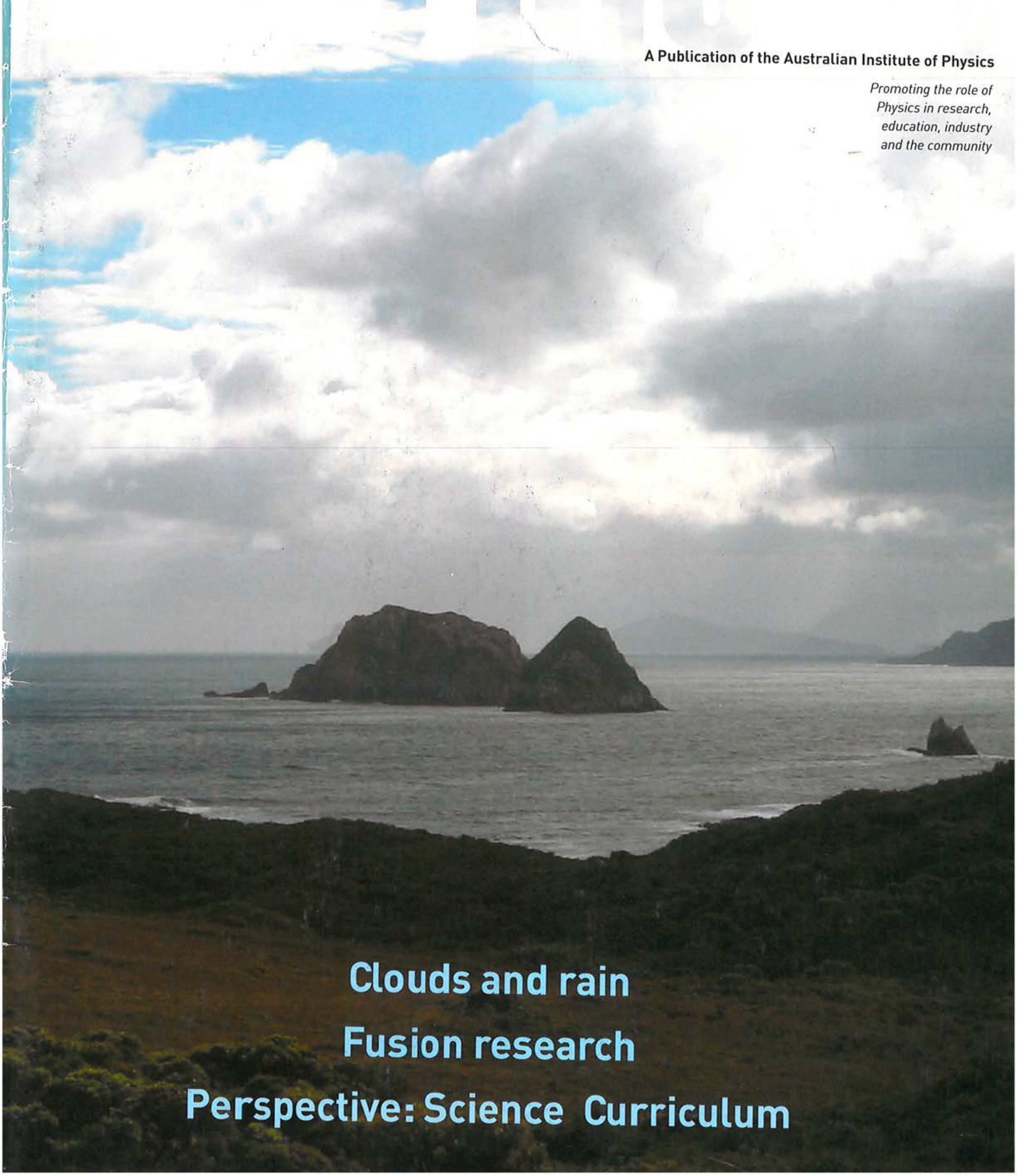
Australian Physics

September/October 2006 Volume 43 Number 4

A Publication of the Australian Institute of Physics

Promoting the role of Physics in research, education, industry and the community



Clouds and rain

Fusion research

Perspective: Science Curriculum

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Cover image: View over Osmiridium Beach, Maatsuyker Group of islands, and the Tasman Sea from the South Coast Track in Tasmania's World Heritage wilderness Southwest National Park. Late on a cold summer afternoon, cumulus and stratocumulus cloud moves quickly through, withshowers over the 1000-metre high Ironbound Range in the distance. 9 February 2005.

Photo credit: Andrew Hollis, Bureau of Meteorolgy

Contributions should be sent to
Corinna Horrigan, Editor
Australian Physics
PO Box 3497
Parramatta NSW 2124
Tel: 0417 775 109
thephysicist@aip.org.au

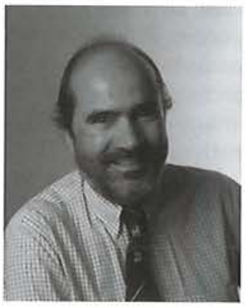
Design
Sophie Campbell
Tel: 0402 101 090

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

Advertising Enquiries
Mrs Leigh Wallbank
PO Box 70
Oyster Bay 2225 NSW 2225
Tel: 02 9528 4362
Fax: 02 9523 9637

Published 6 times a year, on behalf of the Australian Institute of Physics by Cliff Lewis Cronulla Printing Co. Pty. Ltd.
 Pub. No. PP 224960 / 00008
ISSN 1036-3831

President's Column



This demand is certain to continue for the foreseeable future. The rise in technology in our society is a trend which shows no sign of ending. All this adds up to opportunity!

Over the past six weeks, with little fanfare, two of the largest science projects in the history of Australia reached major milestones. Both projects depend on legions of physicists for their principles of function, design and ongoing operation. These projects are the Australian Synchrotron which achieved first light on July 21[1] and the OPAL reactor which became critical on August 12.

The new synchrotron in Melbourne is extremely impressive and I had the chance to spend the day there in early September. It's housed in a giant corrugated iron cylindrical building the colour and shape of an aspirin tablet. Inside, almost filling the building, is the immense concrete vault that houses the 3 GeV electron storage ring. Relativistic electrons, with 6,000 times their rest mass, orbit through contoured magnetic fields to produce intense beams of radiation that will eventually be directed down beam lines onto specimens to reveal new insights into structure and function. For the moment, the storage ring has been filled with electrons and the word from the control room is that early expectations have been exceeded. Presently there are no beamlines in place so the building interior has a remarkably clean and tidy appearance. Hopefully the healthy mess of a productive laboratory will be well developed by the end of 2007 when the first of the 9 beamlines commence operation.

In Sydney, the first uranium fuel was loaded into the OPAL core on August 11[2]. The reactor core is "the size and shape of a small bar fridge" according to the ANSTO web site. Then, one day later, as announced on the web site[3] of the manufacturer in Argentina, the reactor went critical. Good news and congratulations to all concerned. By December of this year, the full 20 MW power levels should be achieved. From then on bright beams of neutrons will be available for experiments and a steady flow of radiopharmaceuticals and precision-doped silicon wafers should begin to disperse into hospitals and factories around Australia and our region.

All this good news from these high profile projects means that Physics continues to boom in Australia. Several other important pieces of information also provide evidence for the boom. Physics graduates appear to be in very high demand. A significant percentage go into careers in research in academia or industry which have such a large demand that there are shortages in other areas, particularly teaching. Graduates opting for a career in physics teaching can expect to be quickly snapped up and will soon occupy leadership positions. In fact teaching offers flexibility and career satisfaction that may not be readily available in other careers.

A salient feature of physics graduates is the immense diversity of career paths. From a major University in Victoria, it is found that about 27% of physics bachelor graduates go into further education (including PhD programs), 25% into business, 22% into the mining industry, 11% into manufacturing industries and 8% into government jobs. Physics graduates can also expect good financial remuneration. According to a recent survey by the Federation of Australian Scientific and Technological Societies, physics and maths graduates can expect higher salaries than those graduating in any other science discipline except the geociences. Furthermore, a July 2006 audit of science, engineering and technology (SET) skills[4] by DEST, the federal Department of Education, Science and Training, found that despite strong demand, there is a "decreasing pool of applicants for SET positions in industry and the scientific research sector". Despite this, the DEST survey shows that this year the demand for science professionals has increased by more than 10,000 with a forecast total demand growth of more than 55,000 to 2013. No doubt this contributes to the higher than average remuneration.

A salient feature of physics graduates is the immense diversity of career paths.

This demand is certain to continue for the foreseeable future. The rise in technology in our society is a trend which shows no sign of ending. All this adds up to opportunity! At this time of the year when year 10 students are selecting subjects for years 11 and 12, the AIP is keen to get the message about the boom in Physics out to the community. We have developed a strategy of targeted press releases to keep Physics in the news. The first of these covered Women in Physics and was released to coincide with 2006 AIP Women in Physics Lecturer Prof Deb Kane's national tour. The second was on the present "Boom in Physics" and was picked up by a number of radio stations around Australia as well as the basis for the *Quantum Leap in Physics Prospects* article in the Australian newspaper on September 6. This release also cited Dan O'Keeffe's work on year 12 physics entry which showed that about 12 to 15 percent of 18-year-olds studied physics at School in 2005. This figure has had peaks and troughs but has shown an overall upward trend for the past 30 years. Future releases will highlight laureate speakers at the forthcoming AIP **Riverphys** Congress in Brisbane (December 3-8 2006), significant accomplishments by Australian Physicists and several important public issues.

Students looking for wide career opportunities, good pay and a chance to be at the cutting edge of discovery will be including physics in their plans!

Prof. David Jamieson

References

[1] *www.synchrotron.vic.gov.au/content.asp?Document_ID=4619*
[2] *www.ansto.gov.au/info/press/2006/OPAL_Reactor_Fuel.pdf*
[3] *www.invap.net/news/novedades-e.php?id=20060815050701*
[4] *www.dest.gov.au/sectors/science_innovation/policy_issues_reviews/key_issues/setsa/ministers_message.htm*

Editorial

I recently had a friend ask me about the pros and cons of nuclear energy and renewable energy sources. This confirmed my feeling that energy consumption has become an issue in the wider community - and not just because of the cost of petrol. It also made me realise that to many people it seems that these are mutually exclusive alternatives.

This conception is odd as we use more than one energy source at the moment. Not only do we have coal-fired power plants, we have hydroelectric power plants and various sources of 'green' energy - enough that you can elect to get a certain portion of it through your normal electricity provider in most states.

So, what's my point? It seems to me that the most important priority should be to reduce the amount of greenhouse gases and various carcinogenic particulates in the atmosphere. To do this, we need to replace as many coal-fired power plants as we can and still provide the energy required to run our homes and industry - and our cars, if possible.

There is no doubt that neither nuclear nor 'green' energy sources are without fault. Nuclear power plants produce long-lived radioactive waste, are still perceived to have safety issues and can be sources of weapons-grade uranium. 'Green' energy sources have various problems, depending on the type; they are seen as inefficient, unreliable and often unsightly. The proponents of each insist that the other has insurmountable faults. Economics and emotion are highly entangled in these complex arguments. Listening to the debates on the issue can be frustrating in the extreme as one struggles to weigh the various arguments and to try and untangle the facts from the opinions. Surely we can use both sources in a balanced way to meet our urgent need for energy sources that are more friendly to the atmosphere!

I certainly haven't got an answer. I'm still working on understanding the various disjointed facts that I'm getting. Meanwhile, it now appears that the ice caps are melting faster than was predicted and there are varying opinions on how long we have to do anything about it - some as short as ten years. And some governments around the world appear to hope that it will all go away if they ignore it.

So I'm left with simple logic: if we do nothing and it all goes away - that's fine: but if we do nothing and it doesn't go away, then the world is going to change drastically and probably in ways we can't yet predict, but probably won't like. On the other hand, if we act to make things better now, then we either just end up with cleaner air or we save the world. Personally, I'm all for saving the world, but people tell me I read too much science fiction.

In this issue: Australian Physics covers a wide range of topics this time - from nanoscience in the clouds to fusion reactors to the science syllabus. Neville Fletcher turns his attention to the science of clouds and rain - something that is increasingly important in this drought-prone land. Boyd Blackwell and his co-authors look at Australia's past contributions to the science of fusion and also look to the future. John Daicopoulos takes a new look at teaching physics in school.

Corinna Horrigan

Deadline for next issue: 20th October 2006

Submission guidelines

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

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

DSTO-AIP Scholarship Scheme

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DSTO-AIP Scholarship Scheme

Closing Date; 28 October 2006

DSTO and the AIP have established the DSTO-AIP Scholarship Scheme to celebrate the Einstein International Year of Physics 2006 in Australia. The purpose of the Scheme is to provide two scholarships to the value $15,000 each to two suitably qualified candidates. DSTO will provide the funding for the Scheme and AIP will administer the Scheme.

Eligibility

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.

Selection Criteria

The AIP must the best select candidates on the basis of:

i) Excellence in the candidate's academic record for second year AND

ii) Either the candidate's academic record for second semester of second year and first semester of third year (for third year students) OR first and second semester of third year (for post third year students) AND

iii) A cover letter provided by the candidate of no more than one page explaining the candidate's motivation to study physics including an outline of their plans for further studies and research AND

iv) A letter of support from the Head of Department or Lecturer from the candidate's third year courses.

Each state and territory of Australia can submit one application to the AIP executive for consideration using the following process. Candidates must submit their applications to the Head, or representative, of the Physics Department in which they plan to undertake their honours year. Details of the Scholarship at posted on the AIP web site: *www.aip.org.au*

AIP QLD Branch

Chair: Paul Meredith
Soft Condensed Matter Physics Group,
Department of Physics
University of Queensland, QLD 4072
Tel: 07 3365 7050 Fax: 07 3365 1242
meredith@physics.uq.edu.au

Secretary: Dr Mark Young
7 Highview Drive
Cleveland
Brisbane
QLD 4163
Tel: 0410 821 129
younma@clevdistshs.qld.edu.au

AIP SA Branch

Chair: Dr Olivia Samardzic
DSTO
PO Box 1500, Edinburgh SA 5111
Tel: 08 8259 5035 Fax: 08 8259 5796
Olivia.Samardzic@dsto.defence.gov.au

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

AIP TAS Branch

Chair: Dr M.L. Duldig
Australian Antarctic Division
203 Channel Highway, Kingston TAS 7050
Tel: 03 6232 3333 Fax: 03 6232 3496
marc.duldig@aad.gov.au

Secretary:
Dr Elizabeth Chelkowska
Maths and Phys, University of Hobart
GPO Box 252-21, Hobart TAS 7001
Tel: 03 6226 2725 Fax: 03 6226 2867
Elzbieta.Chelkowska@utas.edu.au

AIP VIC Branch

Chair: Dr David Abbott
Brain Research Institute
Austin Health, PO Box 5444
Heidelberg West VIC 3081
Tel: 03 9496 4079
d.abbott@brain.org.au

Secretary: Dr Alex Merchant
Applied Physics, RMIT University
GPO Box 2476V, VIC 3001
Tel: 03 9925 3388
alex.merchant@rmit.edu.au

AIP WA Branch

Chair: Prof. Igor Bray
Murdoch University
School of Mathematical and Physical Sciences, South St, Murdoch WA 6150
Tel: 08 9360 6443 Fax: 08 9360 6183
I.Bray@murdoch.edu.au

Secretary: Katrina Lyon
Murdoch University
School of Mathematical and Physical Sciences, South St, Murdoch WA 6150
Tel: 08 9360 2865 Fax: 08 9360 6183
klyon@fizzy.murdoch.edu.au

Samplings

People

Dirac medal for atomic physicist

Peter Zoller of the University of Innsbruck has been awarded the 2006 Dirac medal of the International Centre for Theoretical Physics (ICTP) in Trieste, Italy. Zoller, the scientific director of the Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences in Innsbruck, is honoured for his work in atomic physics, including proposing the use of trapped ions for quantum computing. The Dirac medal — one of the world's most prestigious physics prizes — is given each year on 8 August, the birth date of Paul Dirac.

The Dirac medal, worth $5000, has been awarded every year since 1985 by the ICTP, which is based in Trieste, Italy. Nobel laureates and winners of the Fields medal or Wolf prize are not eligible for the award. Dirac was a close friend of the ITCP form the centre's early days in the early 1960s until his death in 1984.

PhysicsWeb

Astrophysicist and space pioneer dies

The US astrophysicist James Van Allen died on August 9th aged 91. Van Allen was best known for his studies of the Earth's magnetosphere -- the region of space filled by the Earth's magnetic field. In particular, he found bands of intense radiation, later named the Van Allen radiation belts, which he discovered using the first US satellite, Explorer 1. He also conducted the first surveys of the radiation belts of Jupiter and Saturn using the Pioneer 10 and 11 spacecraft.

PhysicsWeb

COBE team wins cosmology prize

John Mather and the Cosmic Background Explorer (COBE) team were awarded the 2006 Gruber Cosmology Prize for their ground-breaking studies confirming that our universe was born in a hot Big Bang. The gold medal and a $250,000 cash prize was awarded at the opening ceremony of the International Astronomical Union's General Assembly in Prague on Tuesday 15 August 2006.

The instruments aboard NASA's Cosmic Background Explorer, launched in 1989, looked back over thirteen billion years to the early universe.

COBE showed us that the young universe was hot, dense, and almost uniform; that it contained weak fluctuations or lumps that grew into the galaxies and stars we see today; that these fluctuations were the consequence of a hot Big Bang; and that the universe is filled with diffuse radiation from previously unknown galaxies.

Since 2000, the Cosmology Prize of the Peter Gruber Foundation has recognized individuals for their ground-breaking theoretical, analytical, or conceptual discoveries. The Cosmology prize is awarded in partnership with the International Astronomical Union.

Gruber Foundation media release

Neutrino Nobel laureate dies

Melvin Schwartz, who shared the 1988 Nobel Prize for Physics, died on August 28th at the age of 73. He shared the prize with Leon Lederman and Jack Steinberger for developing a way to generate beams of neutrinos. Their work, which took place at the Brookhaven National Laboratory in the US in the early 1960s, also showed that neutrinos can exist in more than one type or "flavour".

To study how the weak force behaves at high energies, they designed an experiment using Brookhaven's Alternating Gradient Synchrotron, in which a beam of high-energy protons was slammed into a metal beryllium target. The resulting cascade of particles included some that always came out in pairs consisting of a muon, which is a heavy version of an electron, and a neutrino.

A steel wall was used to remove all particles except the neutrinos, which passed unhindered through the wall in the same direction as the protons. They were then able to detect the neutrinos by watching the sparks created when the particles interacted very occasionally with the atoms in a ten-ton aluminium detector.

Because the neutrino reactions only ever produced muons, rather than electrons, they concluded that neutrinos must come in at least two types — muon-neutrinos and electron neutrinos. In fact, we now know a third flavour of neutrino — tau neutrinos — also exists.

