodiode that is capable of converting single photons into a measurable output signal. SensL uses dedicated fabrication processes to manufacture these sensors to provide the highest degree of sensitivity and device uniformity, which is only possible with silicon CMOS processing techniques from SensL.

SensL's detectors offer several benefits including:
- Small form factor, which allows miniaturized systems. High gain amplification is on-chip to simplify integration with external electronics.
- Immunity to damage by large photon flux. For example, direct sunlight does not damage the sensor.
- Low operating voltages of 30-50V as compared to APD and PMT detectors, which typically use hundreds or thousands of volts.
- Scalable to large area arrays to provide the ultimate flexibility.
- Unsurpassed uniformity between detectors because of the advanced silicon processing techniques employed to fabricate the core detector.
- Insensitive to magnetic fields.
- Higher detection efficiency than PMT detectors. Detecting more photons results in a high signal to noise in demanding applications.

For more information please contact Lastek at: *sales@lastek.com.au*
Lastek Pty Ltd
Adelaide University
10 Reid St, Thebarton, South Australia
Toll Free: Australia 1800 882 215;
NZ 0800 441 005
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NewSpec

Newport Agilis™ Compact Motorised Optical Mounts

- Convenient hands-off remote adjustment
- Impressive 0.2 arc-s adjustment sensitivity
- Ultra-compact — ideal for space constrained setups and system integration
- Set-and-forget long-term stability
- USB interface

Product News

Newport has released a new controller for it's popular range of Agilis motorised optical mounts. The Agilis AG-UC2 controller provides convenient push button remote control and USB computer control of Agilis mounts. For each axis, the AG-UC2 controller features two rows of push buttons for step size settings, precise low speed adjustments and fast coarse motion. Power is supplied through the USB port and if this is not available, an independent power supply is available to independently power the controller.

A software utility that comes with the controller, allows the user to mimic the remote operation of the controller buttons through the computer and the ability to select and operate a specific Agilis mount. A Windows DLL and LabView VI's for all functions are provided as well.

Agilis optical mounts are the first products that feature Newport's new, proprietary, non-resonant piezo direct motors. These highly integrated motors are directly coupled to the moving platen. When idle, spring forces lock the mirror's position for true set and forget long term stability. Agilis mounts have a faster adjustment speed than alternative screw driven designs and are free of the problems associated with backlash or hysteresis. In contrast to ultrasonic motors, the Agilis non-resonant motor concept makes small adjustments more predictable with its 50 nm incremental motion capability, ideal for ultra-sensitive optical alignments.

Agilis optical mounts are the first members of an entire family of piezo motor, remote controllable components that will be introduced by Newport in 2008.

For further information contact
Neil McMahon at NewSpec
Tel: 08 8463 1967
sales@newspec.com.au

High Resolution Laser Beam Profiler

1.4 Megapixel, 12 bit dynamic range
- Real-time beam size measurement and Gausian fit for both CW and pulses
- 350-1310nm spectral response
- 2D/3D intensity plots and X and Y profiles
- Beam centroid tracking and charting
- Software controlled shutter and gain
- Comprehensive statistics and analysis tools
- High Speed USB 2.0

Newport's new LBP-HR Laser Beam Profiler offers true 12 bit dynamic range, and a 1.4 Megapixel CCD for detailed profiles and analysis of most laser sources. The LBP-HR is a powerful software driven device with complete beam diagnostic measurement features, including a multi-measurement routine to increase signal integrity for higher accuracy results.

For continuous or pulsed laser beams, it provides an extensive range of graphical presentations and analysis capabilities of laser beam parameters such as: beam width, shape, position, power and intensity profiles. The LBP-HR communicates with the PC software via USB, and is powered by the USB port on your PC, so no need for and an external AC adapter.

For further information please contact
Neil McMahon at NewSpec
Tel: 08 8347 1967
sales@newspec.com.au

Coherent

Coherent Legend-Elite™ & OPerA™Solo: Better amplified, tuneable, ultrafast, everyday!

