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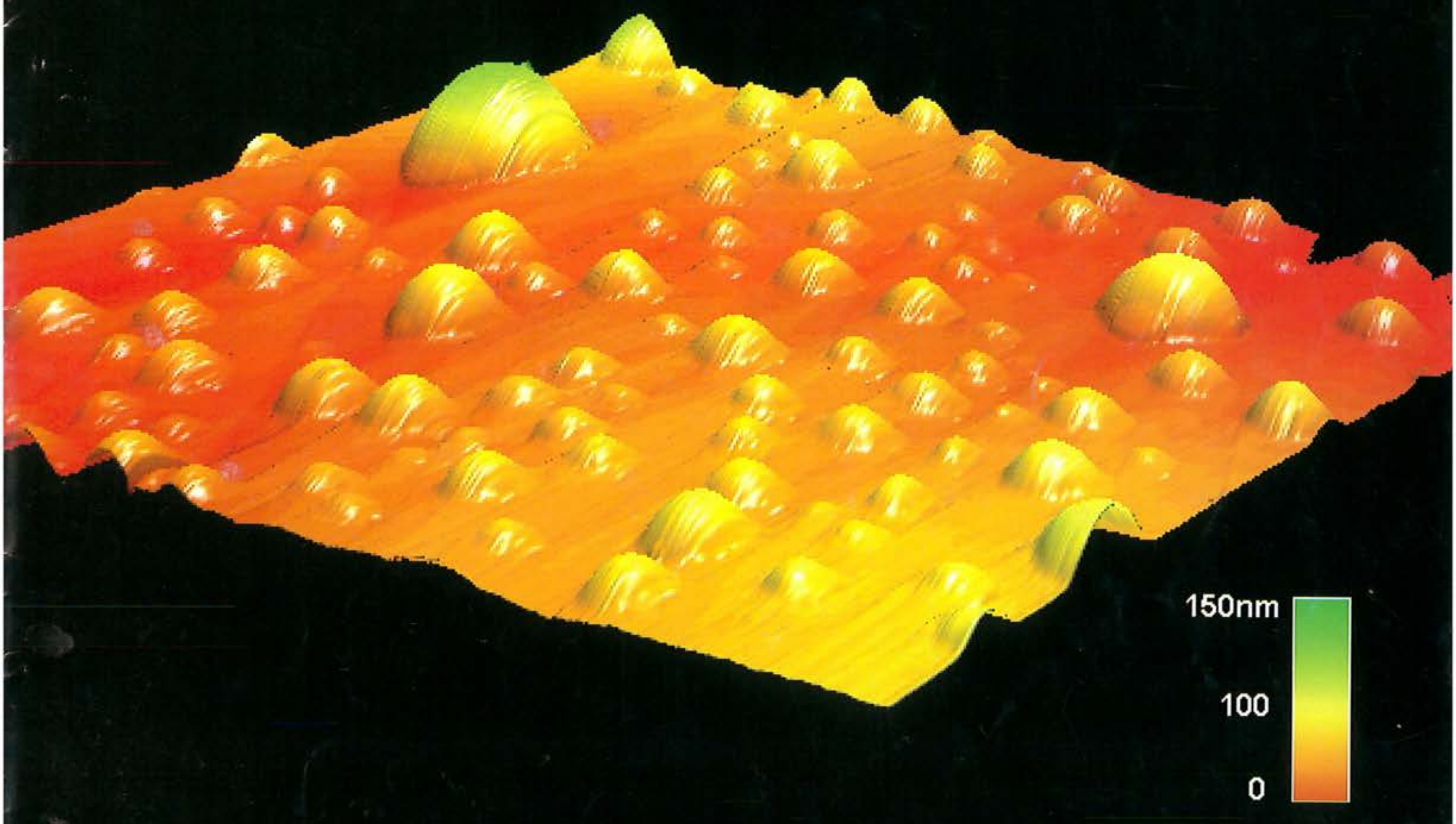
Promoting the role of physics in research, education, industry and the community

Nanobubbles: thin and slippery



Lightning and the pinch effect revisited

Life's nanotubes: a supercomputer view

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Contents

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Cover image: Nanobubbles of air at the boundary between graphite and water, imaged by atomic force microscopy. The picture is 12 micrometres square, and the bubbles are about 800 nm across and 12 nm high. The bubbles are almost flat, but are pictured here with an expanded vertical scale. See story page 7.

Image credit: Xuehua Zhang, University of Melbourne

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President's column – Does age matter?

***"A person who has not made his great contribution to science before the age of thirty will never do so."* Albert Einstein[1]**

Is science only a game for the young? Does this mean I, now in my 50th year, will never again make a useful contribution to science? Should we be loading up ARC grants and research projects with people in their twenties – if we are really serious about supporting research that will lead to major breakthroughs rather than just having incremental impacts?

The relationship between the age of scientists and their performance has been the subject of many studies over the last 50 years. In the recent Productivity Commission Research Report on Public Support for Science and Innovation,[2] released by the Australian Government last month, 10 of its 831 pages discussed this issue.

Different studies of scientific performance (which is itself a whole research field that asks what defines excellence, performance, and breakthroughs in science) have, beginning in 1953, used different measures to determine if age affects performance. As with all epidemiological studies, it is very difficult to identify a simple cause-and-effect relationship. A summary of findings are given below (these references give a few examples from specific studies). The earliest work by Lehman in 1953 showed that, with age, outstanding science contribution showed a peak in an individual's thirties and then slowly fell off[3]. Cole, however, after considering the quantity and quality of papers,[4] found no negative relationship with age. More recent research using a range of different measures, including citations,[5] indicated that scientists became less productive (based on specific measures) with age. The peak productive age seems to vary between the thirties and early fifties, depending on the study and hence the measures that were chosen to define performance.

Various reasons have been put forward to explain these findings. These include, for the physical sciences, the high rate of change of research methods and equipment which advantage young researchers, increased administration and managerial roles as scientists get older and work their way up the hierarchy, achievement of tenure, marriage, increased family responsibilities, and the different personality types ("seekers vs "finders") congregating in specific research fields.[6]

These studies did not look at who initiates the research directions of the productive and successful breakthroughs achieved by younger scientists, or who attracted the research funds to enable research to be undertaken. For example, older researchers will usually hand out their good ideas to younger staff to check out. One researcher, D.K. Simonton,[7] has taken these issues into account and found that, on average, scientists produce their first breakthrough in their 20's, another (and biggest) in their late 30's and early 40's, and then a final one in their 50's.

However in the last 10 years, we have seen the aging of the work force, with many people working longer, sometimes well into their 70's, by either working as honorary fellows or not retiring (note: since 2002 there has been no declared retirement age).

So does age matter?

When we look at the Australian physical and natural science work force in 2005,[2] about 10% are under 30, about 60% between 30 and 49, and 30% are over 50. That is, a smaller share of workers are under 30 years of age and a greater share are over 50, and the work force is rapidly aging. However, if you look at the age distribution in government research laboratories and physics university departments, you will see the following: the larger Go8 physics departments have a younger staffing profile (i.e. less than half of their work force over 44 years), while smaller university departments have 70–80% of their staff over 44. Some government research labs have about 60% of their physicists over the age of 44.