PhysicsWeb

World's most creative physicist revealed

The Nobel prize-winner Philip Anderson is the most creative physicist in the world, according to a new analysis of scientific research papers. Steven Weinberg — another Nobel laureate — is the second most creative physicist, followed by Ed Witten in third. The study has been carried out by José Soler, a statistical physicist at the University of Madrid, who says that his "creativity index" could help universities to recruit and promote the best staff (*physics*/0608006).

Soler's method involves calculating the number of references, *n*, that a particular paper makes to previous papers as well as the number of citations, *m*, that it receives from papers written at a later date. According to his definition of creativity, a paper that has lots of references but only a few citations will have a low level of "creativity", while a paper with just a few references and lots of citations, in contrast, will have a very high creativity. The creativity index (*Ca*) of a particular scientist can then be calculated by summing the total creativity for every paper that author has written, normalized for the number of co-authors in each case.

The advantage of the new technique is that "review" articles, which are often highly cited even though they do not necessarily contain much new information, will have a relatively low creativity index because they contain so many references to previous work. The technique also means that citing your own paper will not boost your creativity index because the reference and citation counts will cancel out. Conventional citation analyses, in contrast, would not take this effect into account.

PhysicsWeb

Short Notes

Giant "starshade" could reveal new exoplanets

An astrophysicist in the US has devised an unusual way to spot extrasolar planets -- by blocking the light from their parent star with a space-based shield. Webster Cash of the University of Colorado says that a thin, sunflower-shaped plastic screen measuring about 50 metres across could be enough to allow planets as small as the Earth to be observed directly. The big snag is that the shield, dubbed a starshade, would have to be attached to a spacecraft and placed tens of thousands of kilometres away from

a space telescope. Cash's design may sound like science fiction, but it has already received a $400,000 funding boost from NASA (*Nature* 442 51).

PhysicsWeb

A new look at high-temperature superconductivity

By observing events at the scale of single atoms, Cornell researchers have found evidence that the mechanism in high-temperature superconductors may be much more like that in low-temperature superconductors than was previously thought (*Nature* 442 546).

The expectation has been that electron pairing in cuprates is due to magnetic interactions. Instead, the researchers found that the distribution of paired electrons in a common high-temperature superconductor was "disorderly," but that the distribution of phonons was disorderly in just the same way. The theory of low-temperature superconductivity says that electrons interacting with phonons join into pairs that are able to travel through the conductor without being scattered by atoms. These results suggest that a similar mechanism may be at least partly responsible for high-temperature superconductivity.

Cornell University media release/PhysicsWeb

Chemical Transistor

A new device, the chemical equivalent of a transistor, might make possible ultrasensitive bio-medical single-antigen detection.

Philip Collins and his colleagues at the University of California at Irvine, use carbon nanotubes as the central working substance of their device. The nanotubes, immersed in a liquid, can be switched from a conducting state to an insulating state by oxidizing them — that is, by chemically removing the free electrons. The chemical reactions are triggered by an electrical potential applied across the interaction area.

The research shows that this process can be performed reversibly and over short periods of time, as fast as 10 microseconds. This is quite slow by today's transistor standards; the more important promise for prospective chemical field effect transistors (or ChemFETs) is the potentially large amplifications. It looks as if only a few electrons' worth of oxidation can be used to switch currents as large as microamps. In a future bio-detector the switching would be provided not by an applied electrochemical signal but by the trace presence of antigens docking with antibodies attached to the nanotubes. In previous detectors, chemical actuation has required the presence of tens of antigens; here, a single antigen might be enough to change the state of the nanotube. Mannik *et al.*, *Physical Review Letters*, 7 July 2006

Physics News

Asian Storms Push the Earth Around

Earth's axis of rotation undergoes several gyrations, such as the precession of the equinoxes, which takes about 26,000 years. Recently two of the most important axis gyrations inadvertently cancelled each other, allowing geophysicists to measure other, subtler gyrations that would normally be difficult to detect. The two larger wobbles are the 433-day cycle Chandler Wobble (whose origin is not very well known) and the wobble caused by annual weather oscillations. Their combined effect is normally to cause the rotational axis to migrate by as much as 10 meters. But from December 2005 to February 2006 their mutual nullification reduced the axis excursion to less than 1 meter. This allowed Belgian scientists to study fainter, lesser forces whose exertions could briefly be measured. The scientists saw signs of what they believe to be an influence on Earth's wobble day by day triggered by storms over Asia and northern Europe. Lambert *et al.*, *Geophysical Research Letters*, July 2006

Physics News

Red Oxygen

A new evolutionary crystallography algorithm predicts the structure of crystals under a range of extreme pressure and temperature conditions on the basis of the chemical composition alone. One of these crystals would be a form of red-colored oxygen. Predicting crystal structures is difficult even for simple solids, partly because of the task of sorting among the astronomical number of possible ways given atoms can compose a basic repeatable unit cell.

Artem Oganov, a scientist at the Swiss Federal Institute of Technology (ETH) in Zurich, in Switzerland, and Colin Glass, a Ph.D. student, approach the problem by combining electronic structure calculations and a specifically developed evolutionary algorithm. In exploring the myriad atomic arrangements, they proceed in a step-by-step, continual-optimization fashion that avoids configurations less likely to succeed. This makes the algorithm very efficient and allows the researchers to make certain specific predictions.

One example is calcium carbonate ($CaCO_3$) at very high pressures. Oganov's team for the first time predicted two new stable structures for this mineral. By now, both structures have been confirmed in experiments by Japanese colleagues. Oganov and Glass have also solved the structures crystalline oxygen at high pressure.

Oxygen is unique from the chemical point of view. The only magnetic molecular element known, under pressure it loses its magnetism and turns red. The structure of red oxygen, which remained unknown for a long time, seems to be finally solved and turns out to be unique; that is, it does not manifest itself in any other element. At even higher pressure oxygen is known to turn black in color and become superconducting, which happens because of the increased interactions between the O_2 molecules. The ETH researchers also predict a new stable phase of sulphur and several new metastable forms of carbon. Oganov and Glass, *Journal of Chemical Physics*, 28 June 2006

Physics News

Expedia's Best Blue Sky

A 27-year-old TV researcher who won a competition to travel the globe in search of the world's "bluest" sky has found that Brazil is the place to be if blue is your colour. Anya Hohnbaum came to this conclusion after visiting 20 different destinations on a 72-day round-the-world trip organized by on-line travel agents Expedia. But to ensure that her findings were as scientific as possible, Hohnbaum used a special portable spectrometer that was adapted for her by scientists at the UK's National Physical Laboratory (NPL). Rio de Janeiro came top of the list, followed by New Zealand, Australia, Fiji and South Africa.

NPL, the UK's national measurement institute, became involved in the project to provide Expedia's Best Blue Sky explorer with the necessary equipment so that measurements of the sky can be made

accurately, using techniques developed by the NPL.

This enabled the measurements to be traceable to the International System of Units (SI), so we can confidently determine where in the world has the best blue sky holiday destination! (At least on the day of the measurement).

The challenge for the NPL scientists, led by physicist Nigel Fox of the lab's optical-radiation group, was to adapt a typical spectrometer so that it would be robust enough and simple enough to be carried in a small suitcase around the world.

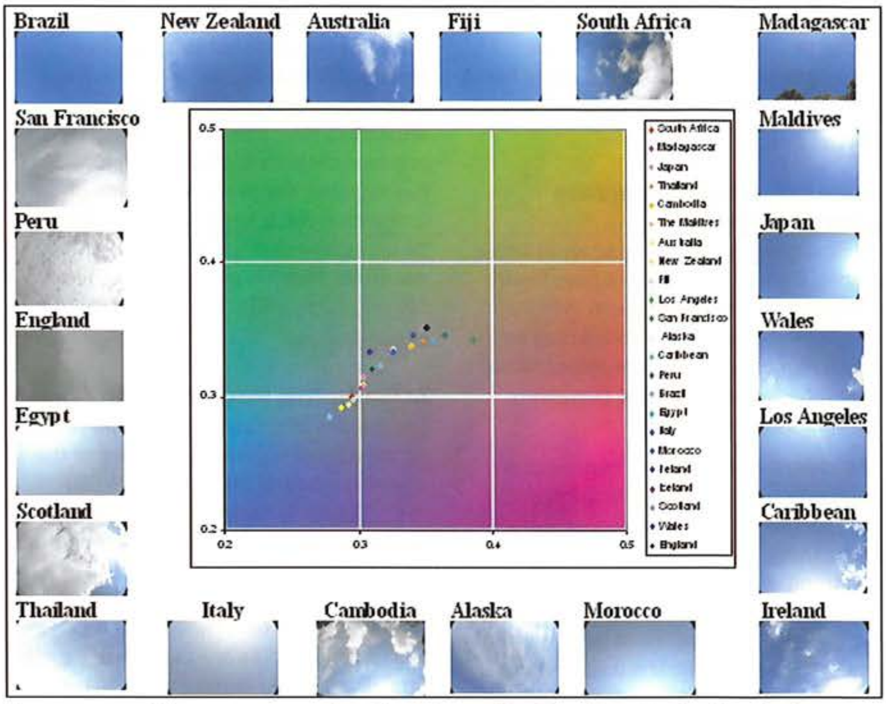
At each destination on her trip, Hohnbaum was asked to point the portable spectrometer at the sky to measure the spectrum of light at that location. All measurements were taken at 10 a.m. local time and in the same direction relative to the Sun. She also had to ensure the spectrometer was properly callibrated at each destination by shining a special LED torch onto the device from a fixed distance. Hohnbaum then sent the data to the NPL via e-mail before heading off to her next destination.

Back at the NPL, Fox and co-workers analysed the "spectral power distribution" at each destination, which is essentially a plot of intensity versus wavelength. This spectrum was then converted into a set of three numbers known as "colorimetric co-ordinates", which show how much red, green and blue light would have to be mixed to recreate a particular overall colour.

The data from Rio de Janeiro were found to be closest to the bluest part of this diagram -- hence Brazil was deemed to have the bluest sky. Bay of Islands in New Zealand came in second, followed by Ayers Rock in Australia, while Cornwall in England came bottom.

More information can be found on the NPL website *www.npl.co.uk/blueskies/* or the Expedia website *www.let-yourself-go.co.uk/blueskyexplorer/*

PhysicsWeb/NPL website



The summary of the spectrometer based results, and the Best Blue Sky Ranking, is shown above. The centre of the chart shows each destination's chromaticity coordinates, on an extract of the chromaticity diagram. The pictures around the outside show the fisheye photographs of each destination in order of which has the Best Blue sky, running clockwise around the chromaticity diagram, starting with Brazil with the Best Blue Sky and San Francisco with cloudy hazy sky! Source: NPL

Dune Tunes

For centuries, world travelers have known of sand dunes that issue loud sounds, sometimes of great tonal quality. In the 12th century Marco Polo heard singing sand in China and Charles Darwin described the clear sounds coming from a sand deposit up against a mountain in Chile.

Singing dunes are one of the most puzzling and impressive natural phenomena. The sounds produced can be heard up to 10 kilometres away and resemble a drum, a low-flying jet or even an organ. The sounds can be as loud as 105 decibels and have frequencies between about 65 and 110 Hertz depending on where the sand comes from. Using sand shipped from the Ghord Lahmar region in Morocco to their lab, Douady and colleagues found they could produce notes from the sand simply by pushing the sand grains together by hand or using a metal blade. This means that the sounds are nothing to do with the dune itself but are produced by the motions of the sand grains — not from the entire dune resonating.

Small avalanches don't produce any detectable sound, while large avalanches produce sound at lots of frequencies (leading to cacophonous noise). But sand slides of just the right size and velocity result in sounds of a pure frequency, with just enough overtones to give the sound "color," as if the dunes were musical instruments. In this case, however, the tuning isn't produced by any outside influence but by critically self-organizing tendencies of the dune itself. The researchers thus rule out various "musical" explanations.

The sand sound comes from the synchronized, free sliding motion of dry larger-grained sand producing lower frequency sound. The scientists — from the University of Paris, Harvard University in Cambridge, Mass., the CNRS lab in Paris, and Ibn Zohr University, in Morocco — have set up a website *www.lps.ens.fr/~douady/SongofDunesIndex.html* where one can listen to sounds from different dunes in China, Oman, Morocco, and Chile. Douady et al., *Physical Review Letters*, upcoming article

Physics News/PhysicsWeb

The Open Agenda Physics Curriculum

John Daicopoulos

"It is, in fact, nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry."

Einstein was not the only one to recognize the need for restructuring the then-modern methods of physics instruction; the entire physics community used targeted efforts to transform a mostly intellectual pursuit into our richly dynamic physics courses. We have, however, reached another level of mediocrity requiring an equally targeted and sustained effort of reformation.

Einstein's reflection has been so well addressed that today's secondary school physics syllabus has been misguided in its single-minded approach to demonstrating that physics is relevant to students. The prevailing educational mantra simply seems to be that if physics cannot be shown to be applicable then it has no value. The curricular focus has been on making each individual topic and concept immediately pertinent rather than on showing that the "how we do" physics is truly more essential; and in our great drive to make physics relevant we have in fact neutralized its essence.

To be fair, physics has stood its ground and remains one of the most content-based subjects in spite of an educational shift towards activity-based pedagogy. Activity-based pedagogy rests on the premise that physical activity in the classroom is the primary avenue for student engagement in the scientific process; unfortunately this narrow focus on "hands-on" activity has diminished the true nature of physics (and science in general).

There is a public appetite for physics, which is not immediately apparent though. The highly positive media attention shown for the International Year of Physics and the terrific audience support of deeply physics-based television such as Brian Green's Elegant Universe have recently made physics fashionable. We should be loath to cater to a fad, however we need to take advantage of this, quite likely temporary, situation.

The relevance and applicability of physics topics should not be understated for student engagement; neither should they be the primary narrative in that engagement.

Physics teaching needs a new narrative, a curriculum whose open agenda is of teaching how physics succeeds and progresses.

The Open Agenda

For students it's easy to define a scientific experiment as an activity designed to collect data based on some stated hypothesis. But what is the origin of the hypothesis itself? Did a scientist wake some morning, randomly make a hypothesis, arrange the necessary equipment then conduct an experiment for some casual purpose? Of course not.

Prior to the experiment, there was a known position of ignorance within a theory requiring specific refinement, or a recognized state of discord between competing theories requiring resolution. It is this latter condition, one of conflict resolution between theories that I believe should become the primary narrative of physics teaching. This "open agenda" syllabus should encompass much more than problem solving, but aim to emphasize a process-centred approach on the identification and resolution of scientific conflict.

This particular process-centred approach should not be confused with a student-centred outcomes-based approach. The process at hand here is that of learning to do physics not the process of how a student learns to do physics. That doesn't mean indifference to the way our students learn. There have been great advances in cognitive and meta-cognitive psychology that have been used to improve the methodology of physics teaching and these developments are not to be dismissed. Indeed we need more empirically based direction in teaching, not less.

The Syllabus

How would this open agenda syllabus unfold? Here then in some (though not completely thorough) detail is a proposed syllabus in its order of study:

1. Uniform Motion. A strong opening description of frames of reference; measuring time intervals; analyzing position and displacement emphasizing their necessary vector and "change in" (Δx) nature; graphical and algebraic aspects of uniform motion; measuring the length of moving objects; kinetic energy and momentum (without a study of collisions); closing with an in depth study of relative motion in one and two dimensions.

2. The Nature of Light. Begin with a strong introduction into critical thinking and the foundations of scientific theories (Personally, I use Michael Shermer's *Baloney Detection Kit*[1]); developing the theoretical and experimental framework on the nature of light from the particle model to wave model; the Doppler effect; Young's experiments; diffraction; and polarization. Ending with the conflict: If light is a wave, then it should behave like other waves...so what is it waving and why can't we see it? (This begins the open agenda.)

3. Electromagnetism. Experimentally and qualitatively reviewing the multiple connections between electrostatics and magnetism (fields, force rules, charges/poles, and materials); delving deeply into the theoretical implications of Oersted, Coulomb, Faraday, Hertz, Ampere, etc.; detailing the empirical account of Maxwell's equations (without calculus) along with the necessary symmetry of the displacement current. Another conflict arises now between two physical foundations: the mechanical (frame of reference) method for measuring the speed of light and an electromagnetic method without frames of reference. How can/will/did physics reconcile this conflict between Galilean mechanics and Maxwellian electrodynamics?

4. Special Relativity. First, a highly qualitative description of how special relativity resolves the conflict between the mechanical and electromagnetic effects of motion; historical elements; the relativistic equations for time, length, mass and energy; supporting evidence and applications of special relativity spiraling back over the previous content to reinforce how physics arrived at this point successfully. Are we done? What about changes in uniform motion?

5. Non-uniform motion. Graphically and algebraically defining acceleration; its necessary vector nature; its fundamental distinction from velocity; acceleration due to gravity and Galileo's analytical achievements; free fall; projectile motion; inertial and non-inertial frames of reference (in a non-dynamic manner); acceleration's independence on a frame of reference; and circular motion.

6. Forces. Exclusively defining force as a function of Newton's First Law, not as pushes-pulls; free-body-diagrams; defining mass; Newton's other two laws; re-defining inertial and non-inertial frames of reference; re-visiting kinetic energy and momentum; collisions; the natural forces and why we quest for unification. Ending with a qualitative discussion on the conflict between gravity and how we define forces? Why can't you feel gravity when it is the only force acting on you?

7. Gravitation. Introduction to local and universal gravity; how gravity is different from the other forces; free-fall, weight and weightlessness in gravitational terms; astronomical studies using gravitation; and gravitational potential energy and escape velocity. Ending the unit with an analysis of the conflict between Newtonian gravitation and special relativity.

8. General Relativity and Cosmology. Explaining in deeply qualitative terms how general relativity has overcome the conflict between Newtonian gravitation and special relativity; its geometric and observational predictions, tests and efforts in verification; its operational description of gravity; (some of) the mathematics of space-time using simple Pythagorean mathematics; advances in observational astronomy. As with special relativity, this treatment of general relativity allows for a complete spiraling back over the entire course's content to tie up loose ends – the end of the open agenda.

Introducing general relativity into secondary education is not such an outlandish idea as it was only a generation ago special relativity and quantum physics were not part of the regular high school physics program, yet now they are staples of it.

This syllabus still leaves ample opportunity for productive and quantitative problem solving in an activity-rich program of study. We should expect nothing less of a physics course, and indeed nothing has been lost.

Year 11

What would this new curriculum leave for Y11? Y11 should introduce students to the fundamentals of physics with a primary focus on the essential tools of: experimentation, the concepts of physical laws and scientific theories, the algebraic manipulation of equations along with problem solving, and many applications of physics in our daily lives. In short a preparatory "physics is fun" syllabus that could stand alone if necessary.