The Legend-Elite™ Series builds on time-proven Legend™ kHz amplifier performance with the following new, added benefits:

-Integrated Evolution pump laser for more compact footprint and ease-of-use.
-Improved optical design of the regenerative amplifier cavity with → 6.0 mJ @ 1 kHz configurations available as standard for high-energy applications.
-Patented back-to-back stretcher / compressor gratings for ease-of-use.
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Prompt Critical Reviews

Blip, Ping and Buzz

To those unfamiliar with active remote sensing, the book title Blip, Ping and Buzz will be obscure to say the least. Its sub-title, Making Sense of Radar and Sonar, will indeed be more enlightening. Here is a book that takes the reader from the early days of radio echolocation to the latest sophisticated sensing systems and speculates on future developments while, with due humility, acknowledges that nature beat us by millions of years: bats and cetaceans leave us for dead.

In his book, system developer Mark Dendy traces the evolution of radar from the primitive but clever CH system that helped win the Battle of Britain through to modern STAP (Space Time Adaptive Processing) methods that almost magically dig target signals out of noise. As usual bats were first, not least because their supply of food depended upon it. Bit like the British imperative, really. The author marvels at the incredible feats of signal analysis effortlessly performed by creatures with brains the size of a pea!

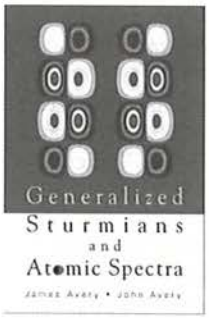
Dendy's book strikes a good balance between depth of science and clarity of explanation with no more than simple but essential mathematics. Plenty of diagrams showing ideas in sixty pages of Technical Notes, followed by a seven page Glossary (essential for making sense of all the acronyms spawned by the subject) and a good index.

The writing style is clear and sometimes whimsical, making for easy reading.

Blip, Ping and Buzz is an excellent addition to the ever-popular genre of books about how things work. Its readership extends from curious high school pupils to serious graduates in science, especially biological.

Published by Johns Hopkins University Press the book is priced at a very reasonable US$27.00 in hardcovers. ISBN: 978-0-8018-8665-1.

Colin Keay
Reviews Editor.



Generalized Sturmians and Atomic Spectra
John and James Avery
World Scientific Publishing, Singapore, 2006 xvi + 240 pp., US$68.00 (hardcover)
ISBN: 981-256-806-9

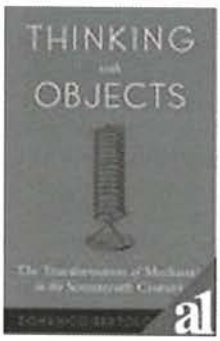
The purpose of this review is to complement the more technical one available at *http://www.worldscibooks.com/physics/6107.html*. First, about the authors; this is a father and son team, with James a computer science and mathematics graduate and John an eminent (now emeritus) Quantum Chemist (and peace activist). Both are at the University of Copenhagen. John is a graduate of MIT, University of Chicago and Imperial College. Accordingly, the book has a particular mathematical rigour and is intended for people with an interest in mathematical, theoretical and computational physics/chemistry.

The subject is the usage of Sturmian (square-integrable) functions in the field of atomic and molecular structure. There is a particular emphasis on analytic solutions as well computationally tractable approaches, paying careful attention to issues of convergence. What is unique about this book is the perspective of using Sturmians for such a broad range of single and multicentre problems with a nonrelativistic or a relativistic treatment. Given that our research interests are very closely aligned (we perform collision calculations with targets whose structure is described using Sturmians) we found the notation to be rather different. This is not necessarily a bad thing, but perhaps indicative of the differences between quantum chemists and physicists.

The text is ideal for graduate students, and ours will certainly be particular beneficiaries. There is a link, *http://sturmian.kvante.org* , to associated computer programs.

The book is detailed and well-organised, and I have no hesitation in recommending it to anyone interested in a rigorous, computationally oriented approach to atomic and molecular structure and dynamics.