So if age does matter, we have not generally set up our work force to capitalise on the innovation and high productivity of early career scientists. Furthermore, as the Australian Productivity Commission report suggests, we need a greater number of scientists to make up for the reduced productivity with age to achieve the same "volume" of work[2] (p 251). There has been are no definitive study to determine the real cause – if it is real – for the reduction of productivity of our senior physicists in Australia. Also all these studies have focused on male scientists.

So should the AIP be doing anything about this? At the AIP Council meeting in February 2007 we determined our priorities for 2007, which included the following:

- Assist early and mid career scientists to achieve their potential and to develop clear career paths, both to assist existing physicists and to attract future physicists; and
- Capitalise on the wisdom, experience, and enthusiasm of our senior physicists, especially those over 50, who have much to offer, and assist them to boost their productivity – which is important for their personal satisfaction at work and to assist physics in Australia.

References

[1] Brodetsky (1942) *Nature*, 150, 699

[2] http://www.pc.gov.au/study/science/finalreport/index.html

[3] Lehman (1953) *Age and Achievement*, Princeton University Press, Princeton

[4] Cole (1979) *American Journal of Sociology*, 84, 958

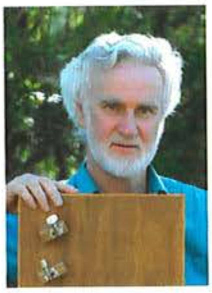
[5] Levin and Stephan (1991) *The American Economic Review*, 81, 114; Bhattachsarya and Smyth (2003) *Economic Papers*, 22, 30

[6] Kanazawa (2003) *Journal of Research in Personality*, 37, 257

[7] Simonton (1999) *International Journal of Aging and Human Development*, 29, 23

continued on page 11

Guest editorial



The realm between physics and biology

Simply put, physics is the study of matter, and biology is the study of living things. What do they have in common, and where can a synthesis of both – biophysics – hope to lead us?

Neither fish nor fowl, I'm a practitioner of such a hybrid discipline, training first in physics and moving into biology. As guest editor for this issue I thought it might be useful to set out a brief map of the territory.

We have always known there is something special about living things. In the nineteenth century this difference gave rise to 'vitalism' – the notion that life embodies a particular essence, a vital ingredient of some kind. At the same time, the century saw the rise of materialism, the 'natural philosophy' we now call physics. The success of the latter encouraged expansion of its domain. Tentatively at first, science began to encompass the living, boldly claiming that the same physical principles that govern the planets and billiard balls underlie the inner workings of plants and animals.

It was Helmholtz, arguably the century's greatest physicist (or biophysicist, for he made notable contributions to both physics and medicine) who first put the energy of matter and the metabolic energy of animals on the same theoretical footing. He had difficulty getting his ideas accepted, or even published, so he published it himself as a pamphlet (shades of today's internet). But in the end his physicalism triumphed, vitalism got a bad philosophical name, and biology ended up playing second fiddle.

Excitingly, the ground has now shifted. Modern physics is now not so much committed to solid matter as it is to quantum fields and patterns and non-locality. For me, one attractive interpretation, put by Roger Penrose and others, is that physics provides a central role for a key biological entity – consciousness – in collapsing the wave function. Although not mainstream, this view confirms our long-felt intuition that life is special; the common thread of consciousness is a distinguishing characteristic shown by all animal life.

And so, in a sense, vitalism has staged a return. We still don't know what consciousness is, but it is now taken seriously in physics, and is starting to become a respectable subject of research in biology after long being banished. Under the behaviourists, consciousness was a word that dare not be uttered, but now whole journals are devoted to its study, elucidation, and speculation.

Physics has led the way, but biology is stirring. It makes sense that the study of life must include the study of consciousness, for ultimately consciousness is our most distinguishing and valuable possession, and an increasing number of scientists are beginning to see that all animals possess that magic spark too.

It opens a whole new can of worms, of course, and the synthesis isn't easy. How can biology and physics talk the same language and make sense of it all? That's an enormous challenge, on the same scale perhaps as the quantum revolution. There's a big metaphysical gap between the brain and the mind, but ignoring the gap won't make it go away. Tackling the nature of consciousness is something that both physics and biology need to address. It makes for exciting science, and I sense a paradigm shift awaiting.

Andrew Bell

Deadline for next issue: 15th June 2007

Submission guidelines

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

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

Letters

Press article on global warming

A topical article by Professor Jamieson entitled "Power to make a difference in a world hit by climate change" was published last year in *The Canberra Times* (Oct 30, p 5).

The article identified the author as president of the Australian Institute of Physics and referred readers to the AIP website, potentially leaving readers with the impression that the article had the imprimatur of the AIP. It concluded unequivocally that *"only nuclear power can deliver the power we need to run our civilization without greenhouse emissions today."*

We are all aware of the strong and persistent negative public attitudes towards nuclear technologies, myself probably more so, as I am an adviser on science and technology policy to an Australian parliamentary party. It was therefore with surprise and misgivings that I noticed the absence of any statement to the effect that the views expressed in the article were those of the author, not the AIP.

Unlike Engineers Australia (IEAust), the AIP apparently has no mechanism whereby its president – informed and empowered by expert panels, member-only workshops, and surveys of members – can make public statements or submissions on important issues, for example to the Uranium Mining, Processing and Nuclear Energy Review. Nor do we appear to have a professional Code of Ethics to guide us and our office-holders in making statements to the media.

What a pity! As a learned society of professional physicists we should surely be contributing our individual and collective expertise to the public global warming debate, involving as it does complex economic, social, and technological issues.

As a former researcher and author in the field of wind-power systems, I know of the practical limits to the penetration of renewables into the electricity grid. However, to imply that nuclear power is the only solution to the planetary greenhouse problem is to ignore renewables and solutions such as energy efficiency, clean coal, carbon sequestration, and carbon taxes; it also probably ignores the views of many members of the Australian Institute of Physics.

Paul Edwards
Emeritus Professor of Electronic Engineering & Applied Physics
University of Canberra

Reply

Edwards raises three issues concerning my article in the *Canberra Times*: the first on ethics of presenting an opinion, the second on mechanisms by which the AIP makes submissions, and the third on the content of the article.

With regard to the first issue: the piece was clearly designated in the *Canberra Times* as an opinion piece, so further disclaimers are unnecessary. It was important to state my AIP affiliation since not all opinions on issues that involve physics are equally valuable. In fact the debate over the generation of electric power is notable for the extravagant claims made with complete disregard for physical laws.

As to the second issue: the mechanisms whereby the AIP makes submissions are managed by the Executive, with reference to co-opted expert reviewers. A list of these submissions was included in the President's report to the AIP Council meeting. Contrary to the claim made by Edwards, the AIP does have a statement of ethics and this is posted on our web site.

With regard to the third issue, I stand by my view that nuclear power is the only alternative that is presently available. Carbon sequestration and other proposed alternatives remain in the domain of research, not application.