In particular the topics should involve: geometric optics, sound and waves, electricity and magnetism, astronomy, and nuclear and atomic physics. I argue for the complete elimination of all kinematics prior to Y12. The nature of kinematics is too complex an idea; one that requires more than the cursory study it presently merits at the earlier grades. Besides there are far more interesting and experimentally rich topics from which to choose for Y11.

Potential Setbacks

There are some considerable difficulties to address before implementation. First, trying to fit an appropriate quantum study into this framework has proven to be problematical. Without a decent quantum element covered in the overall course, trying to convince the greater physics community of its value may be a challenge; however, as Arons points out for any suitably designed syllabus "...it is impossible to include all the conventional topics of introductory physics. One must leave gaps, however, painful this may seem... The selected story line [*read open agenda*] would develop the necessary underpinnings and would leave out those topics not essential

to understanding the climax.[2]"

Secondly, there is a dearth of secondary level texts in this format; admittedly because there is no commensurable state-sponsored curriculum and no author or publisher would produce a text, which does not follow an accompanying syllabus. Therefore brand new texts are required and that is an expensive proposition.

Thirdly, can we entrust our future, let alone present, teaching force to deliver this intense syllabus? Given the results of the *Who's Teaching Science* Report published for the Australian Council of Deans of Science there will be problems of confidence. The report's authors state: "*Nearly 43 per cent of senior school physics teachers lacked a physics major, and one in four had not studied the subject beyond first-year. This, coupled together with the reported difficulties in attracting physics teachers (40 per cent of schools surveyed), paints an alarming picture. No matter how good their pedagogical skills, teachers who lack knowledge in their discipline are manifestly unprepared.*[3]" There are grave consequences in how we mitigate this shortfall in academic qualification. Our teachers should "fit" the syllabus, not the other way around.

When I have had the opportunity to follow this open agenda approach my students were exceedingly receptive, even those bound for a non-physics career. Teaching physics solely as a technical tool rather than as an intellectual tool is self-defeating for our scientific future. Our constant reliance on the practical (real-world relevance) method has diminished all of the sciences. As good as our syllabus is, we have become complacent with it. Just as the physics community addressed Einstein's comment well over a generation ago, we need to re-visit it now.

References

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2. Arons, Arnold B. *Teaching Introductory Physics, Part I*. John Wiley and Sons Inc. New York, 1997. Page 265.

3. Harris, Kerri-Lee et al. *Who's Teaching Science: A Report Prepared for the Australian Council of Deans of Science*. Centre of Higher Education University of Melbourne, Melbourne 2005. Page 9.

John Daicopoulos has been a senior physics teacher and counsellor for sixteen years in both Canada and Australia, with degrees from McGill University, the University of Toronto and Conrad Grebel College. He has been an author, negotiator and mediator and now live with my family in Mildura, but will likely be moving yet again to work on his newest endeavour, RenegadeScience.tv.

The nanoscience of clouds, rain and rainmaking

Neville Fletcher
Research School of Physical Sciences and Engineering,
Australian National University, Canberra

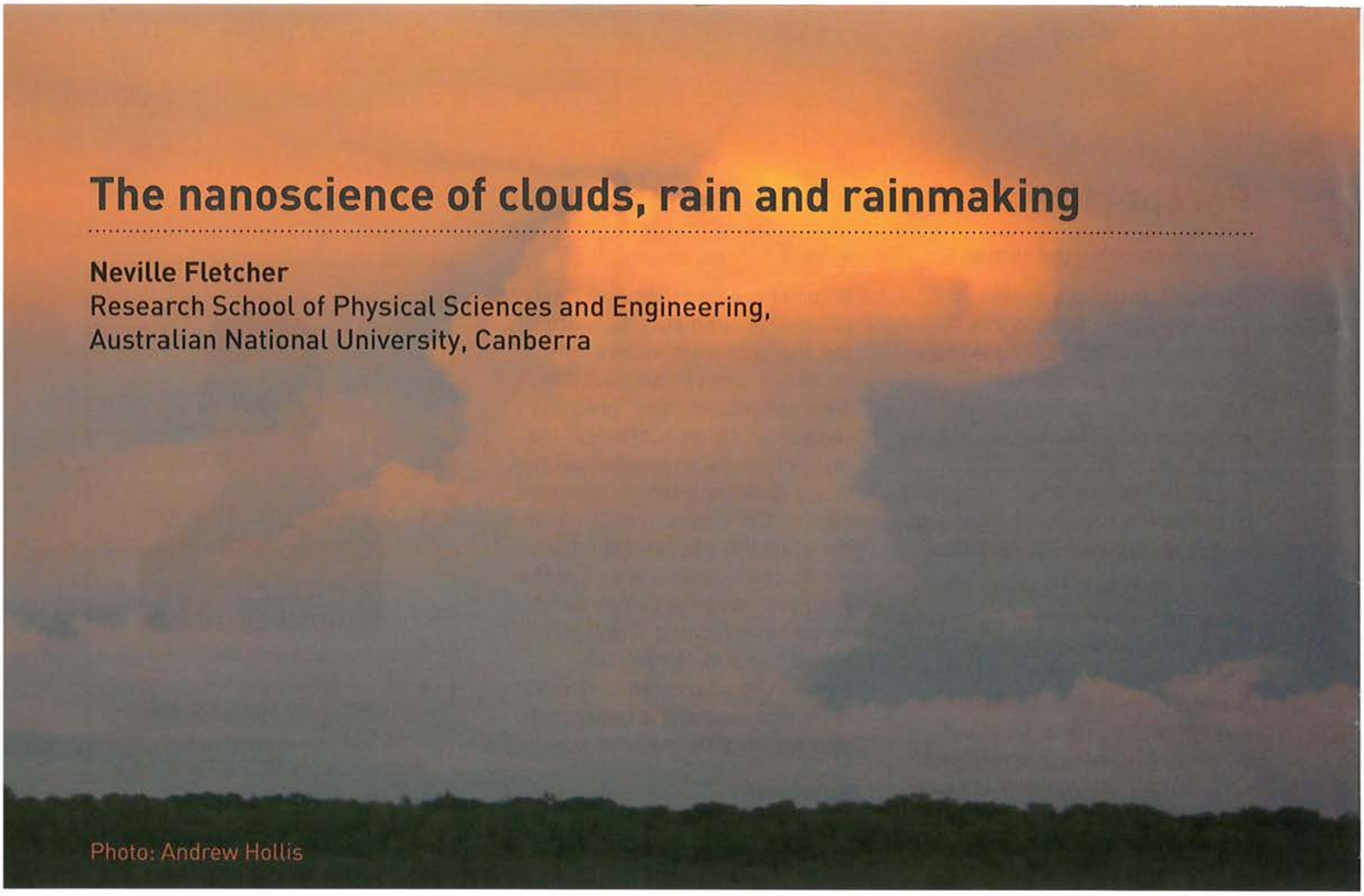


Photo: Andrew Hollis

In these days of droughts and fears of climate change it is instructive to look at the physical processes involved and to see what might be done to aid the future of the human race, and more immediately of Australia.

The range of scales is immense. At the high end we are looking at changes in the ice caps near the North and South poles, at the global ocean and atmospheric circulation patterns and, on a shorter time scale, at the motion of weather patterns around the globe. The length scale in each of these cases is in the thousand-kilometre range, and this is not the subject of the present article, though we shall venture into the kilometre range.

At the mid-scale of tens of kilometres we observe the formation of clouds, their growth, and sometimes the development of rain, hail or snow, and this will concern us. At even smaller scales we examine cloud droplets with diameters initially in the ten micrometre range, and then their development into millimetre-sized raindrops or snowflakes, while the smallest scale leads to consideration of the nanometre-sized particles that nucleate the formation of cloud droplets and sometimes their conversion to ice crystals.

Let us begin at the most conveniently observed cloud-sized kilometre scale. How do clouds form and what is their inner structure? The quick answer is simple: warm moist air rises, reaches the dew point determined by its initial humidity, and then condenses to a population of small droplets. In the absence of condensation, the "dry adiabatic lapse rate" for cooling of air as it expands upon rising is about 1°C per hundred metres. When condensation begins, latent heat is evolved and the "wet adiabatic lapse rate" is established, this depends on temperature but is considerably less than the dry adiabatic rate. The air in the condensing cloud therefore rises much more rapidly, entraining dry air from its sides as it does so, to produce a typical cumulus cloud that may be as much as 5 km in depth. In an alternative scenario, the rising cloud may encounter a temperature inversion, with a blanket of warmer air lying over the colder air below, so that even the wet adiabatic is inadequate and the cloud spreads horizontally to form a stratus cloud layer.

The existence of adequate clouds is, of course, essential for rainfall, whether natural or artificially induced. This is controlled by global climate changes on time scales of hundreds to thousand of years and by global and regional weather variations on time scales of days to years.

The shape and size of clouds provides a great field of study for atmospheric scientists and artists, but here we want to look much more closely and examine the droplets within the cloud. How exactly do they form? How big are they and what is their concentration? Why do some clouds rain and other do not? Is there anything we can do about it? It is here that nanoscience makes its entrance.

Cloud Droplet Nucleation

Let us first consider the process by which a volume of air supersaturated with water vapour changes

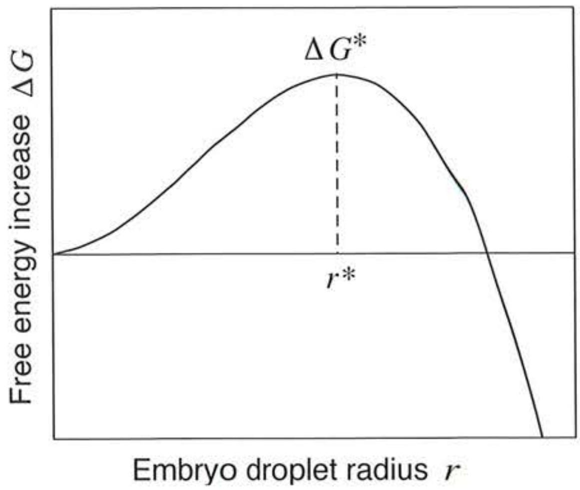


Figure 1. Free energy ΔG required for embryo droplet production as a function of droplet radius r. ΔG^* is the nucleation barrier.

to a cloud of droplets.[1] This can be described thermodynamically in terms of a function called the Gibbs Free Energy G, which is defined as

$$G = U - TS + pV,$$

where U is internal energy, T is absolute temperature, S is entropy, p is pressure, and V is volume. For a uniform system we can divide by the number of molecules involved, and the result, μ, is termed the chemical potential. It can be shown that for any closed system at constant pressure G tends to decrease towards a minimum value, and this provides a means for exploring the development of such systems.

So let us consider a uniform parcel of humid air with a water vapour pressure p, which is greater than

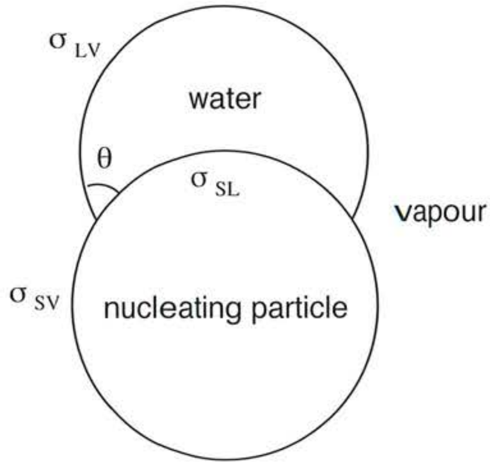


Figure 2. Nucleation of a water droplet on the surface of a solid particle. The contact angle is θ.

the saturated vapour pressure p_0 at the ambient temperature. It can be shown from the definition of G that the chemical potential for a water molecule in the vapour relative to that in liquid water at the same temperature is

$$\mu_V - \mu_L = kT \ln (p / p_0),$$

where k is the Boltzmann constant as usual. The free energy increase from formation of a water droplet of radius r from the vapour is therefore

$$\Delta G = -(4\pi/3)r^3 nkT \ln(p/p_0) + 4\pi r^2\sigma$$

where n is the number of molecules per unit volume in water and σ is the surface free energy of water per unit area, which is the same as the surface tension for a liquid. When this expression is plotted as a function of radius for the case $p > p_0$ corresponding to supersaturated vapour, it has the form shown in Fig. 1 with a maximum ΔG^* at radius r^*.

In equilibrium there will be a population of extremely small sub-critical droplets in the vapour, but in order that stable droplet nucleation can occur, it is necessary to surmount the free energy barrier created by this maximum. The rate at which this occurs can be shown to be

$$J \sim 10^{25} \exp (-\Delta G^*/ kT)$$

per cm^3 per second near normal atmospheric temperature. When values of the parameters are inserted it works out that an appreciable nucleation rate of say between 10^{-3} and 10^{+3} droplets per cm^3 per second requires a saturation ratio p/p_0 in the range 4.0 to 4.8. Such a high supersaturation is achieved only in equipment such as cloud chambers, while atmospheric supersaturation never exceeds a few percent. So how do droplets form?

The answer lies in nucleating particles. In a cloud chamber these are positive ions produced along the trails of the particles being tracked, while in the atmosphere they are tiny particles released from dust or sea-spray or industrial smoke.

Solid particles can act as condensation nuclei with a water droplet nucleated on the surface as shown in Figure 2. As well as the particle radius R, a very important parameter is the contact angle, θ, of water on the particle surface, defined by the force-balance relation

$$\sigma_{SV} = \sigma_{SL} + \sigma_{LV} \cos \theta$$

where σ_{AB} is the surface free energy or surface tension between A and B, with S implying the solid particle, L the liquid water, and V the surrounding vapour. Nucleation theory can be extended to cover this case, with the free-energy barrier ΔG^* then being a function of the particle radius R and the contact angle θ, or

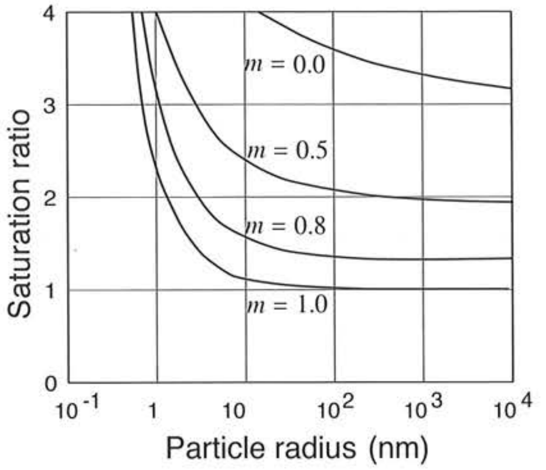


Figure 3. Critical saturation ratio for nucleation of a water droplet in one second[1] on a particle of radius R with a contact angle parameter $m = \cos\theta$.

more conveniently of $m = \cos\theta$, as shown in Figure 3. Since the supersaturation in typical clouds rarely exceeds 1%, it is clear that such solid particles need to have a very small contact angle and to be larger than about 200 nanometres in diameter if they are to have any role in cloud formation.

Soluble particles, however, are much more efficient nucleators, and work by forming small droplets of salt solution even when the surrounding vapour is not quite saturated. For a soluble particle as small as 100 nanometres, the equilibrium water droplet at saturation has a diameter rather larger than this and, most significantly, the barrier to droplet growth can be surmounted at a supersaturation of only a few tenths of one percent. Droplet growth is therefore almost an equilibrium process, with the larger soluble nuclei surmounting the barrier first and depleting the supersaturation so that the smaller nuclei are never activated above their barriers.

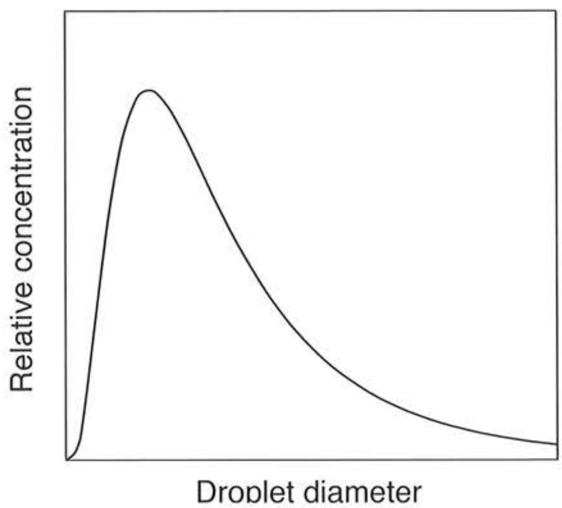


Figure 4. A log-normal distribution of cloud droplet diameters as plotted on a linear scale.

The spectrum of droplet sizes in a cloud will therefore depend upon the size spectrum of the soluble nuclei present and also to some extent upon the rate at which the air parcel is rising, which determines the rate of increase of supersaturation. Measurements on air masses of continental origin show large particle concentrations for diameters below about 100 nm and a rapid decline above this size, while maritime air masses have a much smaller and narrower distribution of particle diameters peaked around 1 μm.

The spectrum of cloud droplet sizes is generally of the "log-normal" type, with the logarithm of droplet diameters being normally distributed, giving the result shown in Figure 4. when plotted on a linear scale. The droplet concentration depends upon the type of cloud and the history of the air mass in which it grows. Clouds originating in warm tropical regions have greater liquid water content than clouds growing in cooler drier climates, the variation being from about 1 down to 0.3 g/m^3. The droplet concentrations also vary between about 50 per cm^3 for clouds growing over the sea up to as many as 2000 per cm^3 for continental cumulus clouds in times of drought. Since the water content is also generally lower in continental clouds, there is a corresponding large variation in mean droplet diameters, the peak in the distribution being observed to range from about 40 μm for maritime clouds down to about 10 μm for continental cumulus clouds.

Rain Formation by Coalescence

Since the air in a cloud is normally rising at a rate that ranges from about 1 m/s in a small cloud to more than 10 m/s in a large thundercloud, the cloud droplets must fall against this updraft. But the terminal velocity of a water droplet reaches 1m/s only if its diameter exceeds 200 μm, and nearly all droplets are much smaller than this, so some sort of coalescence mechanism must be involved. One might think this was simply a matter of slightly larger droplets overtaking slightly smaller ones and colliding with them, but it turns out that droplets do not collide but avoid each other because of air viscosity unless one of them is larger than about 30μm in diameter. Coalescence efficiency then rises rapidly with collecting drop size.