Igor Bray
Theoretical Physics Institute
Curtin University of Technology



Thinking with Objects
D Bertoloni Meli
Johns Hopkins U Press Baltimore 2006
xii + 389 pp.,US$29.95 (paperback)
ISBN 0-8018-8427-6

Those of us who teach physics for a living usually think we know at least the rudiments of the history of our subject. After all, much of the undergraduate syllabus is structured on essentially historical lines, and many of our standard texts have little footnotes on the people who made the key contributions. The reality, however, can sometimes be much more complex.

Teaching first year mechanics usually involves 5 minutes genuflecting at the feet of Newton, and contrasting the Newtonian conceptual view with the Aristotelian. Apart from a brief mention of Galileo, it is almost as if Newton sprang from a vacuum. This book paints a very different picture, with the development of Mechanics from the mid 1500s, to around 1700, as a virtual continuum.

As the title implies, the focus is on mechanics as a practical subject, rather than a mathematical (and abstract) one. Firstly, the Greek authors were re-discovered, and translated into Italian. After that, their work was updated to reflect some new technological developments that had taken place during the middle ages. All machines were seen as levers in disguise, for example.

From these beginnings, falling bodies, the pendulum, river flow and the "pierced cistern", motion in resistive media, and collisions were analysed using the available tools. In many ways, it was the lack of sufficiently powerful tools that was the major holdup. The pendulum was useful for

Conferences

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 12 - 15
The Fifth Harvard-Smithsonian Conference for Theoretical Astrophysics, 21cm Cosmology
Massachusetts, United States
www.cfa.harvard.edu/events/2008/cos2008/

May 21 – 23
Advances in Fluid Mechanics 2008
United Kingdom
www.wessex.ac.uk/conferences/2008/afm08/index.html

June 3 – 6
Chaotic Modelling and Simulation International Conference
Chania, Crete, Greece
www.asmda.net/chaos2008

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

July 14 - 17
The 2008 International Conference on Scientific Computing (CSC'08)
Las Vegas, Nevada, United States
www.world-academy-of-science.org/sites/worldcomp08/ws/conferences/mlmta08

July 19 - 24
6th Congress of the International Society for Theoretical Chemical Physics (ISTCP-VI)
Vancouver, Canada
www.chem.ubc.ca/istcp6

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

June 29 – July 11
BIPM Metrology Summer School 2008
France
www.bipm.org/en/events/summer_school/

July 28 – Aug 1
2008 International Conference on Electronic Materials -ICEM 2008
Hilton Sydney, Sydney
www.aumrs.com.au/ICEM-08/

July 7 – July 10
OECC/ACOFT 2008
Sydney Convention & Exhibition Centre, Sydney
www.iceaustralia.com/OECC_ACOFT2008/

July 7 – July 10
International Commission for Optics Congress (ICO-21)
Sydney Convention & Exhibition Centre, Sydney
www.iceaustralia.com/ICO2008/

July 13 - 20
37th COSPAR Scientific Assembly and Associated Events
Canada, Quebec
www.cospar-assembly.org/

July 28 - August 1
International Conference on Electronic Materials 2008 (ICEM 2008)
Sydney, Australia
www.aumrs.com.au/ICEM-08

August 3 - 10
Quantum Monte Carlo and the Casino Program III
Italy, Tuscany
www.vallico.net/tti/qmcatcp_08/announcement.html

August 13 – 19
XXVII International Colloquium on Group Theoretical Methods in Physics
Yerevan, Armenia
theor.jinr.ru/~group27/

August 25 – 29
International Workshop on Optical Superconducting
Vienna, Austria
www.cs.ubbcluj.ro/~moltean/osc2008

September 1 – 5
Trends in Nanotechnology (TNT2008)
Oviedo, Spain
www.tntconf.org/2008

November 17 - 20
14th International Conference on Thin Films
Belgium, Ghent
http://www.ictf14.ugent.be/

Nov 30 – Dec 2
18th National AIP Physics Congress
Adelaide, South Australia
www.aip.org.au

December 12 - 13
2nd International Conference on Science and Technology (ICSTIE'08)
Penang, Malaysia
www.icstie.com

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