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AIP news

Summary of Executive Meeting E267 held Tuesday 20 March 2007

Productivity Commission report
The Productivity Commission report is of considerable interest to many AIP members. A summary of the report is to be prepared and placed on the web site.

Reviews by FASTS
FASTS has produced reviews on the reports on higher education, school science, and the Bureau of Meteorology. Because of their interest, the possibility of publishing these in Australian Physics is to be investigated.

Professional remuneration survey
Professional scientists have been asked to participate in the professional remuneration survey. A link to the survey has been placed on the web site.

Australian Physics
The editor has advised that, owing to increasing work commitments, she will be unable to continue as editor. The executive will work on producing the next issue while broader issues relating to the publication of *Australian Physics* are being investigated.

Branch budgeting
The guidelines for branch budgeting are not clear. There is considerable variation in the various states on the way in which budgets are expended. Consideration is being given to developing a policy on branch budgeting to clarify the process and to identify budget items that will be supported.

Archiving
There is no system in place for archiving materials. The possibility of having a place on the web site for the archiving of documents is to be investigated.
Outstanding service to physics award
A call is to be made for nominations for the outstanding service to physics award.

Number of physics students
Feedback from university physics departments has been that the number of students enrolling in physics courses is increasing. Enrolment numbers are to be collected to ascertain actual numbers, to be used as the basis for a press release.

IoP subscriptions
Some members have experienced difficulty in renewing their IoP subscription. Effort has been put into this in the past couple of years to simplify the process and reduce the number of administrative steps involved. An article outlining the present process is to be prepared for publication in *Australian Physics*.

Research Quality Framework
Some university physics departments needed assistance to fill out RQF submissions. A working party has been put together to produce a template that would be useful to them.

Science policy
The current science policy document has separate sections on the environment and the public. These will be rolled together to make a more coherent policy. It was noted that the Greens party in NSW had a policy to ban the use of nanoparticles in sunscreens. This issue is to be followed up with the Greens.

Science expenditure
It was noted that, although the amount of funding on science has been increasing, it has not even kept pace with inflation. Funding for the earth sciences has plummeted, whereas the amount spent on health and social sciences has increased substantially. An analysis of the figures is to be carried out so that they can be put into perspective.

Visits by prominent physicists
It was noted that Roger Penrose and Kip Thorne were contemplating visits to Australia. Information will be distributed as it comes to hand, and public lectures will be organised where possible.

Next meeting: Meeting E268 is scheduled for June 7.

Summary of Council Meeting C59 held 19–20 February 2007

Historical sites
The AIP is considering the possibility of placing plaques at sites of significant scientific historical interest. Such sites need to be identified and a register drawn up.

Increasing number of physics students
There have been reports that the number of students in university physics courses is increasing. Because of the importance of physics in so many disciplines, this was a matter of national interest, and the AIP intends to continue publicising physics courses and opportunities in physics, to counter the public perception that physics is an excessively difficult discipline and to emphasise that there are jobs for physics graduates. This is also an issue with guidance counsellors.

Square kilometre array
The WA government had approved the construction of a road through the site identified as the most suitable for locating the SKA. Initial approaches to the government had not been successful in getting this decision rescinded; however, the government has now reserved an alternative site, and has given a commitment to keep the site radio quiet.

DSTO Scholarships
Applications for the DSTO scholarships have been of a very high standard. Winners from the previous year have obtained excellent results in their courses.

Membership
AIP membership has been declining. It was noted that many of those who had taken up membership through discount or special membership schemes have not been renewing their memberships.

Australian Physics
Notice was given that significant changes in the editorship and publication of *Australian Physics* were being considered. A considerable amount of work needs to be done before any changes can be implemented.

2008 Congress, Adelaide
The planning for the 2008 Congress is proceeding. Prof R. Clay has been appointed chairman of the organising committee. One of the important considerations was the publication of papers presented at the Congress.

National physics curriculum
Proposals have been made by the federal government concerning the development of national curricula. This will be followed up and the education convener will be asked to take this on as one of his primary tasks.

Groups
The present AIP structure does not allow for funding of groups in the same manner as applied to branches. It was recognised that groups play an important role in the AIP. The executive has been empowered to approve funding for specific group activities supporting the aims and objectives of the AIP.

Shortage of medical physicists
The ACPSEM informed Council that

Continued on page 15

Nanobubbles: thin and slippery

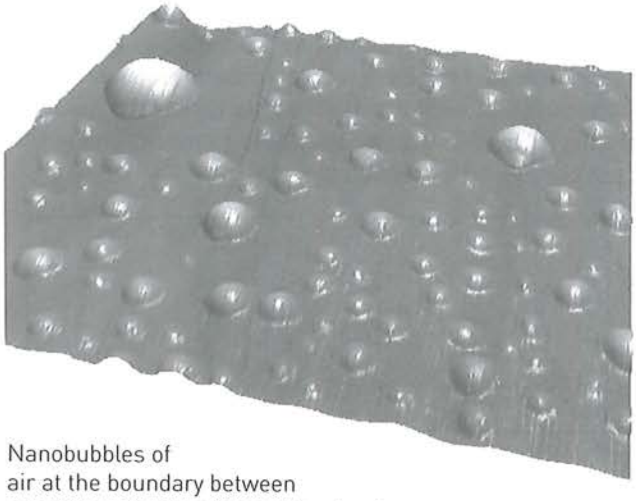
Nanobubbles – tiny air pockets less than one micrometer across – lurk at water-solid boundaries, as the striking image on our cover demonstrates. Surface scientists have been debating for decades whether they might exist, and a concerted, multipronged search for them by William Ducker and his colleagues at Melbourne University has finally collected the solid evidence needed.

Using infrared spectroscopy, atomic force microscopy, and surface plasmon resonance, Ducker's team has found not only that nanobubbles are real, but that they are also long-lasting, with life-times measured in hours to days. Curiously, the bubbles are not hemispherical, but almost flat – typically only about 12 nm thick – and have internal pressure close to one atmosphere.

Ducker believes that short-range van der Waals forces, or other attractive forces, squeeze a bubble down to make it flat. This low profile allows for a small contact angle (much lower than with a macroscopic bubble) and provides a generally low radius of curvature, meaning low internal pressure. The low profile of the bubbles (their height in the images is exaggerated by the expanded vertical scale) explains why they have been so hard to detect.

Previous researchers (typically using atomic force microscopy in a tapping mode) have found suggestions of gas or other discontinuity at surfaces, but the identity of such blobs was obscure. The existence of these bubbles was originally proposed by Phil Attard in 1994 and images were produced by Attard's group in 2002. The "nanolumps", as Ducker calls them, could have been contamination, which has sometimes proven to be the case, as work by Vince Craig and colleagues at ANU has shown. Alternatively, it is possible that the AFM's tapping (at 10–50 kHz) might generate or distort the bubbles. Later, both Hu's group in China and Ralston's group at the University of South Australia produced similar images. It became crucially important to check whether the lumps were actually in the gas state, and this is what Ducker and colleagues have now done with their suite of techniques.