Maritime clouds, or those produced from air masses that have moved for a considerable distance across an ocean, have relatively small concentrations of rather large droplets and can thus produce rainfall efficiently by a simple coalescence process. Clouds growing in continental air masses, on the other hand, particularly if these are loaded with dust or smoke, have very

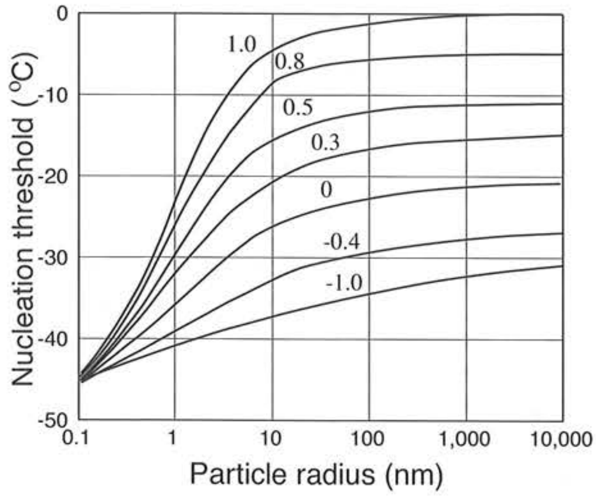


Figure 5. Calculated threshold temperature for nucleation of freezing of water[1] by a particle of radius *r* with contact parameter *m*.

large numbers of very small droplets and these fail to coalesce to produce raindrops.

Raindrops must, of course, be able to fall against the cloud updraft if they are to reach the ground. The terminal velocity for a drop of radius *r* (in mm) increases about as 120 r^2 m/s for small drops but saturates at about 10 m/s for drops larger than about 4mm in diameter. Most raindrops are in the 1 to 3 mm range, and drops larger than 4 mm in diameter tend to break up under aerodynamic forces as they fall.

Freezing and Sublimation

If continental-type clouds cannot produce raindrops by coalescence of cloud droplets, then how do they rain at all? If you look at a large cumulus cloud then you will often see that the top looks different and tends to form an anvil plume that blows off to one side. This is a plume of ice crystals and, on reflection, it is not strange that they form, since the lapse rate should place the freezing level something like 2 km above the land surface, and large cumulus clouds can be very much taller than this. But again we encounter a nucleation problem: exactly how does a water droplet freeze?

The simple theory of homogeneous freezing[1] is very similar to that of homogeneous condensation except that instead of vapour supersaturation being the driving force it is now liquid supercooling. Suppose we have some liquid water at a temperature that is below the freezing point by an amount ΔT, then the chemical potential of the water molecules relative to those in solid ice could be expressed just as before in terms of vapour pressures, but is more conveniently written as

$$\mu_L - \mu_S \approx (L/n)\,\Delta T/T_0 ,$$

where *L* is the latent heat of melting of ice per unit volume, *n* is the number of water molecules per unit volume in ice, ΔT is the supercooling and T_0 is the melting temperature of ice. The problem now, rather as with homogeneous condensation, is that the calculated nucleation temperature for freezing in a moderate sized droplet is about −45°C. Recognising that an ice crystal is not a sphere but a faceted structure makes things worse rather than better!

Once again the solution lies in heterogeneous nucleation on foreign particles suspended in the water droplets and the crucial parameters are the particle size and the contact parameter $m = \cos\theta$, with θ determined from an equation similar to that used before but with appropriately altered subscripts. The calculated results are shown in Figure 5. To be effective at cloud temperatures, the particle must have a diameter greater than about 20 nm.

Another possibility is that ice might nucleate directly from the vapour by sublimation onto the particle concerned. Again the analysis is similar to that for condensation, and when numbers are inserted we find the results shown in Figure 6. To be effective, nucleating particles must now be larger than about 200 nm in diameter and must have a contact parameter m, defined now in terms of ice and vapour, greater than about 0.9.

Once again the crystalline nature of the nucleating particle can be taken into account, but now it is crucial. Since the ice is growing epitaxially on the substrate, the energy of the interface and thus the value of the parameter m depends strongly on the crystalline lattice relations involved. To obtain the desired value of m close to unity requires minimisation of the energy of the ice/substrate interface, and a good crystalline structure match between these two materials will facilitate this.

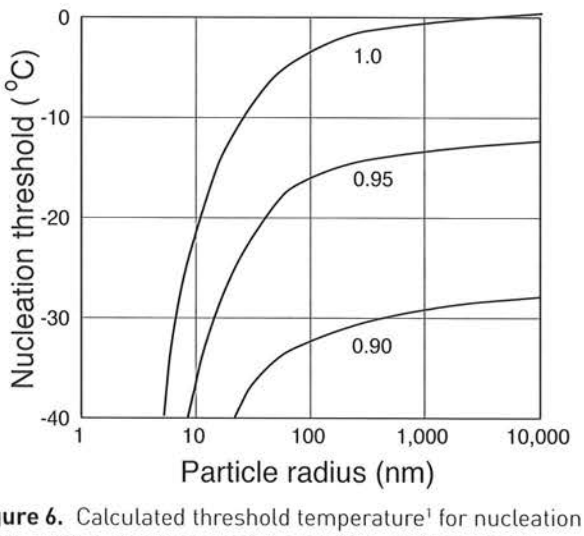


Figure 6. Calculated threshold temperature[1] for nucleation of ice sublimation by a particle of radius *r* with contact parameter *m*.

The nanoscience of clouds, rain and rainmaking

Crystal interfaces have received a great deal of attention, particularly recently in relation to epitaxial growth of semiconductors, and the situation with ice, investigated[1] about fifty years earlier, is very similar since the crystal structure of ice is the hexagonal analogue of the diamond cubic structure of common semiconductors. To obtain an interface with low energy requires a good match in geometry and lattice parameter between the nucleating particle and ice, and such a material was identified in the 1940s by Bernard Vonnegut to be silver iodide. The lattice geometry is the same as that of ice, and the lattice parameter mismatch on (0001) faces is only 1.3%. This gives an m value close to 1 and a nucleation temperature for large particles of about −4°C. Silver iodide remains the preferred nucleation material for cloud seeding up to the present day.

Of course, silver iodide does not occur naturally in the air, if only because it is rapidly decomposed to metallic silver and free iodine by sunlight, just like its photographic cousin silver bromide. But the same principles apply and, while natural minerals do not approach silver iodide in nucleation efficiency, many have nucleation thresholds around −15°C. Individual particles with pits or scratches or pairs of particles clumped together may have higher thresholds, and the abundance of such dust particles in the air, particularly continental air, ensures that most clouds develop ice crystals in their tops once they reach a temperature below about −15°C.

Once ice crystals have formed, they grow rapidly at the expense of the surrounding supercooled water droplets, because the vapour pressure over a supercooled water droplet is greater than that over an ice crystal. The snowflakes thus formed fall through the cloud and collide with cloud droplets which freeze on contact, forming grains of sleet or, if the water content is high, hailstones. These then melt when they fall below the freezing level and finally appear as raindrops. This melting transition is clearly visible as a bright band on radar because the dielectric constant of water is much greater than that of ice at microwave frequencies.

Industrial Pollution

It has been suggested by Daniel Rosenfeld of the Hebrew University of Jerusalem that, because smoke from industrial pollution changes the droplet concentrations in clouds, an effect that is visible from satellite studies, this can have a significant effect on rainfall downwind.

Rosenfeld's conclusions, not particularly those about Australia but those concerning other parts of the world, have excited considerable attention and dispute and the matter is still far from resolved. In general terms, however, it does seem reasonable that any form of atmospheric pollution can potentially have an effect on rainfall, though detailed study is required to discover whether this effect is significant, and indeed also whether it is positive or negative. The effect will certainly depend upon the chemical composition and size range of the particles released.

A report on a specific cloud-seeding proposal for Australia was prepared for the Department of the Environment and Heritage in 2002.[2] Since then Rosenfeld has published details of the studies on which the proposal was based,[3] information that was not made available at the time by his Australian commercial collaborator.

Rainmaking

If human activities are causing a reduction of rainfall in areas where water is in short supply, then the next question is what to do about it. Much the same question must be asked in relation to rainfall changes that are associated with natural or long-term variations in climate and weather patterns.

Physical understanding suggests that there are basically two options for increasing the rainfall from clouds: (i) add large salt particles (by which we mean a few micrometres) below cloud base to initiate nucleation and produce a reasonable concentration of large droplets before the small ones can form, or (ii) introduce efficient freezing of sublimation nuclei to produce ice crystals not too far above the freezing level. Both these possibilities have been tried and found to work at a reasonable level in individual clouds. In early experiments, condensation nuclei were distributed by spraying sea-water from an aircraft flying just below cloud level, or ice crystals were produced by dropping pellets of dry ice from an aircraft flying above the cloud tops. More recently silver iodide smoke, produced by dissolving silver iodide in acetone with the aid of an potassium iodide co-solvent and releasing smoke from the burning solution from an aircraft flying through the cloud near the freezing level, has become a standard method in many places. In other cases, as will be discussed below, the silver iodide smoke may be released into the cloud from burners at ground level and carried up by the updraft. There has also been some renewed interest in a process involving spraying of liquid CO_2 into the cloud from an aircraft flying just above the freezing level.

But the actual seeding technique is not the whole story. For a cloud seeding program to be effective it needs to be economically viable over an adequately large area and, because of the large variation in weather and cloud patterns, it needs to be evaluated statistically with appropriate controls over a long period. This has usually been done in one of several ways. One is to set

up the cloud-seeding system and then, on each day or perhaps each week, toss a coin to decide whether it is to operate or not and then compare seeded to un-seeded periods. To make this even better, it should be done on a "double-blind" basis with neither the operator nor the analyst knowing which periods were seeded and which were un-seeded, for example by having a concealed and coded switch on the silver-iodide supply to the burner.

Many variations of this scheme are possible, for example by having two neighbouring areas with similar rainfall patterns and seeding either one or the other on a random basis.

There is a possible problem with these procedures, however, in that the seeding agent may perhaps remain in the area for a considerable time, for example upon the leaves of trees, thereby causing initially promising results to decrease in significance as time progresses. This appears to have happened in some cases.

Cloud seeding has been in operation in Australia since it was begun on an experimental basis by CSIRO in the early 1950s. One of the most promising areas has been the tablelands of Tasmania, where any increases in rainfall has large commercial value since the water is used for hydroelectric power generation. This program continued and is still in operation, the latest analysis confirming an average 8% increase in rainfall in the target area and no detectable decrease in downwind areas. A similar program was operated in the 1960s in the Snowy Mountains of New South Wales, where again the rainfall is of high commercial value. The results at the time were controversial so the program was not continued on an operational basis, but about four years ago another program was launched in the area with improved methods of analysis and is currently in operation.

Current Australian programs use ground-based seeding in mountainous areas where the smoke is carried efficiently up into the clouds. This is a much less expensive procedure than using aircraft, but some programs in Texas in the USA are based upon targeting individual cloud areas using radar and despatching aircraft for selective seeding. This may be a more efficient way to proceed from a seeding point of view but it is much more expensive, and this must be taken into account. The same is true of attempting seeding operations over widespread areas of relatively flat agricultural land, where ground-based seeding may not be very effective and the commercial value of added rainfall is lower.

There is, in some areas, the possibility of an adverse effect from cloud seeding with silver iodide smoke. This can occur when, for some reason, the clouds already contain adequate ice-forming nuclei so that their tops are already glaciated. If large additional concentrations of freezing or sublimation nuclei are added, then the result may be that very large concentrations of very small ice crystals are produced, leading to a problem similar to that of coalescence in continental cumuli and a consequent possible reduction in rainfall. Such an effect could, however, be expected to be associated with air masses coming from particular directions, and the cloud-seeding procedures could be modified to take account of this. Something of this nature was found in a recent analysis of the long-term results of the Tasmanian cloud-seeding project, where precipitation from clouds in air masses coming from some particular directions was significantly increased while that from air masses from some other directions was not. Analysis of the Tasmanian experiment also showed no depletion of rainfall in areas downwind of the seeded regions.

My conclusion is that cloud seeding using silver iodide is an appropriate technique to apply in areas where the value of the rainfall is high and where preliminary experiments have demonstrated that it works.

Some people have expressed queries about the possible danger of dispersing silver iodide nanoparticles in the atmosphere, particularly when they end up in water supplies. There do not, however, appear to be any grounds for concern. The amount of silver iodide dispersed is extremely small — less than one part in ten billion in the resulting raindrops — and within a few hours it is converted to metallic silver by the action of sunlight. The co-solvent material, potassium iodide, also readily disappears since it is soluble in water and is also in minute quantities in the rainfall. It constitutes no hazard.

Cloud Seeding and Pollution

The other area that is presently under attention is the use of cloud seeding techniques to reduce the possible adverse effect of industrial pollution on rainfall in downwind areas. The suggestions that have been made range from seeding clouds with silver iodide released either from aircraft or ground-based burners to similar seeding efforts using salt water to introduce large hygroscopic particles.

My view on this matter is that, while cloud seeding might help to alleviate the effects of industrial and other pollution, it is probably not the way to proceed in the Australian situation. Here most of the major pollution sources are large coal-burning power plants, so that the sources are localised and clearly identifiable. Rather than trying to overcome the problem by seeding clouds far downwind, the obvious remedy seems to be either to reduce the emissions at the source, or else to inject suitable concentrations of salt particles into the chimney exhausts, perhaps by using sprays of sea water. The matter is still under discussion.

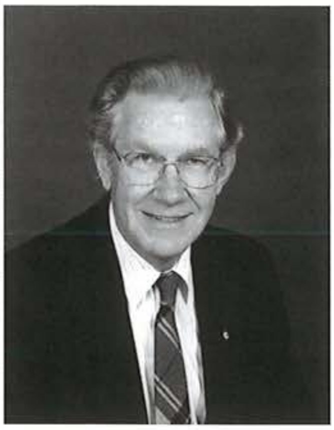
Conclusions

The behaviour of clouds is a mixture of phenomena at all scales from mega to nano. Humans can have influence over the long term at the kilometre stage through land and water management, but one of the most promising fields involves use of nanoparticle technology to influence the behaviour of cloud droplets which are themselves in the micrometre domain.

The field has now been under development for about sixty years, but results and predictions remain controversial. Part of the reason for this is that every region of the world is different, and what works well in one place may be ineffective in another. The only way to discover is to try experiments, which must be both well designed and extended in time if they are to produce reliable results.

References

1. N.H. Fletcher The Physics of Rainclouds (Cambridge University Press 1962, 1966)
2. N.H. Fletcher Advice on the Impact of Pollution on Rainfall and the Potential Benefits of Cloud Seeding (December 2002)
3. D. Rosenfeld, I.M. Lensky, J. Peterson and A. Gingis "Potential impacts of air pollution aerosols on precipitation in Australia" (2006) available on the web site *www.earth.huji.ac.il/staff-main.asp?id=149*



Neville Fletcher, who is currently a Visiting Fellow at the Australian National University, has done research in many areas of physics, ranging from semiconductor materials and devices to the acoustics of musical instruments, and hearing in insects. Along the way, while at CSIRO in the 1950s, he worked on the physics of ice and water and also the nucleation and growth of water droplets and ice crystals in clouds. He continues his interest in all these areas today.

Lead photo: Taken on 11 Feb 2006. A towering cumulonimbus builds at sunset during the wet season at Fogg Dam Conservation Reserve, 70km east of Darwin.

Centre of Expertise in Photonics Opening

It's official! The newly founded Centre of Expertise in Photonics at the University of Adelaide is open. The Centre, whose research revolves around the design, fabrication and characterisation of micro-structured soft glass optical fibres but also includes laser development, sensing technology and proteomics, is the latest addition to the already strong University of Adelaide physics research programme.

The opening, which took place on 31st of May, was by all accounts a great success. Representatives from The University of Adelaide, DSTO and government were in attendance as well as staff and students from the newly opened centre.

Undoubtedly the presence of a *heavily* pregnant Professor Tanya Monro, Director of the Centre, is proof of her extreme enthusiasm and devotion to this undertaking. The key guest speakers in their addresses to the assemblage mirrored these sentiments.

University of Adelaide Vice-Chancellor, Professor James McWha spoke of the dual nature of this venture by saying "The Centre exemplifies how the University is forging valuable partnerships which aim to lead the nation in new and exciting fields of technology and research, as well as providing students with a rewarding opportunity to be part of this new evolving world." He expressed his concern that fewer students were pursuing physics as a vocation and that this is contributing to a skills shortage.

Deputy Chief Defence Scientist (Information), Mr Neil Bryans, echoed Professor James McWha's concerns by noting that this skills shortage is already being felt at DSTO. Mr. Bryans also spoke of the fundamental importance of photonics to the defence industry, "Scientific expertise in photonics is fundamental to the development of many modern defence systems, especially communications and remote sensing, therefore the Centre is a strategic initiative to build Australia's defence and industry sector photonics capability."

The Minister for Science and Information Economy, The Honourable Karlene Maywald, spoke of the strength of the defence industry in South Australia and its potential for continued growth as a result of the inception of the Centre of Expertise in Photonics, "With the development of optical fibres, we can further grow the State's electronic warfare industry base and increase the chances of winning future defence contracts."

All guests were treated to an afternoon tea against a backdrop of speculative discussion between members of industry, government and academia about the direction for photonics research in South Australia. During the proceedings groups of interested individuals from all sectors were treated to a laboratory tour that was concluded with a demonstration of an optical fibre being created in the recently installed soft glass fibre drawing tower

The existence of this tower is a testament to the huge financial support that the Centre of Expertise in Photonics has enjoyed. Both industry and government support have been integral in the acquisition of infrastructure and staff. DSTO have already committed $400,000 for initial infrastructure establishment and ongoing funding of $400,000 per year for up to five years. In addition they have pledged support for a range of research tasks so far exceeding $1million.

The South Australian Government has provided the Centre with more than $400,000 from the Premier's Science and Research Fund and from the State Government Defence Unit.

With such strong support from Government and Industry coupled with the infectious enthusiasm and dedication of Professor Tanya Monro and her group it is hard to see how this venture could do anything but excel.

Officials and guests at the opening of the new photonics centre. From left; Prof. James McWha, Prof. John Carver, Hon. Karlene Maywald, Neil Bryans, Prof. Peter Rathjen, Prof. Iain Reid, Prof. Tanya Monro, AVM Roxley McLennan AM.