The Melbourne team has used high-resolution infrared spectroscopy (in a mode allowing up to 50 total internal reflections to occur) and optical plasmon resonance to prove that the material seen at the surface by atomic force microscopy was indeed a gas, not contamination or an artifact. Their work was published in the 30 March issue of *Physical Review Letters*.



Nanobubbles of air at the boundary between graphite and water, imaged by atomic force microscopy. The picture is 12 micrometres square, and the bubbles are about 800 nm across and 12 nm high. The bubbles are almost flat, but are pictured here with an expanded vertical scale.

Slip or no-slip?

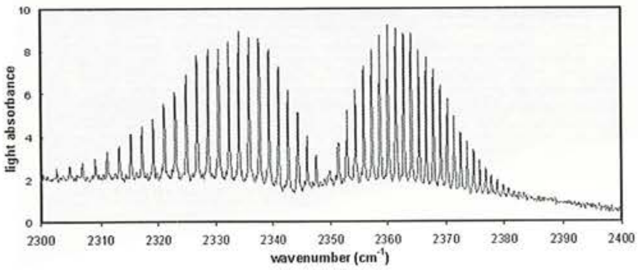
What happens at the interface between water and hydrophobic solids is a contentious subject that has been debated for decades. Whether air bubbles form or not is important because of its implications for the energy cost of pumping liquids though pipes or forcing boat hulls through water. Air has low viscosity, so the presence of bubbles on the solid would make the boundary far more slippery than it otherwise would be, potentially lowering energy costs.

The presence of adsorbed bubbles explains some of the published measurements of large "slip lengths" at hydrophobic surfaces. Such data has been used to suggest that the widely accepted "no slip" assumption of fluid dynamics at solid-liquid interfaces might be wrong. The presence of a low-viscosity gas layer would permit liquid to slide over the solid with much less drag, producing the same effect as slip but by a different mechanism. The analogy is often made to water droplets sliding easily over a lotus leaf because of an air film trapped at the leaf's waxy surface.

The implication of being able to turn on a "lotus leaf effect" in pipelines or on boat hulls is potentially enormous, and many researchers are on the trail. The Melbourne work opens the way for directly experimenting with these elusive but important gaseous lubricants.

Ducker and his team are at the Department of Chemical and Biomolecular Engineering at the University of Melbourne, and the recent PRL paper was a collaboration involving Xuehua Zhang and Abbas Khan. Their work has investigated carbon dioxide bubbles as well as air, and surfaces as diverse as

gold, graphite, and silicon, with similar results. The advantage of using carbon dioxide is that, in gas form, its molecules produce a tell-tale rotational spectrum – unambigous evidence that the surface blobs seen by atomic force microscopy are really gaseous, and in this case composed of carbon dioxide.



The tell-tale infrared spectrum. The rotational bands give unambiguous evidence that in this experiment the nanobubbles contain carbon dioxide gas.

In a complementary approach, surface plasmon resonance was used to show that the nanolumps contained only a low density material, which is consistent with a gas. Surface plasmon resonance measures the refractive index of a film from the reflectivity of light from an interface. Conclusively, after the nanolumps were generated on gold film, the reflectivity changed in a way consistent with a lower refractive index, and therefore consistent with a gas state on the solid.

Low pressure bubbles

The infrared technique was also able to give a direct measure of the average pressure in the nanobubbles, and the paper reports a value of 1.1 ± 0.4 atmospheres. This is consistent with the radius of curvature figures, derived from the AFM images, of about 4 μm. Satisfyingly, the corresponding pressure, calculated from the Laplace equation, is 1–1.7 atm.

Ducker makes the observation that the nanoscale gas state is an unusual one. A typical bubble 12 nm high and 800 nm across contains only about 40 000 molecules. The mean free path of a molecule is about 50 nm, longer than the height of a bubble, so most of the time molecules will bounce up and down between the upper and lower surfaces without colliding with other gas molecules. A majority of them will therefore be rattling up and down like a ping-pong ball caught between bat and table – except that in the molecular case the travel time is only 30 picoseconds.

Andrew Bell

Award: 'Outstanding Service to Physics in Australia'

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

There are many individuals within the profession who give great amounts of time and effort to the furtherance of physics as a discipline. While some of these would also be contenders for one or other of the research-oriented awards, others would not. They tend to be quiet achievers, sometimes more devoted to teaching and its development than to research.

The AIP has therefore inaugurated an award for 'Outstanding Service to Physics in Australia.' The award will recognise an exceptional contribution on the part of an individual. Nominations for the award may be made by a State Branch committee or by three members of the AIP. The nomination should be accompanied by a clear 1- or 2-page citation describing the outstanding service given by the nominee.

Nominations for the award will be called for in May or June of each year. The decision of the judging panel will be announced in November of each year. There will be no more than three awards nationwide in any one year and the selection committee, which will be appointed by the Executive, will reserve the right to make no awards in any one year.

There is no special nomination form. Nominations for the 2007 awards, with the accompanying citation, should reach the Honorary Secretary by Monday 21 May.

Ian Bailey,
Hon. Secretary.
Email: secretary@aip.org.au
or by post to
P.O. Box 16,
Willetton, WA 6955

A huge lightning strike, and discovery of the pinch effect

Brian James
School of Physics, University of Sydney

In 2005, the centenary of Einstein's golden year that was celebrated by the International Year of Physics, another centenary of local interest passed virtually unnoticed. In 1905 the Royal Society of New South Wales published an intriguing paper, 'Note on a Hollow Lightning Conductor Crushed by the Discharge' by J.A. Pollock, Professor of Physics at the University of Sydney and S.H. Barraclough, Lecturer in Mechanical Engineering at the same institution [1]. The paper is now acknowledged as giving the first explanation of the electromagnetic phenomenon now known as the pinch effect.

The lightning conductor referred to was installed on the chimney stack of the Hartley Vale Kerosene Refinery (near Lithgow, NSW). Following a lightning strike to it, a crushed tubular section was sent to Professor Pollock by Mr G.H. Clark, under whose supervision the lightning conductor had been erected. The tubular section, near the top of the conductor, joined a short solid rod attached to a ball (with one large spike at the top and four smaller radiating ones) to the main solid conductor to ground. The crushed conductor (see photo) remains in the School of Physics at the University of Sydney where it is regularly used in undergraduate lectures to exemplify the pinch effect.

The authors show that for a current I_0 in a thin tube of radius a, the inward acting force per unit area due to the magnetic force on the current-carrying conductor is given by (in SI notation)

$$\frac{\mu_0}{4\pi}\frac{I_0^2}{2\pi a^2} \qquad (1)$$

The derivation is straightforward. Assuming an axially symmetric conductor, the average magnetic field within the thin wall of the tube is readily calculated to be $\mu_0 i_0/4\pi a$, and from this the force per unit area on the tube directly follows.

The discussion is unsettling in one respect, however, in that it appears to ignore the vector nature of force. A solid conductor is considered first. Although it is noted that the magnetic 'forces at all points [are] directed radially inwards in planes at right angles to the axis of the cylinder', the first quantity derived is 'the sum of the mechanical forces acting throughout the matter contained in unit length of the cylinder'. To a modern student of physics this apparent sum of the magnitudes of forces acting in different directions is non-sensical. A little calculus indeed confirms that the quoted result (in SI notation)

$$\frac{\mu_0}{4\pi}\frac{4I_0^2}{3a} \qquad (2)$$

is, as suggested, the scalar sum of the magnitudes of the forces on unit length of a filament of infinitesimal cross-section.

The derivation is repeated for a tube of non-negligible thickness, from which the limiting case of a thin wall is obtained. The final result (equation 1), used for further analysis, is easily confirmed to be the radial inwards force per unit area on the wall of a thin tube. This is not surprising since, for the purposes of calculation, the problem may be approached by considering the tube to be split along its length and flattened out, in which case the vector nature of the problem becomes irrelevant.

The authors express this in terms of a relationship between the current I_0 and the equivalent external pressure increase that produces the same radial stress. Substituting the radius of the tube (a = 9.0 mm), the result is given (in SI units) as

$$I_0 \approx 2.2\times10^4\sqrt{n} \qquad (3)$$

where n is the equivalent excess external pressure (in atmospheres) which would produce the same radial stress in the copper

◀What several hundred thousand amps can do: the crushed Hartley Vale lightning rod. More than 100 years old, the 18-mm-diameter copper tube is still in possession of the School of Physics at Sydney University.

J.A. Pollack, FRS, 1865–1922, who was Professor of Physics at the University of Sydney from 1899 to 1922. (University of Sydney archives; date unknown)

tube.

The authors consider the possibility that for a brief lightning current pulse, skin effects may be present but are able to show that this would be negligible in the circumstances under consideration.

The main problem in determining the effect of this compressive stress on the copper tube is a lack of knowledge of temperature increases in the copper due to the current pulse, and how this would affect the compressive strength of the tube. The authors point out that while the tensile and elastic limits for copper are known, copper has no defined compressive strength. It does, however, have a well-established elastic limit in compression. The latter quantity is known to decrease with temperature, with measurements available (at the time) up to about 600°C, well short of the melting point of 1054°C. The authors were able to draw on extensive investigations of the external pressures necessary to produce collapse of tubes (needed for the design of boilers).

As an example, the authors calculate that if the temperature of the tube were 'as low as 500°C', the current required to collapse it would be about 100 000 A. From a detailed examination of the collapsed section of the tube, the authors believed that the tube was probably plastic at the time of collapse, a result of heating by the discharge. In this state they suggest that the tube 'gave way under forces equivalent to an excess pressure outside of the order of not more than an atmosphere; this would indicate a current of about 20,000 ampères...'

The possible range of current deduced, 20–100 kA, with a most probable value at the lower end of this range, is consistent with the knowledge of lightning discharges obtained from extensive studies later in the 20th century. In fact, statistics based on observations of many lightning discharges yield typical peak currents of ~30 kA, with only a few percent above 100 kA [2].

Following a talk I gave on the subject to the Royal Society of New South Wales in May 2006, Geoffrey Walsh [3] pointed out that a simple calculation – requiring only values for the density, resistivity, and specific heat of copper – shows that even for a current as high as 100 kA the predicted temperature rise would be less than 1 K for a typical return stroke duration of 50 μs. Even if there were multiple return stokes, the effect on the temperature of the copper would still be negligible. If we therefore assume that the copper remains at ambient temperature, rather than the 500°C assumed by Pollock and Barraclough, the compressive elastic limit of copper would be around 9 times larger than they assumed, leading to a current of around 300 kA. Lightning currents as large as 500 kA are rare, but not unknown. In the light of the discussion above, perhaps a more reasonable conclusion would be that the tube collapsed due to the pinch effect from an unusually large lightning strike, most likely involving a current of several hundred kiloamps.

S.H.E. Barraclough, 1871–1958, who was Lecturer in Mechanical Engineering at the time of the work described here. He was subsequently Professor of Mechanical Engineering, Dean of the Faculty of Engineering, and Fellow of the Senate of the University. (University of Sydney archives; date 1940s)

It is possible that the skin effect during current flow could produce surface heating, resulting in modification to the surface. A simple calculation suggests, however, that this would not be significant.

It is puzzling that the authors did not make a similar calculation, although it should be mentioned that their paper, at the beginning of the 20th century, pre-dated detailed experimental studies on lightning. They were thus not in a position to conclude that the current values they proposed were reasonable, and presumably had little information on the duration of the high-current component of a lightning discharge.

Pollock and Barraclough did not coin the term pinch effect. This occurred 2 years later in a paper by Northrup [4], which described the contraction of cross-section when a large alternating current flows in a liquid conductor. Northrup did not reference Pollock and Barraclough's paper (in fact, there is only one reference in Northrup's paper – to J.C. Maxwell!).

The most common textbook references to the pinch effect occur in plasma physics texts, where the earliest reference given is usually a 1934 paper by W.H. Bennett [5], which describes the magnetic self-focussing of a fast stream of electrons in a neutralising ion background. The magnetically pinched linear discharge (also called a z-pinch or Bennett pinch) was one of the first devices used in fusion research. The description of the MHD equilibrium of the linear pinch, and associated

Continued on page 30

Conference report – Wagga 2007

Affectionately referred to simply as "Wagga" by its regulars, the 31st Annual Condensed Matter and Materials Meeting was held at the Wagga Wagga campus of Charles Sturt University from 6–9 February, 2007.

The meeting has been held annually since 1977, but the broadening of its scope is reflected by name changes from "solid state physics meeting" and "condensed matter physics meeting" through to the current name. In line with this evolutionary process, the 2007 meeting welcomed the formal involvement of the Materials Division of the Royal Australian Chemical Institute (RACI). The AIP and the RACI now officially recognise each other as a "cognate society."

The 2007 meeting was organised by the ANU's College of Science: Ian Jackson (chair), Neil Manson, Matt Sellars, Tim Senden, Ying Chen, Darren Goossens, Ray Withers, Zbigniew Stachurski, John FitzGerald (publications editor), and Auke Barnhoorn, with invaluable administrative support from Kay Provins. As usual, it was a low-cost, informal conference (just $295 for full registration, meals, and air-conditioned accommodation) with heavy discounts for student participants and special opportunities for younger researchers to present their work and gain experience in chairing sessions.

In addition to funds provided from the reserve fund and the RACI Materials Division, the meeting was generously sponsored by AINSE, the ARC Australian Research Network for Advanced materials (ARNAM), and the Australian Synchrotron Research Program. Exhibitors included the Australian Synchrotron, JAVAC Pty Ltd, Micromaterials Ltd, AVT Services Pty Ltd, Scitek-Pfeiffer Australia Pty Ltd, and the Taylor & Francis group of publishers.