Conferences

2006

Sep 25 - 29
5th Symposium on Turbulence, Heat and Mass Transfer
Dubrovnik, Croatia
130.83.243.201/thmt-06/announce.html

September 27 - 1
17th International Mass Spectrometry Conference
Prague , Czechoslovakia
www.imsc2006.org

October 5
16th First Annual Ig Nobel Prize Ceremony
Cambridge, MA, United States
www.improbable.com/ig/ig-top.html

October 15-20
15th Pacific Basin Nuclear Conference
Sydney, Australia
www.pbnc2006.com

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

20 Nov 20 - 22 Nov 2006,
Acoustics 2006
Christchurch, NZ
www.conference.co.nz/index.cfm/acoustics06

December 3-8
17th Biennial Australian Institute of Physics Congress
Brisbane, Queensland, Australia
www.aipc2006.com/

December 11 - 13
Australian Society for Biophysics 30th Annual Scientific Meeting
Sydney, NSW
www.biophysics.org.au/

2007

February 6 - 9
31st Annual Condensed Matter and Materials Meeting
Charles Sturt University,
Wagga Wagga, NSW
http://rses.anu.edu.au/em/Wagga07/index.html

July 4 - 6
International Conference and Exhibition on Materials and Austceram 2007
Sydney NSW
www.materialsaustralia.com.au/ma2007/

July 8 - 12
World Conference on Science and Technology Education
Perth, WA
www.WorldSTE2007.asn.au

July 9 - 12
14th International Congress on Sound and Vibration
Cairns, QLD
www.icsv14.com/

September 9 - 14
14th International Union of Air Pollution Prevention and Environment Protection Associations (IUAPPA) World Congress/18th Clean Air Society Conference
Brisbane, Australia
www.casanz.org.au

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

November 21 - 23
15th AINSE Nuclear and Complementary Techniques of Analysis
Melbourne University, Melbourne, Australia

2008

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

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

Upcoming Physics events and activities

Taking Astronomy to the Masses in 3D - VIC

Thursday 14 September, 6:30pm
Swinburne University

Presented by Matthew Bailes, director of the Centre for Astrophysics and Supercomputing at Swinburne University of Technology.

For more details: *alex.merchant@rmit.edu.au, vic.aip.org.au*

Out of Africa – SA

Free public lecture
Wednesday 20 September, 7:30pm
Union Hall, University of Adelaide

Enrico Fermi's experimental nuclear reactor, constructed in the 1940's under a sports stadium in Chicago, is often described as initiating the world's first nuclear chain reaction. But the fossil remains of a natural reactor have been discovered in Africa that operated 2 billion years ago. Robert Loss of Curtin University will describe what was found and how the Oklo Reactor worked.

For more details: (08) 8201 2093, (08) 8277 7036 (a/h), *www.physics.adelaide.edu.au/aip-sa, aip-sa@physics.adelaide.edu.au*

Physics Industry Day - NSW

Wednesday 27 September
CSIRO Lindfield, NSW

Forging links between physicists in all sectors – government, university and industry. Exploring the commercialisation and industrial use of the results of physics research. The NSW AIP Physics in Industry day will include talks, poster presentations, a forum and lab tours. The plenary lecture, "Is manufacturing in Australia viable?", will be given by Bob Lundie-Jenkins from Austool. Hear industry speakers from Cap-XX, Coclear, Bishop's Technology, and ResMed, and tour the labs of CSIRO Industrial Physics and ANSTO Materials and Engineering Science. Students will compete for the NSW AIP Physics in Industry Student Prize.
For more details: Ken Doolan,*k.doolan@uws.edu.au*

Physics at Adventureworld Day - WA

Thursday 28 September
Adventureworld, Bibra Lakes

Students must experience acceleration and forces to understand motion - and at Physics Students' Day they can experience and measure both in a big way - with themselves at the centre of the action! Will a teacher's greater mass provide enough momentum for them to beat their students down the speed-slide? Traffic and Safety police will test it with radar guns!

For more details: Science Teachers Association of Western Australia, (08) 9244 1987, *info@stawa.asn.au*

eV Challenge - WA

21 October
Swan Tafe Midland Campus

Electric vehicles designed and built by student teams compete for prizes. The students drive them in an endurance event to see who can record the most laps in the time given, often solving technical problems and making emergency repairs on the way. Spectators welcome

For more details: Science Teachers Association of Western Australia (08) 9244 1987,*info@stawa.asn.au, evchallenge.swantafe.wa.edu.au*

VicSouth Desert Spring Star party - VIC

10-13 November

The VicSouth Desert Spring Star Party is an annual weekend of astronomy in western Victoria during the mild weather of spring - when the skies in the region are generally clear at night.
Enjoy a weekend of social and astronomical activity as well as some nice observing targets at the Little Desert Nature Lodge, 16km south of the town of Nhill - about halfway between Adelaide and Melbourne. VicSouth is jointly hosted by the Astronomical Society of Victoria and the Astronomical Society of South Australia

For more details: *www.vicsouth.com*

Science Education Conferences

Bridges to the Future - Joint conference of the Science Teachers Association of Queensland and the Queensland Association of Maths Teachers
4-6 October, All Hallows School, Brisbane
http://qamt.org/jointconference06/index.htm

ConSEA*ACT – Science Educators Association of the ACT conference
2-3 November, CSIRO, Campbell
www.seaact.asn.au

STAVCon - Science Teachers Association of Victoria state conference
23-24 November, La Trobe University, Melbourne
www.stav.vic.edu.au/home/conferencesandevents

Meetings

Synchrotron Users Meeting - VIC
30 November – 2 December
www.synchrotron.vic.gov.au

Convention

National Skeptics Convention – Science, Truth and the Media
18-19 November, Melbourne
How well does the media present science? Is there too much emphasis on the paranormal? These and other questions will be explored by speakers including scientists, science journalists and some well-known media personalities.
www.skeptics.com.au/convention/2006

(compiled by Tiki Swain, Science in Public)

News

Eureka Prizes

Presented at the annual gala dinner, the prestigious Eureka Prizes reward outstanding achievements in Australian science and science communication. Begun in 1990, they cover a comprehensive range of research activity, leadership and innovation, secondary school science, science journalism and science communication.

A full list of the winners can be found at *www.amonline.net.au/eureka/*, but some physics related awards were:

- **University of New South Wales Eureka Prize for Scientific Research** - Christian Weedbrook, University of Queensland, Dr Thomas Symul, Andrew Lance and Dr Ping Koy Lam Australian National University for their new way of encrypting information using quantum physics.
- **Australian Government Eureka Prize for Promoting Understanding of Science** - Dr Fred Watson, Anglo-Australian Observatory, Coonabarrabran, NSW

Australian Museum website

ANU Scientists take 'mini science circus' to Zululand

Zulu students and schools will be the winners as two intrepid ANU science communicators take a mini science circus on the road with *Science on the Move – South Africa*.

The program from Centre for the Public Awareness of Science at The Australian National University gives disadvantaged South African children a chance to experience the fun side of science, as well as empowering science educators in Zululand by combining rigorous staff training with science shows, teacher workshops and a travelling display.

"Many Zulu classrooms only have chairs, desks and a blackboard," said presenter Cristy Burne. "It's a very special thing for students to have an interactive science display and shows come to their school."

The two-month trip will involve travelling to schools each day and seeing up to 1500 students a day.

The ANU volunteers will present shows on science curriculum topics such as pressure, fire and energy, as well as teaching local staff to do the same. They will also conduct teacher workshops on hands-on science activities using cheap materials – a must for the disadvantaged communities they are focussing on.

The final component is a series of tabletop interactive exhibits; the hand-powered radio is a favourite amongst the African students.

ANU media release

Cosmos Bright Sparks

Cosmos magazine announced its first annual Bright Sparks Awards. The winners, chosen by the Editorial Advisory Board of COSMOS Magazine, are considered by them to be Australia's top 10 scientific minds under the age of 45. They were profiled in a special feature in the August/ September issue of *COSMOS* Magazine, and celebrated at an awards night in August at the ABC Studios in Sydney. The editor of *Cosmos*, Wilson da Silva, said that they hope to make it an annual feature.

Four of the winners were physicists:

- **Michelle Simmons** – Physicist (Professor of Physics, University of New South Wales)
- **Howard Wiseman** – Physicist (Federation Fellow, Griffith University)
- **Tanya Monro** – Optical Physicist (Professor of Physics, University of Adelaide)
- **Stuart Wyithe** – Astronomer (Lecturer, School of Physics, University of Melbourne)

The full story can be found at *www.cosmosmagazine.com/node/472*

Cosmos website

Cosmic stocktake reveals what's left of big bang

The Universe has guzzled its way through about 20 per cent of its normal matter, or original fuel reserves, according to findings from a survey of the nearby Universe by an international team of astronomers involving researchers at The Australian National University.

The survey, released at the General Assembly of the International Astronomical Union in Prague, revealed that about 20 per cent of the normal matter or fuel that was produced by the Big Bang 14 billion years ago is now in stars, a further 0.1 per cent lies in dust expelled from massive stars (and from which solid structures like the Earth and humans are made), and about 0.01 per cent is in super-massive black holes.

The survey data, which forms a 21st century database called the Millennium Galaxy Catalogue, was gathered from over 100 nights of telescope time in Australia, the Canary Islands and Chile, and contains over ten thousand giant galaxies, each of these containing 10 million to 1000 billion stars.

According to the survey leader Dr Simon Driver of St Andrews University, Scotland, the remaining material is almost completely in gaseous form lying both within and between the galaxies, forming a reservoir from which future generations of stars may develop.

One of the unique aspects of this program was the careful separation of a galaxy's stars into its central bulge component and surrounding disc-like structure. This allowed the researchers to determine that, on average, roughly half of the stars in galaxies reside in discs and the other half in bulges.

The Millennium Galaxy Catalogue consists of data from the Anglo-Australian Telescope, The Australian National University's 2.3 m telescope at Siding Spring Observatory, the Isaac Newton Telescope and the Telescopio Nazionale Galileo at the Spanish Observatorio del Roque de Los Muchachos of the Instituto de Astrofisica de Canarias, and also from the Gemini and ESO New Technology Telescopes in Chile.

Financial support for this project was jointly provided through grants from the Australian Research Council and the United Kingdom's Particle Physics and Astrophysics Research Council.

ANU media release

RMIT scientists awarded prize for nanotechnology research

RMIT Professor Irene Yarovsky and her team of researchers from the RMIT's School of Applied Sciences and BlueScope Steel scientists have won a $10,000 nanotechnology prize for their cutting-edge research to speed up the development of new products for use in the building and construction industry.

The team included research fellow Dr David Henry and PhD researcher George Yiapanis as well as Dr Evan Evans of BlueScope Steel.

They received a *2005/06 Prize for Outstanding Contribution to Industrial Nanotechnology* from Nanotechnology Victoria for their innovative molecular modelling of coating systems for BlueScope Steel's pre-painted Colorbond steel products.

"The research looked at identifying the options available to produce contamination-resistant coatings for BlueScope's Colorbond products," Professor Yarovsky said.

In awarding the prize, the CEO of Nanotechnology Victoria said, "The work of the RMIT-BlueScope Steel team was truly outstanding. They have demonstrated how molecular modelling and simulation can be a critical tool in materials design, with real benefits for a major Australian firm. We expect the RMIT team will make a significant contribution to many materials businesses in the future."

The research was conducted with the support of an Australian Research Council Linkage Grant in partnership with BlueScope Steel.

Nanotechnology Victoria is a consortium of Victoria's leading nanotechnology research institutions, dedicated to commercialisation of nanotechnologies for Victorian and Australian industry. Its annual prizes are awarded to teams which produce outstanding nanotechnology-based innovations directed at commercial outcomes.

RMIT media release

Science education program wins publishing award

The education program *Primary Connections: linking science with literacy* has won the Primary School (Teaching and Learning) category of the Australian Awards for Excellence in Educational Publishing for 2006.

The winners were announced on 27th July by the Australian Publishers Association.

Primary Connections is a partnership between the Australian Academy of Science and the Australian Government Department of Education, Science and Training (DEST).

It is an innovative program, linking the teaching of science and literacy in Australian primary schools.

Academy President, Professor Kurt Lambeck said, 'Quality primary school science education is essential if we are to harness our children's natural curiosity and develop their passion for exploring the way in which the world works. This philosophy is the foundation of *Primary Connections*.

Primary Connections is fully funded by DEST until the end of 2008 and has been developed in consultation with representatives from all states and territories. The program has been trialled in primary schools throughout Australia.

The Australian Awards for Excellence in Educational Publishing were established in 1994 and are sponsored by inLigare Book Printers. The Awards build on the concept of improving the quality of Australian educational materials. The Awards are judged for clarity of writing, pedagogical implications, illustrations, special features and characteristics, quality of subject matter, innovation and flair.

Visit the *Primary Connections* website at *www.science.org.au/primaryconnections*

AAS media release

New VC for JCU

Professor Sandra Harding was appointed Vice Chancellor of Australia's leading tropical research university James Cook University on 10th August by the University's Council.

She will replace Professor Bernard Moulden who retires at the end of this year after almost ten years as JCU Vice Chancellor.

Professor Harding is presently Deputy Vice Chancellor (International and Development) at Queensland's biggest university, Queensland University of Technology.

JCU media release

Discovery may mean safer, faster airport checks

Airport security checks may soon involve detecting residual vapours of chemicals, explosives and biological agents without delving into people's luggage.

Research by Queensland University of Technology lecturer, Dr Dmitri Gramotnev, has discovered special metallic structures that may allow detection and identification of extremely small amounts of substances, even separate molecules in the air

"Currently, to detect explosives, chemicals or biological agents a piece of tape is brushed over a person's luggage and it's taken away for testing. With the newly developed 'nano-focusing' technology, luggage could be monitored and any vapours from suspect agents detected as people pass through airports."

The co-leader of QUT's Applied Optics Program said the structures, called plasmonic waveguides, could focus light into nanoscale regions, unachievable in conventional optics.

The plasmonics research at QUT is conducted in close collaboration with the University of Tokusima in Japan and the Center for Nano-scale Science and Engineering at the University of California Berkeley.

Former QUT PhD student Dr David Pile was also chosen to work as a post-doctoral fellow at the University of California Berkley to further the research started at QUT.

QUT media release

Science film festival winners announced

The winners of SCINEMA 2006, the 6th International Festival of Science Film, were announced Sunday 20 August at the Powerhouse Museum in Sydney.

The 45 films from around the world competed for 15 trophies. The winners were selected by a jury of scientists, journalists and film-makers, chaired by Wilson da Silva, editor of the Australian popular science magazine, COSMOS, and joint winner (with Sally Browning) of the 2000 AFI Award for Best Documentary for *The Diplomat*.

This year's theme was sustainability, and the films screened in 89 venues around Australia during National Science Week, August 12-20, to an audience of over 10,000.

This year's event was the sixth SCINEMA Festival, growing from a small Canberra-based event in 2000.

It's the first time the awards ceremony came to Sydney.

In 2006, COSMOS magazine became a partner in SCINEMA and helped bring the awards ceremony to Sydney.

The jury consisted of Robyn Williams, Australia's most respected science journalist and broadcaster; Dr Bryan Gaensler, former Young Australian of the Year and University of Sydney physics professor; Dr Cornelia Hentzsch, managing director of pharmaceutical company Mundipharma; Joachim Putz, German film-maker and special festival guest; Ian Cuming, award-winning producer and director of The Future Eaters; and Dr Jonica Newby, an author and former veterinarian who is a reporter and producer on the weekly ABC TV science program, *Catalyst*.

"The range of films was impressive: from stylish productions narrated by Hollywood actors like Matt Damon to professionally-produced and engaging stories made by university film departments," said jury chairman, Wilson da Silva.

"The diversity was enormous: from the birth of the written word in Ukrainian, to following two young medical students in an Aboriginal community in the Arnhem Land; from creating Olympic athletes on the snowfields to unravelling the mysteries of a distant star in Flemish," he added. The winners in the 15 categories were:

Grand Prix: *Planet of the Rings* by Richard Smith, *'Catalyst'*, ABC TV

Prix du Jury: *Crossing the Line* - Producer Rod Freedman, Director Kaye Harrison (tied with) *Strange Days on Planet Earth* - Producer Johnathan Halperin, Director Drew Takahashi

Best Director: Andrea Ulbrick for *Nerves of Steel*

Best Cinematography: Allan Collins ACS and Warwick Thornton for *Five Seasons*

Best Documentary: *Shaken* - Producer/ Director Deborah Fryer

Best Short Film: *A Stem Cell Story* - Producer Kate Doherty, Director Cameron Duguid

Best Student Film: *Butterfly Man* - Director Samantha Rebillet

Best Narrative Film: *Kardia* - Producer Paul Barkin, Director Su Rynard

Best Experimental Film: *Mesh* - Producer Konrad Polthier, Director Beau Janzen

Best Science Television: *Sex in the Bush* - Producer Emma Ross, Series Producer Josie Matthiesson, Executive Producer Dione Gilmour - ABC TV Natural History Unit

Best Children's Science Television: *Backyard Science*, Executive Producer John Luscombe - Beyond Television

Award for Scientific Merit: *The Talking Star* - Producer Lut Govwy, Director Jacquei Servaes - For VRT, Belgium

Best Multimedia: *Scope* website - Network 10/CSIRO - *www.csiro.au/scope/*

Scinema website: www.csiro.au/scinema/aboutus/index.html

Parkes finds unexpected 'heartbeats' in star

A US-Australian research team found that a "magnetar" - a kind of star with the strongest magnetic fields known in the Universe - is giving off extraordinary radio pulses, which links this rare type of star with the much more common "radio pulsars".

The findings are published in the journal *Nature* on 24 August, and were also presented at the International Astronomical Union General Assembly in Prague (14-25 August).

The research team, led by Dr Fernando Camilo of Columbia University in New York, includes staff of the CSIRO Australia Telescope National Facility and the US National Radio Astronomy Observatory.

The discovery observations were made on 17 March 2006 by CSIRO scientist John Sarkissian. Further observations at Parkes were made by the Observatory's officer-in-charge, John Reynolds. "We hoped to detect a radio pulse if we were lucky," Mr Sarkissian says. "But we were genuinely surprised at how strong it actually was."

Dr Reynolds says the unexpected strength of the pulsar puts it in a category of its own. "The pulsar was so strong we could easily see and hear individual pulses of emission at the discovery frequency, which is rare enough," Dr Reynolds says. "But we were stunned to find that as we tuned to higher and higher frequencies the single pulses kept booming in."

The object in question is a neutron star - a small star made of extremely dense "neutron matter" - called XTE J1810-197. It lies about 10,000 light-years away in the constellation Sagittarius. The Parkes observations found it to be emitting radio pulses at every turn of the star, or every 5.54 seconds. These pulses have now been confirmed and studied with other telescopes in Australia, the USA and Europe.

Radio pulsars are neutron stars that put out regular pulses of radio waves. In almost all cases these pulses are easiest to detect at low frequencies, and get fainter and much harder to detect at higher frequencies.

"But this object is extraordinary," Dr Camilo says. "Its brightness is essentially the same over a factor of 100 in frequency. For wavelengths less than about a centimetre, it is brighter than every other known neutron star."

CSIRO media release

Something in the air

The world's first machine to simultaneously measure two vital properties of airborne nanoparticle pollution is going on an overseas trip to a leading atmospheric chemistry laboratory in Switzerland. The analyser, developed by the Queensland University of Technology's International Laboratory for Air Quality and Health, measures the volatile and hygroscopic (water absorbing) properties of nanoparticles emitted from vehicles.