Some 105 individual contributions, dealing with a wide range of topics, were presented in 8 oral and 2 poster sessions. A successful innovation was that all 75 posters were displayed for the full duration of the meeting. Thirty-five manuscripts will be published in the proceedings, with each manuscript peer reviewed by two referees (and therefore qualifying as DEST 'E1' refereed conference publications). The Proceedings of the Condensed Matter and Materials Meeting will appear under "publications" on the national Australian Institute of Physics web site.

The oral program brought speakers from interstate – NSW (2), SA, Victoria (2), and WA – and had a strong international character with invited speakers from China, Germany, UK, and the US. Two invited talks informed us about the status of the OPAL research reactor and the Australian Synchrotron, two of Australia's most exciting research infrastructure developments. A topical conference dinner talk on solar energy was presented by the ANU's Prof Andrew Blakers.

The program involved many early career and student presenters. Excellence in presentation was encouraged and student prizes were awarded to A. Alexander, R. Barry, L. Li, and B. Saensunon for best posters and to N. Sharma and V. Peters for best oral presentations.

Two popular events were the tasting of the Charles Sturt University's wine and cheese products and a trivia night at which tables of eager participants vied for the "Lindsay Davis Cup". Such events would have been relished by Peter Fisher and Terry Sabine, two foundation Wagga participants who passed away in 2006. They will be remembered for their valuable contributions to Australian condensed matter and materials research, and to Wagga.

The next annual Condensed Matter and Materials Meeting will be held from 29 January to 1 February, 2008 at the regular venue and will this time be organised by people from the University of Sydney and the University of Technology, Sydney. Don't miss it!

Glen Stewart
School of Physical, Environmental and Mathematical Sciences
UNSW at ADFA, Canberra

President's column

continued from page 3

Thank you for our past executive

Since the last edition of *Australian Physics*, the AIP has held its AGM and elected a new executive for the next 2 years. I would like to acknowledge and thank the members of the past executive who have completed their term.

David Jamieson (now the Immediate Past President for the next 2 years) has been a dynamic and hard-working leader of the AIP who made physics outreach a successful and major role for the institute. David has worked tirelessly over his 4 years on the executive and I am sure will continue to do so.

Peter Johnston was Registrar for 6 years; during that time he led the Accreditation Program, implemented a new membership data base, and provided much wisdom and good sense to the executive.

Rob Elliman completed his terms as Vice President, President, and Immediate Past President; over this time Rob led the AIP to become a modern and professionally run organisation, along the way updating the constitution, simplifying the membership levels, and now working as our web master to make the AIP website a major membership benefit.

Finally, thank you to Scott Martin who was the Honorary Treasurer for the last 2 years. Scott is still on the executive to assist with special projects. As Treasurer he made the finances more systematic and moved the AIP towards electronic financial transactions.

Cathy Foley
AIP President

Electron band theory loses Geoffrey Fletcher

Geoffrey Fletcher, known to Australian physicists for his work on electron band theory, passed away on 11 November 2006.

Born on 26 March 1922 in England, Geoff's early education was at Christ's Hospital, Sussex, and Upper Latymer Secondary School in London. After a period in the public service, he was called up by the RAF in 1941. He trained in Rhodesia as a navigator, and was posted to Bomber Command's colloquially named 'Ghost Squadron', so called since its crew were frequently shot down). Indeed, a fortnight after his 21st birthday, Geoff was shot down over Germany and sent to Stalag Luft 3, the PoW camp that is widely remembered as the scene of the "Great Escape" and where Geoff spent much time crafting wood for the escape tunnel. Fortunately for the advancement of electron band theory, his number did not come up even when the tunnel was discovered by his captors.

Following the end of the war and Geoff's repatriation, he entered Imperial College, London, and graduated BSc with 1st class honours in physics (1948) and mathematics (1949). His DIC (in mathematics) followed in 1950, after which he undertook post-graduate research in solid state theory, initially at Imperial College and later at Exeter University College where, as an assistant lecturer, he received his PhD in 1953. He remained on the staff at Exeter as a lecturer in applied mathematics until 1957. Then, having married Jeanne, he emigrated to Australia to take up a senior lectureship in applied mathematics at the University of Sydney.

He remained there for 8 years, forming close links with colleagues in the CSIRO National Measurement Laboratory, at that time located in the grounds of Sydney University. He also spent a period with the Westinghouse Electric Corporation in Pittsburgh undertaking experimental research on silicon carbide.

In 1965, he was appointed senior lecturer in the Department of Physics at Monash University. He lectured across a broad range of undergraduate physics and continued his research on electrons in solids. He is best remembered for his fruitful interactions with experimentalists, as reflected in some of his 27 peer-reviewed publications. Among these is one now cited 180 times – a classic paper on the band structure of nickel (*Proc. Physical Soc. London,* A65 (1952), 192). During his years at Monash, he also published his highly regarded book, *The Electron Band Theory of Solids* (North Holland, 1971).

In 1992, shortly after his 70th birthday, Geoff was honoured by his Australian colleagues through a Festschrift called "Electrons in Solids: the 1990s and beyond", papers from which were subsequently published in the *Australian Journal of Physics* (*AJP* 46 (1993) 597–728). The contents of this issue reflect the breadth of Geoff Fletcher's lifelong research on the influence of electron energies on the physical properties of solids, and evidenced too by his own publications on band structure calculations for nickel, iron, manganese, rhodium, gold, and complex alloys such as Ni_3Al, Co_3Ga, and Co_3MnGa.

Thoroughly a gentleman and scholar, Geoff is also remembered with affection for being a real character. A former Monash postgraduate student, recalling Geoff's years at Monash and the period's Departmental research seminars, remarked most kindly, "I never ceased to be amazed at Geoff's ability to sleep through a large part of a seminar and then to wake up in time to ask very challenging and relevant questions at the end."

Following his early retirement in 1983, high temperature superconductivity in ceramic materials was discovered. Geoff duly came out of retirement and retyped his old punch-card programs in order to calculate electron bands for colleagues in CSIRO at Clayton, who were working on high-T_c superconductivity. For this I believe he received not a cent in remuneration – a far cry from corporate conditions today!

To the best of my knowledge, Geoff retired early to pursue some of his other passions in life, one of which was the performance of Gilbert & Sullivan. As well as being an enthusiastic singer, particularly of G&S, he was keen to apply his experimental woodworking skills to the construction of props, essential for any quality production of G&S to the paying public.

Geoff is survived by Jeanne, his wife of 53 years, his two daughters, Joanne and Rebecca, and seven grandchildren.

Trevor Finlayson
School of Physics
Monash University

The caricature shows Geoffrey Fletcher as he was in 1978 when an academic at Monash.

(Reproduced by permission of Sue Alward.)

Conferences

2007

June 12 - 13
Nanopolymers 2007
Berlin, Germany
www.rapra.net/products_and_services/Conferences/Nano_Conference_2007.asp

Jun 18 – 20
Photovoltaics Summit
Long Beach, CA

Jun 24 – 27
6th International Conference on the Optical Internet (COIN) and 32nd Australian Conference on Optical Fibre Technology (ACOFT)
University of Melbourne
www.coinacoft2007.com.au

Jul 1 – 5
Astronomical Society of Australia Annual Scientific Meeting
Macquarie University
http://asa.astronomy.org.sa/asm.html

July 8 - 13 ,
18th International Conference on General Relativity and Gravitation & 7th Edoardo Amaldi Conference
Sydney, Australia
www.grg18.com/

July 4 - 6
Materials and Austceram 2007
Sydney, Australia
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/

Aug 5 – 9
Microscopy & Microanalysis Meeting
Ft Lauderdale, FL
http://mm2007.microscopy.org

Aug 13 – 17
9th International Conference on Biology and Synchrotron Radiation
Texas, USA
www.srs.ac.uk/bsr2007

Sep 3 – 7
Trends in Nanotechnology
San Sebastian, Spain

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

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

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

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

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

2008

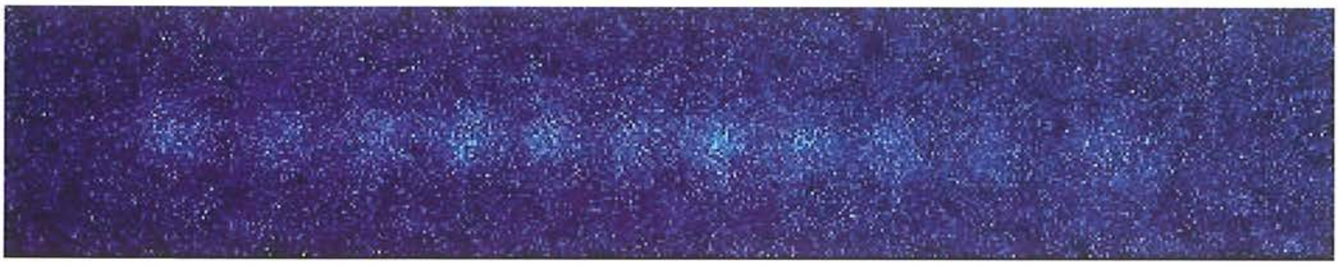
Jan 29 – Feb 1
32nd Annual Condensed Matter & Materials Meeting
Charles Sturt University, Wagga Wagga, NSW

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

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

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



News

Red Square nebula through adaptive optics

An international team led by Sydney University astronomer Professor Peter Tuthill has found a new member in the pantheon of exotically beautiful celestial objects.

Images of the bipolar nebula christened "The Red Square" show startlingly symmetrical and complex details of form.

An article announcing the find appears in the most recent issue of the journal *Science*, co-authored by Professor Tuthill and James Lloyd of Cornell University.

"Discoveries as beautiful – and interesting – as this one don't come around very often in astronomy," said Tuthill, "and it took some of the world's most advanced telescopes, together with a good dose of luck, to find this jewel hidden among the myriad stars in the galaxy.

"The key to finding it was in the revolutionary new imaging technology of Adaptive Optics, which acts like a myopia cure for a telescope," said Lloyd. "Startlingly clear images capable of revealing objects like this are now possible."

The pair was studying a hot star called MWC 922 in the constellation Serpens. Their images combine data from the Mt Palomar Hale telescope and the Keck-2 telescope taken in near-infrared light (1.6 μm), and show a region 30.8 arc-seconds on a side around MWC 922. As the outer periphery of the nebula is very faint compared to the core, the image has been processed and sharpened to display the full panoply of detail and structure.

University of Sydney media release

Photonic chips are looking up

Researchers at the Centre of Excellence for Ultrahigh-bandwidth devices for Optical Systems (CUDOS) have developed a photonic chip capable of replacing the electronic racks responsible for regenerating optical signals. The chip can analyse the light, store and slow it down, regenerate it and switch it, all without electronics.

"Ultimately we are pursuing a device that would remove the need to convert light to electronic signals and back, be the size of a thumbnail, cost a fraction of a router, and consume very little power," said Professor Ben Eggleton, director of CUDOS at the University of Sydney and an ARC Federation Fellow in the School of Physics.

In current optical fibre systems, signals transmitted via optical fibres must pass through racks of electronics in order to regenerate, buffer and switch that signal. This creates a bottleneck of information as light signals are converted to electronic signals and back again. "Because regeneration won't rely on electronics, it's much faster," he added.

CUDOS has identified and started working with at least three different end-users and has started to apply the photonic chip to applications outside traditional telecommunications. These include the next generation optical communications systems, advanced defence communications and a range of mid-infrared sensing applications, including astronomy.

The Red Square nebula. The key to the finding was using adaptive optics, which acts like a myopia cure for a telescope.

Fibre optics is the backbone of the telecommunications industry, the technology behind the internet revolution. But although the next generation of optical telecommunications networks promises greatly increased bandwidth, it also requires novel components for signal processing that are beyond the scope of today's electronics.

At CUDOS researchers are looking to develop a new all-optical signal processing device that would allow hundred-fold increases in the rate at which information is transmitted. The centre has recently received an injection of $7.5 million in Australian Research Council funding, which will allow its work in photonics to continue for another 3 years.

The research at CUDOS will be organised as six major projects, utilising expertise in microphotonic and nonlinear photonics, with 12 new partner investigators from Australian industry, defence and research institutions, as well as international partners from Europe, the USA and Asia–Pacific.

Based in the School of Physics, CUDOS involves researchers from Sydney

News

University, the Australian National University, Macquarie University, Swinburne University of Technology and the University of Technology, Sydney. From 2008 RMIT University will join the collaboration.

University of Sydney media release

Bright outlook for solar technology

The University of NSW has signed three new agreements to supply photovoltaic technology with Asian solar cell manufacturers. One of these was with Suntech Power, the NYSE-listed solar cell company formed by a UNSW graduate. The other two deals were with E-Ton Solar Tech Co in Taiwan and CEEG Nanjing PV Tech in China.

The $1.7million licensing agreement with E-Ton Solar Tech includes a collaborative research program to develop two of UNSW's latest high efficiency solar cell technologies for commercial production. E-Ton is a rapidly growing solar cell manufacturer specialising in high performance products. By combining their existing technology with UNSW's research they hope to ensure they stay at the cutting edge of solar cell manufacture.

The second deal is a $1.4 million licensing agreement with CEEG Nanjing PV Tech in China. This agreement includes a collaborative research program to adapt UNSW's world-record holding PERL solar cell technology to suit large-scale commercial production.

The third deal with Suntech is a research agreement that focuses on developing an innovative way of forming metal contacts to improve solar cell efficiency. This deal follows the successful development of Semiconductor Finger Solar Cell technology which came out of previous collaborative research between UNSW and Suntech.

The Chinese Government expects that by 2020 renewable energy will account for 16% of the country's total energy supply. Once its Renewable Energy Law came into effect in February 2005, the race was on among solar cell manufacturers to see who could make the most efficient and cost-effective products.

In finding the world's best technology these manufacturers came to the UNSW's ARC Photovoltaic Centre of Excellence, a world-leading group working under the directorship of Professor Stuart Wenham.