Airborne nanoparticles are believed to have a role in the formation of lung and heart disease.

Nic Meyer and Dr Zoran Ristovski, whose visit is funded by the European Science Foundation, will take the analyser to the Paul Scherrer Institute, near Zurich, where Swiss scientists have built a copy of the QUT machine. The two devices will be standardised to enable future collaborative research in conjunction with researchers from UK and Swedish universities. Mr Meyer said the analyser had opened the door to important research into the structure and behaviour of nanoparticles emitted into the air from both man made and natural sources.

QUT media release

Product News

WARSASH Scientific Pty Ltd

Versatile Vibration Isolation Workstation

Warsash Scientific, introduces the MK26, a versatile new Vibration Isolation Workstation designed for ultra-low natural frequency applications from Kinetic Systems Inc. The workstation utilizes Minus K® patented negative-stiffness vibration isolators to provide a compact, passive workstation with ultra-low natural frequencies, higher internal structural frequencies, and excellent vertical and horizontal isolation efficiencies.

The Minus K® vertical isolator uses a stiff spring and a negative-stiffness mechanism to achieve a low net vertical stiffness without affecting the static load supporting capability. Horizontal isolation is provided by beam columns connected in series with the vertical-motion isolator. Adjusted to a ½ Hz natural frequency, the workstation achieves 93% isolation efficiency at 2 Hz, 99% at 5 Hz, and 99.7% at 10 Hz.

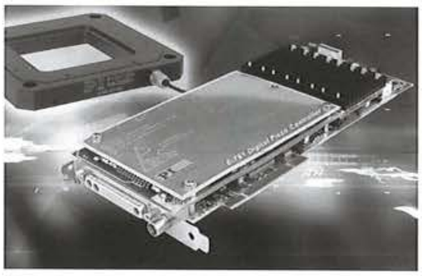
Produced in collaboration with Minus K Technology, Inc., the Kinetic Systems MK26 Vibration Isolation Workstation can be configured for a wide variety of applications where disturbances due to external vibrations can adversely affect the operation of sensitive equipment. Customization options for specific applications include guard rails, padded armrests, overhead equipment shelves, monitor stands, non-isolated shelves for supporting equipment off the tabletop, oversized keyboard shelves, retractable casters, Faraday Cages to protect sensitive operations from electromagnetic interference, tabletop enclosures to protect against harsh manufacturing environments, and electrical accessories such as outlet strips for lighting.

The MK26 is available with up to 295kg gross load capacity. It is Class 100 cleanroom compatible, with Class 10 available as an option. Tabletops can be ordered in two sizes (30" x 36" and 36" x 48") and either in lightweight "honeycomb" or composite construction.

Applications for the MK26 Vibration Isolation Workstation include analytical balances, cell injection, confocal microscopes, patch clamping, optical microscopes, wafer probing, sensor calibration, and atomic force microscopes in fields such as semiconductor processing, telecommunications, aerospace engineering, and medical research.

Further information on these and other vibration isolation systems is available from WARSASH Scientific Pty Ltd at (02) 9319 0122 or *sales@warsash.com.au*

New Motion Controller



Physik Instrumente (PI) has announced the release of their new E-761 PCI bus piezo nanopositioning digital motion controller.

The E-761 PCI controls three logical axes of closed-loop piezoelectric nanopositioning systems with capacitive position feedback.

Its PCI interface provides high-throughput and precise motion synchronisation with frame grabbers and other peripheral devices. The system also has a high bandwidth analogue position control input for external triggering applications.

The four onboard piezo drivers require no external amplifiers.

Features include a 32-bit digital signal processor, 24-bit digital-to-analog converters for subnanometer position resolution, polynomial linearization and coordinate transformation.

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The Matisse™ offers features and benefits emanating from significant progress of ring laser cavity designs that implement key electro-optical technologies. Like other products from Spectra Physics, the Matisse™ also utilizes cutting edge digital electronics and control. Furthermore, composite materials are used to dampen the effects of performance reducing vibrations. Other major advantages offered by this new laser are the electro-optic modulator that stabilizes the cavity length, and the very stable, temperature stabilized wavelength reference cavity.

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Product News

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Newport Release 1935-C Optical Meters.

Newport expanded its family of power and energy meters with the launch of the 1935-C series of optical meters. This new product family is ideal for measuring optical power and energy from any type of laser, laser diode or broadband light source. Designed to be easy-to-use, the meters are well-suited to various research and development applications, as well as in QA testing, and manufacturing.

"Newport has supplied the industry's most innovative power and optical meters for over a decade, and the new 1935-C series builds on this excellence. We believe it will be another flagship instrument for the laser and photonic industry, thanks to its powerful combination of features,

performance and versatility," says Ron Hartmayer, Newport's Director of Marketing for Photonics Instrumentation.

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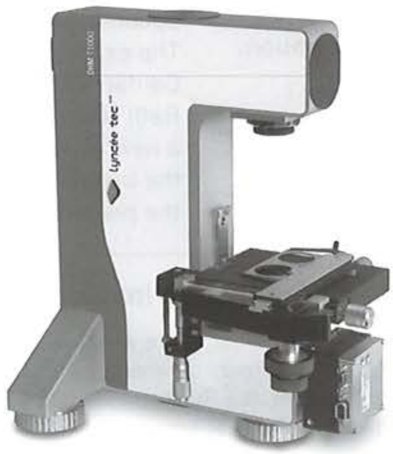

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web: *www.lastek.com.au*

Fusion research: Australian connections — past and future

B. D. Blackwell*, M.J. Hole, J. Howard* and J. O'Connor†**

* Plasma Research Laboratory, Research School of Physical Sciences and Engineering, College of Science, Australian National University.

** Department of Theoretical Physics, Research School of Physical Sciences and Engineering, College of Science, Australian National University.

† School of Mathematical and Physical Sciences, University of Newcastle.

Three recent articles in *Nature: Physics*, on plasma physics issues relevant to the ITER fusion power experiment, have Australian connections. Although Australia does not yet have any formal involvement with what is claimed to be the world's largest truly international scientific experiment, this connection is not surprising in view of the long and distinguished history of Australian contributions to fusion research. Beginning with the discovery of nuclear fusion, and the "triton" (tritium or 3H ion) by Sir Mark Oliphant and Lord Rutherford in 1933, Australians have made notable experimental and theoretical contributions both at home and in various overseas laboratories. Australia can claim the first tokamak in the western world - the Liley Torus. The "Rotamak", a spherical device, was invented by Professor I. Jones of Flinders University, and later at ANSTO, produced the world's first demonstration of a spherical torus configuration.

Recently the focus of Australian toroidal plasma confinement research has been the H-1 National Plasma Fusion Research Facility, based on the Heliac (helical axis) plasma configuration, a toroidal plasma of the stellarator type, first demonstrated in Australia. H-1 allows basic research into advanced plasma shapes and provides a test-bed for the development of advanced plasma measurement systems.

At a time when Australians are discussing possible participation in the international plasma fusion experiment ITER (*see box, below, on the Australian ITER forum workshop October 11-13*), it is appropriate to review past Australian contributions to fusion research, present research directions, and future opportunities, including potential involvement in the ITER.

Thermonuclear Ringtones and Fuzzy Boundaries

In the May issue of *Nature: Physics*, the article *Thermonuclear Ringtones*[1] describes recent studies of the time evolution of the spectrum of Alfvén Eigenmodes in tokamaks, a key physics issue for the upcoming ITER experimental plasma fusion reactor. The experiments on the DIII-D plasma device in California reported[2] in *Physical Review Letters* by Dr. Raffi Nazikian and a team of researchers, demonstrate a new aspect of this phenomenon, the excitation of the instability by thermal particle distributions (in the presence of steep temperature gradients). Dr.

ITER and the Workshop: "Towards an Australian Involvement in ITER" - October 12-13

ITER is an international fusion science experiment to demonstrate a self-sustaining deuterium-tritium fusion reaction on a scale suitable for the generation of clean, safe, low emission energy. The ITER partners comprise the European Union (represented by Euratom, including Switzerland), Japan, the Russian Federation, the United States of America, the People's Republic of China, the Republic of Korea and India. The ITER experiment will explore the physics of magnetically-confined "burning plasma" - plasma heated by fusion-generated alpha particles. In addition the broader ITER project aims to realize the technologies essential to a functioning reactor, including components capable of withstanding high neutron and heat-flux.

Inside the cryostat of the ITER tokamak showing magnets and vacuum vessel with protective tiles and divertor added to the left side and reference person below. (published with permission of ITER)

A group of over one hundred scientists and engineers have formed the Australian ITER Forum, which aims to develop the case for an Australian role in the ITER project, both by participation, and the formation of an international centre of research excellence in fusion science. With Federal Government support, the Australian ITER Forum has scheduled a workshop for October 12-13, "Towards an Australian involvement in ITER" www.ainse.edu.au/fusion. It will bring together the research community, industry, government, and the ITER partners to discuss a possible role for Australia, building on its past accomplishments, to participate in the pioneering demonstration of the ultimate clean, sustainable base load energy source.

(a) (b) (c)

Figure 1 a) The Rotamak spherical torus showing indicative magnetic field lines b) The H-1 heliac. The copper coloured circular conductor creates twist in the confining field lines. Only 18 of the 36 toroidal field coils are shown (grey) c) Cutaway view of the complete heliac, the centrepiece of the H-1NF.

Nazikian, a Principal Research Physicist at Princeton Plasma Physics Laboratory and Head, DIII-D Collaboration Division of the PPPL, graduated from the University of Melbourne, and studied plasma scintillations on the LT4 tokamak at the Australian National University for his PhD thesis.

The article addresses a critical issue for fusion reactors: the effect of the energetic fusion-generated alpha particles on the stability of the hot plasma. If the velocity of the alphas approaches the Alfvén velocity, they can drive an instability at the Alfvén resonant frequency, typically in the supersonic to sub-Megahertz range. As burning fusion plasma relies on the power from fusion alphas for heating, the effect of this instability on plasma confinement in general, and the confinement of those energetic alphas in particular, is crucial, and has been designated a priority area (Topical Group) under the International Tokamak Physics Activity(ITPA). In addition to the coincidence of the Alfvén phase velocity with the energetic alpha velocity, gaps or stationary points in the Alfvén dispersion relation can impede propagation of energy away from the source, allowing the oscillation to grow to large amplitude.

While this has been an active area of investigation for over a decade, this report is the first evidence of the instability being driven by resonant particles in a thermal distribution function. The authors suggested that steep temperature gradients near a thermal barrier were an important factor in this case. A related phenomenon observed on the H-1 National Facility in Canberra will be described below (*sonogram in Fig 2). Finally, why "ringtones"? The data published in *Nature* showed a sonogram ("voiceprint") made up of a cluster of frequencies resembling a touch tone dial signal, instead of the single frequency shown in Figure 2.

Two articles in a later issue of *Nature: Physics*[3], report aspects of an advance in plasma physics that may provide a solution to the crucial technological problem of extreme power density at the edge of a plasma fusion reactor such as ITER. In tokamak plasma, edge localised modes (ELMs) of instability release energy in powerful bursts, which could create intolerable thermal stresses in the plasma facing components, especially the divertor plates, and disrupt radio frequency plasma heating systems. By deliberately introducing a small chaotic region of magnetic field at the edge of the DIII-D plasma, a team of researchers[4] including ANU plasma physicists Prof. Jeffrey Harris and David Pretty showed that the large ELM spikes were controlled or suppressed. This technique was successful on a range

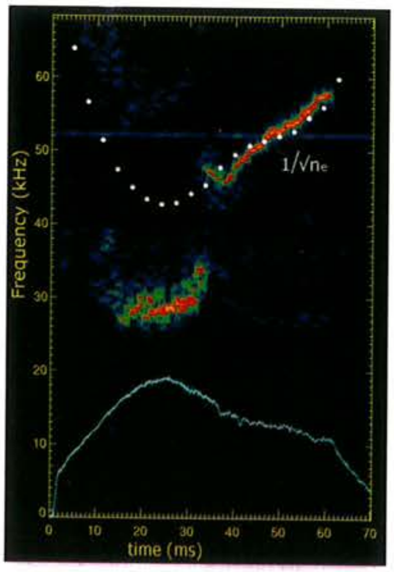

Figure 2 Frequency-time diagram of magnetic fluctuations in H-1NF showing the plasma density n_e in blue, and Alfvénic scaling with $1/\sqrt{n_e}$ (white).

of plasma configurations, including those that were designed to imitate ITER plasma. Although the results bode well for that experiment, a number of physics questions have been raised in relation to stochastic transport theory when applied to these "collisionless" rapidly rotating "pedestal" (edge) plasmas.

A brief history of Australian fusion research

The Australian connections in fusion research have a distinguished history. In 1933[5], while investigating the interactions between positive ion beams and various solids at the Cavendish laboratory, Cambridge, Sir Mark Oliphant and Lord Rutherford discovered the heavy hydrogen isotope tritium, and the ^{3}Helium isotope, by bombarding deuterated compounds with deuterons of energies up to 400kV. Energy balance analysis corroborated their postulate of a nuclear fusion process, and from stopping distances, energies of the emitted neutron and He^3 ion were estimated at 2 and 0.7MeV respectively, within 20% of the presently accepted values. Oliphant was an early advocate of fusion energy.

In 1958, under Oliphant, Hilary Morton started research into plasma physics at the Australian National University. In 1963, Bruce Liley, a plasma theorist born in New Zealand, joined the group and began the construction of LT-1, which he described as a "slow toroidal theta-z pinch". This turned out to be the first tokamak outside of Russia. Initially the most successful plasma confinement device, the "tokamak" was a doughnut-shaped ring of plasma confined by a toroidal magnetic field and a large current flowing around the torus. This current also heated the plasma, but was the source of serious "periodic disruptive" instabilities. The Russian inventors concentrated on stabilising these instabilities and stunned the international community by demonstrating a hot, well-confined plasma in the T-3 tokamak in 1968.

The Australian group realised that they had a very interesting plasma device and focussed on studying the instabilities in detail; they produced important insights into the phenomenon, for example, that a disruption rapidly redistributed the current throughout the plasma column[6].

Sizeable plasma research groups were founded at the University of Sydney in 1961 by C.N. Watson-Munro and later (1964) at Flinders University by M. Brennan, focussing on plasma diagnostics and wave propagation in a variety of linear geometries, with shock wave, radiofrequency and axial current heating. These groups established a strong tradition of research in Alfvén wave phenomena[7] which later became the focus of the Sydney TORTUS tokamak, and continues in the work on Alfvén Instabilities described later in this paper. Later, at Princeton University, R.L. Dewar[8] discovered a modification to the dispersion relation, caused by mode coupling, that produces some of the key features of Alfvén eigenmodes.

I. Jones[9], at Flinders University invented and developed the "Rotamak" configuration - an approximately spherical plasma configuration created by a rotating r.f. magnetic field in the sub-Megahertz range. This led to the world's first demonstration of a "spherical torus" configuration[10] in collaboration with the plasma group at the Australian Nuclear Science and Technology Organisation. This configuration is a compact form of the tokamak which is expected to be more efficient as a fusion reactor, with a larger plasma volume for a given device size. Along with the stellarator, this configuration is a contender for the experiment that will succeed ITER.

Conceived by an international team, the first heliac confinement device, "SHEILA" was built at the Australian National University in 1985[11], followed in 1992[12] by the H-1 heliac, the first heliac of sufficient size to approach "hot plasma" conditions (neutral particles are ionised before reaching the core, and charged particles sample the full extent of the magnetic geometry before experiencing a collision). The heliac is a toroidal confinement geometry defined by a magnetic field generated entirely by currents in external conductors. In particular, the twist of the magnetic field lines is generated by current in a central circular conductor instead of the current in the tokamak plasma. This avoids the instabilities inherent to the internal plasma current of the tokamak, and obviates the need for a transformer to drive this current, which limits the tokamak to pulsed operation. The heliac is distinguished from other stellarators by its helical plasma axis; both the magnetic field lines, and the plasma itself are highly twisted. This combination of twists increases the rotational transform (twist per turn) to 1 – 2, well above that attained in the tokamak (1/3 – 1/2), and provides stability at higher plasma pressure. Furthermore, H-1 is a "flexible heliac", by virtue of a helical control winding wrapped around the circular conductor, with the same helicity as the plasma. Relatively small currents (~10%) in this winding allow control of the plasma shape and vary the rotational transform from 0.6 to 1.5.

Australian Research in Fusion Science: Plasma and Atomic Physics and Materials Research

Present day research related to the development of fusion power is spread over a wide range of topics and locations in Australia. The plasma physics component of this is part of a larger research community in basic and applied plasma physics, but in this article, we will focus on the research potentially relevant to

plasma fusion reactors, and in the near term, the ITER experiment. Some specific examples are given which are directly applicable to ITER.

The present focus of Australian toroidal plasma confinement research is the ***H-1 National Plasma Fusion Research Facility***, based on the H-1 Heliac device, which was upgraded in the first round of the Major National Research Facilities funding. Although not intended (and not large enough) to produce fusion, H-1NF allows basic research into advanced plasma shapes for the generation of devices following the ITER tokamak. The facility consists of the H-1 heliac, two high frequency heating sources, and a 12 MW dual precision magnet power supply. The H-1 plasma has an average minor radius up to 0.2 m, a major radius of 1 m, in a 33 m^3 vacuum tank, containing 39 coils designed to produce magnetic fields up to 1 tesla. Typical operation is in H, He or D at 0.5 tesla, where the electron cyclotron second harmonic frequency matches the 28 Ghz, 200 kW microwave heating source, or at low fields in radio frequency heated (7 MHz, 100 kW) Argon plasma, where a higher pulse repetition rate is possible, and Langmuir probes may be used.

The flexible magnetic geometry of H-1NF can be summarised by three quantities, the rotational transform (ι) of the magnetic field lines described above, the spatial derivative of this ("shear") and magnetic well, a measure of the decrease in average magnetic field in the centre of the plasma. These quantities are central to the stability of magnetically confined plasma, and their variation can be used to test fundamental stability theories over a much wider range of parameters than is possible in highly optimised machines.

In addition to providing a "test-bed" for plasma diagnostics, and plasma conditions similar to edge plasma in a reactor, H-1 allows investigation of several fusion plasma phenomena on a smaller scale. Originally, transitions to a "high confinement" mode were reported by Shats[13], that reproduced most of the characteristics of those found in the largest machines, but were more conveniently accessed, and allowed detailed examination of the physics involved. The present design for ITER relies on a high confinement mode for successful operation of in a "burning plasma" mode.

Phenomena closely related to the fast particle driven Alfvén eigenmodes described earlier are observed in H-1. The spectra shown in Figure 2 are less complex than those of Nazikian et al., but using H-1 Facility we are able to explore a wider range of parameters with more detailed measurements than the large scale plasma experiments. For example, the absence of significant plasma current, and the ability to map the magnetic configuration in vacuum means that the rotational transform is much more precisely known than in a tokamak such as ITER. This, in conjunction with the world's only fully tomographic 2D imaging plasma interferometer for plasma density measurement[14], allows unequalled precision in the prediction of the Alfvén dispersion relation which is at the heart of these instabilities. Another advantage of the configurational flexibility in H-1NF is access to the low shear or reversed shear configurations of next-generation fusion reactors such as advanced tokamaks or stellarators.

In addition to their main lines of research in plasma processing, the development of materials for fuel cells and the helicon plasma thruster, the Space Plasma Power and Propulsion (SP3) group in the RSPhysSE at ANU carries out research into the physics of high beta (ratio of plasma pressure to magnetic pressure) plasmas and the behaviour of instabilities both parametric and pressure driven. Primarily the research is experiment driven supported by analytical modelling and a variety of PIC and hybrid computer simulations. Initial visits to American and German Laboratories confirm that SP3 has the opportunity and the plasma systems to take part in programs that are related to fusion and in particular ITER. Collaborative programs have been initiated with W7X in Greifswald and the Ruhr University in Bochum.

Plasma Theory

Australia can make a low-cost, high-impact contribution to ITER science in theory and modelling. Areas of active research include energetic particle mode physics (e.g. Alfvén waves), multiple-fluid modelling, 3D MHD equilibrium and stability studies, and integrated-modelling. The plasma theory group at ANU (Prof. Robert Dewar, Dr. Rowena Ball, Dr. Matthew Hole and Dr. Ruysuke Numata) is also very active in turbulence studies and dynamical systems modelling. These research efforts aim to understand the causes and conditions of turbulence suppression (which leads to higher performance) and develop dynamical system models to describe their behaviour.

Fusion plasmas are complex and turbulent environments. In a hot, magnetically confined plasma, free energy is readily available to small wavelength instabilities. At saturation, these instabilities can give rise to turbulent plasma mixing, reducing plasma confinement. Research by Dewar, Numata and Ball seeks to understand the dynamics of turbulence, and explore conditions under which turbulence can be suppressed such as the formation of zonal flow patterns. This fundamental research offers the promise of developing improved confinement configurations on ITER.

Fusion research: Australian connections — past and future

Magneto-hydrodynamic (MHD) theory treats plasma as a highly conducting fluid, and the "ideal" approximation (zero resistivity) has been remarkably successful in describing the equilibrium and stability of various plasma configurations. However, according to ideal MHD theory, plasma configurations that do not have an ignorable coordinate (3D plasmas) should not, in general, be able to support a continuous nonzero pressure gradient. In such plasmas theory predicts the pressure gradient to be zero in chaotic magnetic field regions, which arise due to the non-integrability of the magnetic field, viewed as a Hamiltonian dynamical system. In practice however, 3D plasmas, such as stellarators and weakly asymmetric tokamaks exhibit good performance, in which the observed pressure gradient appears to continuous and nonzero. The purpose of this research is overcome a long-standing problem in ideal MHD, by the development of a stepped pressure-profile model of 3D plasma configurations. Practical outcomes include better tools for modelling non-axisymmetric toroidal systems[15].

Integrated Plasma Modelling

Fusion plasmas are far from thermal equilibrium. They are driven systems, with multiple energy reservoirs and sinks, including fusion-born alpha particles, collisional heating (e.g. neutral beams), wave-particle resonant heating, magnetic reconnection and cold gas puff injection. Hole et al. has developed an energetically resolved fluid model, which treats the different energetic populations as different fluids. Steady-state model solutions provide a self-consistent description of the plasma, providing energy resolved equilibria in realistic geometry, and form a basis for modelling the excitation of Alfvén eigenmodes described at the beginning of this article.

Significant improvements in diagnostics and numerical models have led to the need for more complete data integration algorithms and approaches. Folding data together from thousands of diagnostics as input into numerical reconstruction codes is a heavily over-constrained problem. Applying these models to well diagnosed plasma such as the future ITER experiment normally means folding together highest-confidence data, and optimizing the data set to minimise a global measure of fit.

Plasma Measurement Systems

Plasma measurement systems under development by the Australian National University and the University of Sydney will allow improved monitoring of the state of the plasma. Supersonic helium beam probes provide localized sites of helium neutral and ion emission, which allows spatially resolved measurement of plasma density and temperature at the ITER plasma edge. The extension of the system to metastable He ions will enable electric fields to be included in the measurements.

New ***coherence interferometry*** techniques provide measurements of the distribution of ion velocities and temperatures. Research on the tomography of vector fields, especially in relation to Doppler spectroscopy of plasma flow fields[16] in the H-1 National Facility at ANU has led to the development of novel optical "coherence imaging" systems (CIS). This work, undertaken by John Howard and his group, at ANU[17], has spawned several patents, and resulted in installation of CIS optical plasma diagnostic systems in fusion labs in the US, Korea, Germany and Italy.

The CIS technology, which is based on the use of spatial and/or temporal multiplex techniques to image the optical coherence of a given spectral scene, has also led to the development of "coherence pyrometry" systems for measuring temperature, emissivity and emissivity-slope in thermography applications. A four-quadrant system has been recently trialled successfully under contract to Bluescope Steel to monitor the molten iron stream at their blast furnaces in Wollongong.

Based on polarizing interferometric techniques, CIS offers the important advantages of high light throughput and the capacity to spectrally image simple two-dimensional scenes. A variant of this technology[18] is presently being developed under contract for trial on the laser Thomson scattering system at the JT-60U tokamak in Japan – the world's second largest fusion device. Successful operation will almost certainly see this technology adopted for the Japanese laser Thomson scattering systems on the ITER tokamak.

Plasma Wall Interaction

In fusion plasmas, ions and electrons have kinetic energies ranging from several eV to over 50keV. Across this whole energy range, particles which lose magnetic confinement will collide with the first wall and can modify its surface structure and composition. In fusion plasmas the problem is pronounced, because plasma edge temperatures are high, and particle energies (~1keV) span the range for maximum sputtering and erosion. A separate problem is the consequent introduction of neutral atoms into the plasma, which cannot be confined by magnetic fields, and can radiate (by line emission) the stored energy of the plasma.

Plasma-surface interaction physics is an ongoing research topic at the University of Newcastle, where such low and medium energy ions have been used routinely for surface analysis and modification. Current research includes studying the effect of low energy bombardment of TiSiC alloys to ascertain which enrichment and sputtering processes

dominate.

An understanding of electron-atom and atom-atom collisions is particularly important at the plasma edge, and in the magnetic divertor which controls impurity and heat flux. This is an active area of research for Prof. Igor Bray and Dr. Andris Stelbovics of Murdoch University. They have ongoing collaborative projects with The International Atomic Energy Agency to provide electron impact data for the light atomic and ionic species in fusion plasmas, as well as alkali atoms injected into the plasmas for diagnostic purposes.

Dusty Plasma

Charged dust particles form an additional plasma species, and add fascinating complexity, such as quasi-crystalline ordered states and an electronic charge that depends on frequency. Recently, there has been a significant increase in interest by the fusion community in the role of dust in fusion plasmas. It is well known that fusion devices are rather "dusty" in the periphery regions; however, the impact of dust on the performance of fusion plasmas is not clear at the moment. The dust can affect the transport and re-distribution of eroded material of first wall components as well as plasma auxiliary heating. As we advance to high-power, burning plasma experiments such as ITER, it becomes more crucial to understand the physics of radioactive, mobile, and, therefore, potentially hazardous substances like dust.

Research in dusty plasmas performed in the Complex Systems Group (S. Vladimirov) that includes theoretical/computational/modelling studies as well as dusty plasma experiments at the Complex Plasma Laboratory (A. Samarian) can be related to priority research areas. These are designated in the International Tokamak Physics Activity (ITPA) High Priority Physics Research Areas for the ITER Physics Design, in the areas of Internal Transport Barrier properties, pedestal physics and the scrape-off layer and divertor area. The world-class quality of dusty plasma research at the Complex plasma Group of the University of Sydney is exemplified by the recent invitation of Prof. S. V. Vladimirov to the Japanese National Institute for Fusion Science as a Visiting Professor in January-March, 2006.

Materials Development and Testing

ITER will place extreme demands on materials. The first wall will face a high temperature plasma, high heat loads, radiation damage from 14 MeV neutrons and potential neutron activation. In addition, the first wall must have the capacity to remove heat from the reaction products, minimize plasma contamination from heavy elements, maintain structural integrity and allow lithium to be exposed to the maximum neutron flux to allow the production of tritium as a fuel. No one material can meet all these demands so there will be different materials at various stages through the process. Australia has a wealth of experience in materials synthesis and characterization that can benefit the development of new alloys with extreme properties.

One area of particular interest and current research is the production and characterization of **MAX phase alloys** which combine the electrical properties of metals with the oxidation and thermal resistance of ceramics. A variety of production process options are available including self-propagating high temperature synthesis, plasma deposition and hot isostatic pressing. This work involves collaborative research by ANSTO and the Universities of Sydney and Newcastle, with additional research activities at UTS and UNSW. Advanced materials growth facilities have been developed at these sites to explore new materials combinations expanding the capability envelope of materials. World-class facilities for the sophisticated probes (electron, x-ray, neutron) required for the micro-structural analyses of these advanced materials are readily available at the Australian Key Centre for Microscopy and Microanalysis (electron), the Australian Synchrotron (x-ray) and ANSTO-OPAL (neutron).

The expertise and facilities developed at the University of Wollongong over the past 30 years in physical metallurgy, high temperature materials, characterisation and welding research is of direct relevance to the challenging materials research problems associated with fusion energy systems. Key aspects of the materials performance of structural alloys used for the construction and maintenance of fusion reactors include weldability, resistance to high heat flux and radiation, the embrittling effects of H and He transmutation elements and the high thermomechanical loads that produce significant stresses and time-dependant strains. Further, a key factor that has not received sufficient attention to date is the consideration of weld regions in fabricated components, as these are often more structurally heterogeneous and more likely to contain detrimental transformation products or structural defects. This range of expertise represents an invaluable asset to an Australian fusion science initiative.

Relatively low level fusion neutron fields have the potential for causing defects in semiconductor electronics that will be used for a wide range of diagnostics and monitoring on ITER. Moreover, dosimetry and other radiation health effect issues need to be considered in this environment. Australia has the local expertise for producing small-scale fusion neutron sources, based on the electrostatic confinement of energetic plasma, which will enable these studies to be carried out. A prototype device,

using hydrogen plasma, has been demonstrated by Dr. Joe Khachan of the School of Physics, University of Sydney, and an improved deuterium device is under construction. In such a device electrostatic confinement results when a deep electrostatic potential is created in a plasma. Ions that are accelerated and trapped by the potential have a much increased chance of fusion events taking place. It has been shown[19] that with a modest power input (i.e. 5 - 10 kW, in D-D plasma) it is possible to produce 10^8 2.45 MeV neutrons per second operating in the electrostatic confinement mode. It is therefore possible to produce 14 MeV neutrons at a factor of a hundred higher (i.e. 10^{10} neutrons/second) in a D-T plasma [20]. In addition, these devices are on a scale such that they can be built to a desktop size with matching small scale costs.

Prospects for a stellarator fusion reactor

One may ask, given the high level of international interest in the ITER tokamak, and the potential for Australian involvement, "why is the H-1 Facility a stellarator?" The H-1NF configuration was chosen with an eye to the future: the step beyond ITER. Present performance parameters of tokamaks significantly exceed those achieved so far in stellarators, so ITER will be a tokamak. However the fundamental advantage of the stellarator configuration - that it does not require a large current flowing in the plasma - combined with highly encouraging recent results has led some to propose that the subsequent device, the "demo" reactor, be an advanced stellarator.

The superconducting stellarator "LHD" in Japan has already achieved plasma durations of more than 30 minutes. In the last decade, significant breakthroughs were achieved in the computer optimisation of magnetic field coils to achieve "quasi-symmetry" [21], one of several symmetries in magnetic coordinate space, even though in real space, the shape is far from symmetric. Recent stellarator reactor designs are competitive in size and performance with advanced and spherical tokamaks. The next generation of superconducting and highly optimised stellarators will hopefully confirm, on a larger scale, the freedom from disruption and the promising results on confinement and stability recently observed in Germany and Japan[22]; the high density high confinement mode (HDH[23]) exceeded operational limits of tokamaks both in rotational transform and plasma density. If so, we may well see a "demo" reactor in the form of a highly optimised stellarator.

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Several of the topics presented here will be covered in more detail in papers at the Pacific Basin Nuclear Conference in Sydney 15-20th October.

Fusion science and plasma physics are multi-disciplinary fields which offer a variety of rewarding projects and careers. Prospective postgraduate students are invited to consider opportunities on the Australian ITER forum website. AINSE bursaries are available to cover return airfare and accommodation for successful applicants to attend the workshop *(see earlier inset).*

Press Room Government media releases relating to science

Greater diversity is a high quality higher education market

An agreement by State, Territory and Australian Government ministers will diversify Australia's higher education market and provide greater choice for students to study at a variety of high quality higher education institutions.

The Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA), has agreed on 7th July to a new set of National Protocols for Higher Education Approval Processes ("the National Protocols") which will allow high quality higher education providers to accredit their own courses, bypassing costly and time consuming reaccreditation processes run by State Governments. Currently only universities and a handful of other institutions established by State or Commonwealth legislation can accredit their own courses.

In addition, MCEETYA has agreed to specialist institutions having access to a university title, meaning that we may, over time, see the establishment of a Sydney University of Performing Arts, or a Western Australian University of Minerals and Resources, or similar. This change will bring us into line with overseas practice and provide significant additional diversity and choice within Australia's higher education sector.

The new Protocols also clarify requirements for overseas higher education institutions seeking to operate in Australia, and reduce research and higher degree teaching requirements for new universities in their first five years of establishment.

The new Protocols will be reviewed no later than 2012. The rapid pace of change in global higher education means Ministers will clearly need to revisit these issues by then.

The revised Protocols and guidelines are due to be implemented by the end of 2007, pending legislative change in all jurisdictions.

New era in Australian nuclear research

On July 14, the Minister for Education, Science and Training, the Hon Julie Bishop MP welcomed the decision by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to grant the Australian Nuclear Science and Technology Organisation (ANSTO) a licence to operate its new OPAL nuclear research reactor.

Minister Bishop said the OPAL reactor will provide world class facilities for scientists to undertake nuclear research in areas such as biotechnology, food and molecular biology, nanotechnology, health, environmental management processes and engineering.

The licence was granted following an exhaustive examination, including cold commissioning tests. ARPANSA was also advised by overseas consultants, including an International Atomic Energy Agency (IAEA) review team.

The granting of this licence shows that OPAL has met the highest possible standards imposed upon the nuclear industry.

The granting of the licence allows ANSTO to load nuclear fuel and begin its second commissioning phase, where further testing will take place to ensure OPAL's performance meets expectations. When this is complete the current ANSTO reactor, HIFAR, will shut down. This is expected to occur early in 2007.

OPAL and its research facilities are attracting interest from scientists around the world. This will increase when the reactor becomes operational and will contribute to the organisation becoming a world leader in nuclear science research.

Research capability to be boosted by improved collaboration

On 31st July, the Minister for Education, Science and Training, the Hon Julie Bishop MP, announced six new initiatives that will support greater collaboration between researchers, both domestically and internationally.

The Australian Government has allocated $15 million under the Systemic Infrastructure Initiative for six highly collaborative proposals as part of its ongoing commitment to strengthen innovation and improve research outcomes.

The proposals will provide Australian scientists with access to research infrastructure that will enhance Australia's research capabilities and will:

- deliver improvements in access to distributed information, data resources, and research facilities;
- develop and implement innovative models of collecting, analysing and linking research results; and
- will fill significant gaps in the tools and resources available to researchers.

In making the announcement, Minister Bishop said the new initiatives will provide Australian researchers with a world-class information infrastructure enabling both national and international research collaboration.

These projects add to the suite of strategic infrastructure investments under the Australian Government's $8.3 billion *Backing Australia's Ability* initiative.

1. Australian Research Enabling Environment (ARCHER)
Lead institution: Monash University
Partners: James Cook University, The University of Queensland
Funding recommended: *$4,545,000*

This project will build on the architecture and prototype software developed by the Dataset Acquisition Accessibility & Annotation e-Research Technologies (DART) project to adopt a common information management architecture and infrastructure across the many data intensive research areas represented in the 9 high priority capability areas under NCRIS

2. Research Activityflow and Middleware Priorities (RAMP)
Lead institution: Macquarie University
Partners: University of Melbourne, The Australian National University, Charles Sturt University, University of Southern Queensland, Macquarie University Library, ADL Australia
Funding recommended: *$2,900,000*
The RAMP project will improve national research effectiveness by addressing two challenging components of the national research information infrastructure: the development and implementation of open standards authorisation for protected repositories; and research into and demonstration of people-oriented research workflows (often referred to as research activityflows).

3. Australian Research Repositories Online to the World (ARROW) – Stage 2
Lead institution: Monash University
Partners: National Library of Australia, The University of New South Wales, Swinburne University of Technology
Funding recommended: *$4,355,000*
The Australian Research Repositories Online to the World (ARROW) project has been very successful in providing tools to enable accessibility and discoverability of research from institutional repositories.

4. Legal Frameworks for e-Research
Lead institution: The Queensland University of Technology
Funding recommended: *$1,050,000*
This project will extend and reinforce the work already being undertaken by the Legal Protocols for Copyright Management for Open Access project.

5. Australian Partnership for Sustainable Repositories (APSR) – Stage 2
Lead institution: The Australian National University
Partners: University of Queensland, The University of Sydney
Funding recommended: *$1,870,000*
APSR is an open partnership of research and higher education institutions, funded under SII, committed to strengthening the national research infrastructure through the development of digital repositories and the provision of associated research-linked discovery, access and management services.

6. Integrated Content Environment for Research and Scholarship (ICE-RS)
Lead institution: University of Southern Queensland
Funding recommended: *$196,000*
ICE-RS will create open standards based technical solutions to facilitate and encourage the efficient creation of flexible documents in the process of conducting and reporting on research.

Tasmanian Branch

After an extremely busy EIYP year the Branch returned to more typical activity this year. Our first public lecture was held at the end of May when Prof Frank Larkins spoke on the topic *Transforming Australian science with the Australian Synchrotron*. Prof Larkins is a former Chair of the Tasmanian Branch (and was, incidentally, the Chair of the RACI in the state at the same time!!) and his lecture was also a welcome reunion for many of our members. He opened with a discussion of what a synchrotron is: a powerful light or photon source that can be tuned from the far infrared to hard x-ray ranges and can be employed in a range of experiments in many fields of physical and life sciences. It is an expensive instrument at $160 million to build but its versatility and long lifetime supporting such a range of research make it good value. Prof Larkins described the system including the linear accelerator, booster ring, storage ring and the beam exits and the timeline for construction. He explained that the beam would be more than a million times brighter than the sun allowing very fast data collection or very small samples. Prof Larkins described a range of research topics that could be addressed with the synchrotron as well as the benefits from the infrastructure development and a training ground for the next generation of scientists. He closed with a suggestion to the young members of the audience who were contemplating physics or engineering at university that here was a ready made source of employment for a lot physicists and engineers for at least 30 years, starting about the time they would graduate, and that they could do well to follow such a path at this exciting time.

One of our younger members, Stuart Morgan, visited 2 year 12 physics classes in Hobart to promote physics and try to encourage them to continue with physics at university. At the Friends' School in North Hobart he spoke to a small but enthusiastic group of people. A month later he visited the Hutchins School in Sandy Bay and was lucky enough to speak to a much larger group. Stuart started off asking the students to try to name as many famous physicists throughout the ages as they could, and then asked them to name as many famous other scientists as they could. As they were much more successful at the first task than the second, he noted, "if you want to be a famous scientist, be a physicist!" Stuart then explained the structure of the course at the University of Tasmania. This helped the students as it came at the time they would be starting to think about what would happen next year, but it was not so late that they had already made their decision. Stuart finished by listing some career opportunities for physicists (such as working on Mythbusters) and emphasising just how many devices that we take for granted today were invented by physicists. Overall Stuart felt both the talks were quite successful, and hopefully in the future he will be able to visit more than just two schools. He felt that the most difficult hurdle was getting some enthusiasm from the teachers! However, the teachers who took part are now keen for Stuart to return so this initiative may grow through word of mouth.

The Branch's second public lecture was held in early August with Dr Barry Green from the Directorate-General for Research of the European Commission. Dr Green is an expatriate Australian who has spent most of his working life in fusion research. Naturally enough Dr Green's topic was related to fusion power and was entitled "Fusion energy and ITER – an opportunity for Australia". Dr Green opened his talk with a discussion of the critical issue of energy supply and demand and the problem of the environmental effects of the majority of power generation methods today. He described the ideal energy supply mix as being economically viable, potentially large scale (or alternatively solve the energy storage problem), having a secure supply of 'fuel', being "safe" and being environmentally acceptable. A cost effective fusion power system would meet all these criteria. Dr Green described the fusion reactions proposed for power generation and noted that fossil fuel has an energy density of 32-45 MJ/kg, fission has 1,000,000 MJ/kg whilst fusion has 200,000,000 MJ/kg and in the latter case all the materials you need can be found in 45 litres of ordinary water and a lithium watch battery. The fuels for fusion are abundant, the system is clean with no significant waste (only low activation of system components that are safe after relatively short storage times) and there are no weapons applications. Furthermore fusion power generation should be cost competitive and eventually be similar in cost to fission generation. Dr Green then talked about the engineering aspects of fusion power. Heating the plasma is easy but the trick is to confine it. He discussed the tokomak principle and the fact that it is already a demonstrated technology. He then went on to talk about the European Union ITER project as the essential next step toward commercial fusion power generation. This project is second only to the space station in size of operation. The initial aim is to produce an output power 10 times the input energy to achieve 400 MW for 400 seconds. The second aim is produce a continuous five fold output to input power ratio. This talk generated a lot of public interest and a lively question and discussion session after the talk. It was encouraging to see a good number of high school students in the audience and to hear their insightful comments and questions. Dr Green's talk was part of a national tour organised by an Australian consortium interested in being a part of ITER and it was coordinated by ANSTO.

Finally, the Branch had held its annual teachers development symposium over two days late in 2005 jointly with the RACI and a major topic of discussion and concern was the state Education Department's Essential Learnings (ELS) programme that involved outcomes based learning and the removal of a formal syllabus structure. Because the program had proved to be so contentious, being roundly criticised by the public, academics and some teachers who felt secure enough in their jobs to be outspoken, the Education Department was invited to send some representatives to put the Department's case before the teachers and for some open discussion. The exchange was useful in more fully informing academic members of the AIP and RACI and in allowing a closer discussion between teachers and the Department representatives about how the program might be actually put into practice in a constructive way. At the end of the symposium the teachers were not satisfied that the program was in the best interests of students who wished to continue their education beyond year 12 level but understood better how they could work within the system, whilst the Education Department representatives had a clearer picture of the underlying concerns regarding the assessment based on outcomes and the risk of teachers only addressing the 'assessed outcomes' rather than the complete outcome set. In the end there was such a large public backlash that the Minister for Education barely regained her seat in the subsequently called state election and she was removed from the Education portfolio by the Premier. The new Minister has just announced (at the end of August) the scrapping of the ELS program and a revamping of the syllabus in a direction that the Branch is delighted to see. There are still aspects of outcomes based learning but the importance of the enabling sciences has been recognised as has literacy and history and the concept of a syllabus structure has returned so that critical elements of knowledge will be enshrined in the education system.

Marc Duldig

Australian Institute of Physics Merchandise

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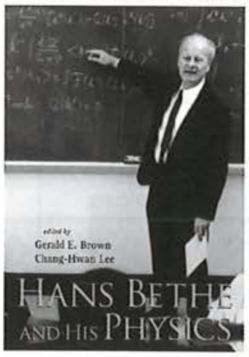


Biographies of great scientists written by those who worked closely with them are, to my mind, the most fascinating. They often combine revealing insights into the way great minds work while at the same time disclosing those foibles of behaviour that reveal the human touch. Such is the latest wonderful festschrift titled "Hans Bethe and His Physics". It has been compiled and edited by his close collaborator, Gerald Brown, assisted by Chang-Hwan Lee. A few chapters are from tributes published in a special issue of "Physics Today" last October. But there is much new material on Bethe the man, as in Christoph Adami's detailed diary of three weeks with him.

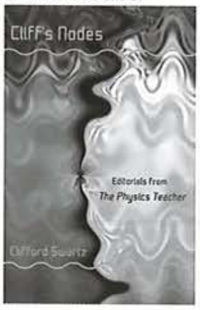
Freeman Dyson recognised the late Hans Bethe as the supreme problem solver of the past century. And it was not only in physics that Bethe's huge intellect shone. His versatility was amazing, astonishing even to those who worked closely with him. There are many who would rank Bethe above the great Einstein himself. After all, Einstein's most original work was performed as a young man and was achieving very little by the time he was sixty but Bethe on the other hand continued to make seminal contributions well into his nineties.

Less well known is Bethe's vital input to arms control and the cessation of nuclear weapons tests in the atmosphere. And I'm amazed at Bethe's prescience as far back as 1977 on global energy problems as they are emerging at the present time. Read about it in a revealing essay by Boris Ioffe.

I highly recommend this handsome volume published by World Scientific and priced at US$98 bearing the ISBN 981-256-609-0. I believe a paperback edition is also available for US$38.

Colin Keay
Reviews Editor

Cliff's Nodes



Clifford Swartz
Johns Hopkins University Press, Baltimore 2006.
xviii + 338 pp.
US$25.00 (softcover)
ISBN 0-8018-8307-5

Clifford Swartz was for 29 years the editor of *The Physics Teacher*, which is a journal with around 12,000 subscribers, aimed at those teaching introductory physics at any level. This book is a collection of over one hundred of his favourite editorials, mostly equation-free but assuredly not free of trenchant expressions of opinion.

What can we learn from this book? If you are an old hand, you can reminisce over a lot of things that have happened for good or bad (mainly the latter?) during your career. If you are a greenhorn, the book will have predictive power: e.g., " there will be a never-ending series of new learning theories, each fad having a peculiar name and lasting about ten years but exerting very little practical influence".

There are certain things in the book which need to be kept as professional secrets. For example, the nine educational reasons and five financial reasons for not having student labs: were these to surface on the Dean's or the Minister's desk, the consequences would be swift. The following two editorials examine what features laboratory programs should have to make them worth saving.

Cliff's Nodes is a great book to dip into, for some pepper to add to your arguments ("Precision is expensive. Don't get it if you don't need it."), and for that pinch of salt to add on the latest pedagogical advance (see The Hawthorne Effect: "In physics teaching, as in most human endeavours, it's the loving that counts"). But above all, you will learn that "plus que ça change ...".

Ross C McPhedran
School of Physics
University of Sydney.

High Magnetic Fields: Science and Technology Vol.3. Theory and Experiments II.

F Herlach and N Miura (eds).
World Scientific, Singapore 2006
vii + 311 pp. US$55.00 (hardcover)
ISBN 981-02-4966-7 (Vol. 3)

The study of the effect of externally applied high magnetic fields on physical systems is valuable because, if the strength of the coupling of the magnetic field to the system is comparable to the internal interactions of the system, new physical behaviour will result which may either be of importance in its own right or enable the functioning of the system to be understood better. This book contains ten concise reviews of progress in high field studies that has been made in the last twenty years. A variety of systems are considered. They are mostly of the traditional solid-state physics variety but also less usual ones such as plasma, biological and astrophysical systems.

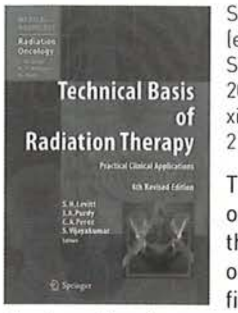
Due to technological progress, high magnetic fields that are used in the laboratory are higher than they used to be: over 20 Tesla (T) for persistent mode superconducting magnets, 33 T for water-cooled copper coils, 45 T for hybrid magnets, 70 T for pulsed magnets and up to 10^3 T for exploding coils that produce flux compression but destroy the sample. The articles are all of good quality. There is a lively review of quantum Hall effects in the two dimensional electron gas. There is a new treatment of the old topic of permanent magnets jointly written by a theorist, an experimentalist and a materials scientist that elegantly integrates those three approaches. High temperature superconductors make excellent permanent magnets due to their flux pinning but suffer from the disadvantage that they become demagnetized when they warm up. This reviewer learnt some interesting facts about high fields in the astrophysical world. From calculations of the energy levels of the hydrogen atom in ultra-high fields it is deduced that neutron stars may have fields as high as 10^{11} T.

This book lists the high field facilities in the world. There are twelve in Europe, three in the USA seven in Japan but sadly none in Australia or New Zealand. It will be of interest to specialists in high field studies but probably not to the general reader.

A M Stewart
Department of Theoretical Physics
Australian National University

Reviews

Technical Basis of Radiation Therapy.



S H Levitt, et al, (eds)
Springer, Berlin
2006
xiii + 861 pp., EUR 213.95 (hardcover)

The application of radiation to the treatment of cancer is a field that blurs the boundary between medicine and physics. Physicists wishing to enter this field need to gain an understanding of the complexities of human anatomy, physiology and evidence-based medicine, whilst clinicians require a firm grounding in the physics of radiation generation and interactions. This book provides a detailed outline of radiation therapy (RT) from both of those aspects, though it is principally aimed at clinicians.

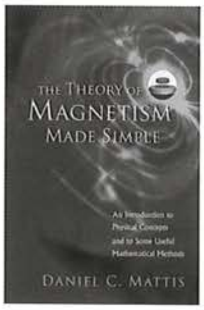
Some 59 authors have contributed to 33 chapters. The text is divided into two ections: 'Basic Concepts in Treatment Planning' and 'Practical Clinical pplications' The first part examines specific components of the treatment process (such as imaging for RT, technical concepts of brachytherapy, IMRT, treatment planning) with contributions from renowned clinical physicists such as James Purdy and Daniel Low, as well as biologic aspects of treatment prescription and response from some of the legends of radiobiological modelling: Eric Hall, Jack Fowler and David Brenner.

The second section examines treatment approaches with each chapter dedicated to a specific disease site. The detailed anatomy, diagnosis and histology of these diseases are examined along with summaries of related clinical trials. However, the emphasis is on treatment approaches for each disease site and the practicalities of patient setup, field placement, fractionation etc. Although the text is extensive in its coverage of cancer types, each chapter is sufficiently succinct to be quite readable (the chapter on breast cancer for example is only 24 pages with many illustrations).

The manner in which the text has been compiled suggests it will rival similar previous texts such as Walter and Miller's "Textbook of Radiotherapy". Although it is rimarily aimed at radiation oncologists, the text will be of use to physicists and radiation therapists. For example, if you want to know just what those clinicians were talking about in this morning's chart review, then you will find this text a useful resource!

Martin A. Ebert
Chief Physicist
Newcastle Mater Hospital

The Theory of Magnetism made Simple



Daniel C Mattis
World Scientific Publishing, Singapore
2006
xiii + 565 pp., US$88 (hardcover)
ISBN 981-238-579-7

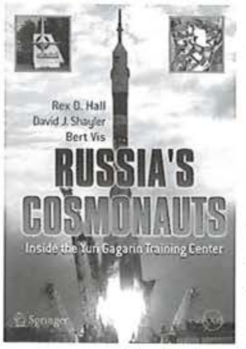
The recent explosion of advanced sample preparation techniques and experimental research in the area of magnetism and magnetic materials continues to provide a wealth of new physics. Recent technological developments such as spintronics and the giant magnetocaloric and colossal magnetoresistive materials drive this effort. From a theoretical point of view, the challenge is to understand the behaviour of these new materials.

It is within this context that Daniel Mattis has updated his classic 1981 and 1985 texts, *The Theory of Magnetism vols 1 and 2*, which will be familiar to many readers. Sub-titled *An introduction to physical concepts and to some useful mathematical methods*, this book begins with a detailed discussion of the history of magnetism and continues with chapters on Angular Momentum, the Many-Body problem, Spin dynamics, Magnetism in metals, the Statistical Thermodynamics of magnetism and the Ising model. Within this broad discussion are topics such as superexchange, the Hubbard model, magnons and solitons, antiferromagnetism, spin-glasses and disorder, the XY model, frustration and the Kondo effect. The breadth of the treatment of the physics of magnetism is vast and, as Mattis says in his prologue (perhaps only half-jokingly) "Let us see whether all of theoretical physics might not be a special case of the theory of magnetism". I can't say if this has been proven definitively but, having read this book, I doubt if Mattis' claim is very wide of the mark!

The book is extremely well presented and includes references up to 2004 (with a few 2005 preprint references). As one would expect, all the classic papers are referenced. This book is an excellent resource for anyone working in magnetism or theoretical condensed matter physics in general and would be invaluable to research students in these areas. It is probably too advanced for undergraduate use.

J M Cadogan
School of Physics
University of New South Wales

Russia's Cosmonauts



R Hall, D Shayler and B Vis
Springer/Praxis, Chichester, 2005
xxxiv + 386 pp., EUR 24.95 (softcover)
ISBN 0-387-21894-7

The advent of the internet means that nothing of historical note, in terms of scientific and technological advances, need now be lost. I find it staggering that so much of the history of physics has survived from past centuries, but also lament what has disappeared. We know much about Isaac Newton, because he himself ensured he would not be forgotten, but comparatively little about Robert Hooke, whose memory his enemy tried to erase. If only one portrait of Hooke had survived, so as to confirm that he was a hunchbacked dwarf, we might take a different view of what Sir Isaac meant when he wrote to Hooke that "If I have seen farther, it is by standing on the shoulders of giants."

By scanning photographs and documents of historical importance, and making them available on the internet, the information is dispersed and no longer subject to destruction by flood, fire or insurrection. But first someone has to dig those documents and pictures out, and organise them. With the downfall of the Soviet Union, and the pressing concerns that therefore arose for the space industry there, the history of the 'other' manned space program could have been lost forever.

That this can no longer occur is due in no small part to enthusiasts like

the authors of this book. Diligently they have gathered together a host of appropriately-monochrome photographs, maps and detailed information concerning the Soviet space effort, particularly the manned program rather than the robotic space exploration projects, and gathered them into a hefty tome.

This is not scintillating reading, and some of the illustrations are almost amusing because of their apparent obscurity; for example, "The formal order transferring Pavel Popovich to the team in 1960." On the other hand, this book provides a welcome counterpoint to the sort of glossy production deriving from the American space program. It's not glitzy, but it's a significant printed resource. Doubtless it will soon be scanned and on the web itself.

Duncan Steel
Ball Solutions Group
Canberra, ACT

Book Notice

Modern Meteor Science

R Hawkes, I Mann and P Brown (eds)
Springer, Dordrecht 2005
744 pp., EUR 114.95 (hardcover)
ISBN 1-4020-4374-0 (Incl. CD-ROM)

During the past half century meteor research has evolved into a comprehensive multidisciplinary science yielding unique information about our atmosphere, space environment and even interstellar dust particles. New sub-disciplines in other areas such as astrobiology are gaining from studies of the chemistry of minor interplanetary material and laboratory as well as observational data on its properties. New findings are flowing from the ever-broadening range of investigative techniques that are being employed to great effect by the contributors to this book..

This comprehensive overview of leading edge research by well over one hundred authors is an essential resource volume for scientists and engineers conducting studies and exploration of the solar system. It demands a place in the libraries supporting their activities.

WAGGA WAGGA

2007

First Notice
31st Annual Condensed Matter and Materials Meeting
Charles Sturt University, Wagga Wagga, NSW
6 - 9 February, 2007

Wagga 2007 will be held at the Convention Centre at Charles Sturt University, Wagga Wagga, NSW. Arrival formalities will commence from 4.00pm on Tuesday 6 February 2007, with scientific sessions commencing 8.50am Wednesday, 7 February and concluding with lunch on Friday, 9 February 2006. Accommodation will be available on the University Campus near the Convention Centre. This meeting is an opportunity for **all** condensed matter and materials scientists to meet in an informal atmosphere to discuss their current research, future direction and other matters of importance in the field. The usual Wagga format will apply with emphasis on contributed poster papers plus a number of invited oral papers and selected contributed oral papers. Students are particularly encouraged to submit oral presentations. The Organising Committee welcomes suggestions concerning invited speakers to deliver broad keynote presentations.

Abstracts: Contributed papers are requested in all areas of condensed matter study. Further details of abstract format together with template files will be available at the wagga2007 website.

Conference Proceedings: Participants are invited to submit a manuscript for publication in the conference proceedings which will be peer-reviewed and published electronically on the website of the Australian Institute of Physics.

Dates: Second and Final Notice: distributed 27th October 2006
Registration deadline (with payment): 8th December 2006
Abstract submission deadline: 8th December 2006
Formal notification of acceptance of
oral/poster presentations: 12th January 2007
Manuscript submission: 6th February 2007

***Further Information:* WWW:** *http://rses.anu.edu.au/em/Wagga07/index.html*
email: *wagga07@anu.edu.au*
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