The ARC Photovoltaic Centre of Excellence has collaborative research work also taking place in Japan and Korea, and the technologies these companies produce is sold in products throughout the world. The group are also developing R&D capacity in Singapore with the support of the Singapore Government.

UNSW media release

Parts for a quantum computer

Trapped ions are currently the leading technology for quantum computing experiments. This requires laser cooling ions to form a linear 'crystal' such that each ion can be individually resolved optically (see image below). This has been achieved in only a handful of labs around the world, and has now been done in Australia for the first time in the ion trap quantum computing laboratory of Dr David Kielpinski in the Centre for Quantum Dynamics at Griffith University.

A linear crystal of 10 trapped ytterbium ions.

The team that realised this accomplishment also includes Dr Erik Streed and Mr Geoff Genn. Small ion crystals form the starting point for trapped ion quantum computing experiments, as each ion can acts as a qubit, that is, storage for one bit of quantum information.

In the experiment, singly charged ytteribium ions were confined electrically in a linear RF Paul trap and cooled with a frequency-stabilised UV diode laser operating at 369.5 nm. The ions crystallise into localized positions when the Coulomb repulsion energy between individual ions is greater then the thermally driven kinetic energy. Notable aspects of this experiment include operation of the shortest wavelength laser diode (used for direct laser cooling), and frequency stabilisation to the ion absorption signal from a hollow cathode discharge lamp.

Howard Wiseman / Griffith University

AIP news – continued from page 6

there was a shortage of medical physicists and the situation was projected to get worse. The federal government has put forward an initiative for the accreditation of medical physicists. This is an issue that can be taken up by the universities.

International Commission on Optics meeting

There was to be an International Commission on Optics meeting at Darling Harbour later in the year. This meeting is to be held in conjunction with the general relativity and gravitation meeting.

Underwriting of AIP Congresses

It was resolved that the chairman of the congress committee was to be a member of the AIP, unless there were exceptional circumstances.

FASTS

The AIP is a primary member of FASTS and is central to its organisation. FASTS has an important lobbying and informational role. It is difficult to obtain support from politicians, and fewer politicians are choosing to participate in Science Meets Parliament.

AIP priorities

The meeting drew up a list of AIP priorities. These were to be followed up by the executive.

Media liaison

The AIP has engaged a public company to provide media liaison services. Council supported the continuation of the contract with Science In Public, subject to budget constraints.

Web site

Consideration is being given to a common hosting for the national and state branch web sites.

Research Quality Framework

It was recognised that the completion of RQF documents provided considerable difficulty, especially for smaller departments. The executive has been asked to develop a template for the drawing up of RQF submissions.

Ian Bailey, Hon secretary

Bionanotubes: the ultimate units of the physiology of life

Shin-Ho Chung
Research School of Biological Sciences, Australian National University

The cell membrane is the ultimate unit of the physiology of life. Its task is to confine ions and molecules on one side of the membrane and exchange them with others on the opposite side.

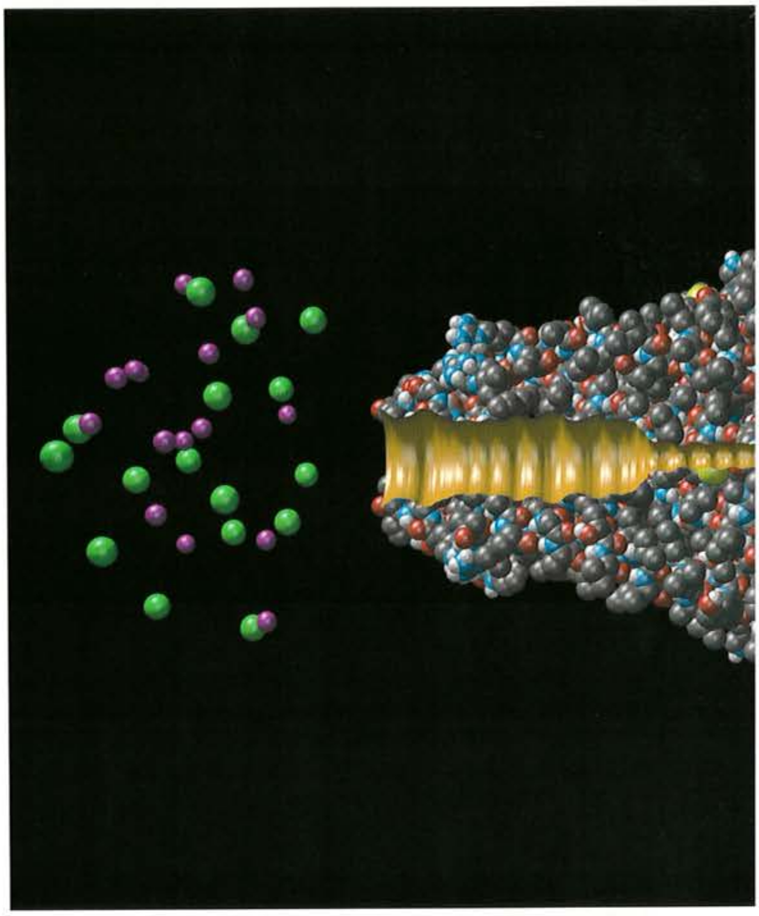
This delicate task of regulating the transport of ions across the membrane is carried out by biological nanotubes known as 'ion channels.' These channels are water-filled, angstrom-unit-sized pores formed by large protein molecules embedded in the cell membrane. They play crucial roles in the existence of living organisms. All electrical activity in the nervous system, including communication between cells and the effects of hormones and drugs, are regulated by the opening and closing of ion channels.

Because ion channels are elementary blocks of brain function, understanding their molecular workings represents a fundamental problem in biological physics. We now know that many inherited neurological, muscular, and renal disorders arise from the malfunctioning of ion channels. Among them are epilepsy, migraine, cystic fibrosis, and diabetes. Thus, elucidation of how ion channels work will ultimately help find the causes of, and potentially cures for, a wide range of inherited disorders.

In recent years, enormous strides have been made in our understanding of channels. These advances have come about by the combined efforts of experimental and computational biological physicists. In recent breakthroughs, the x-ray structures of several different types of ion channels have been determined. It is expected that crystal structures of many other ion channels will follow, ushering in a new era in ion channel research in which the main quest will be predicting the electrical function of channels from their atomic structures. Parallel to these landmark experimental findings, there have also been important advances in computational biophysics. Improved analytical methods have been matched by greater computational power, and theoretical models of ion permeation have become increasingly sophisticated.

We are now at the point where the atomic structure of an ion channel can be related to its function through the fundamental laws of physics governing electrolyte solutions. Macroscopically observable channel properties can be seen to emerge from simulations of the stochastic dynamics of aggregated molecules. Quantitative statements based on rigorous physical laws are replacing qualitative explanations of how ions permeate through the membrane's narrow pores.

Here at the Research School of Biological Sciences, we are making use of a powerful supercomputer to work out how ion channels operate. We are attempting to follow the motion of ions as they move through a channel, trying to understand how a channel can select only the correct type of ion to traverse it. How many ions can a single channel process per second, and how is the channel switched from closed to open?



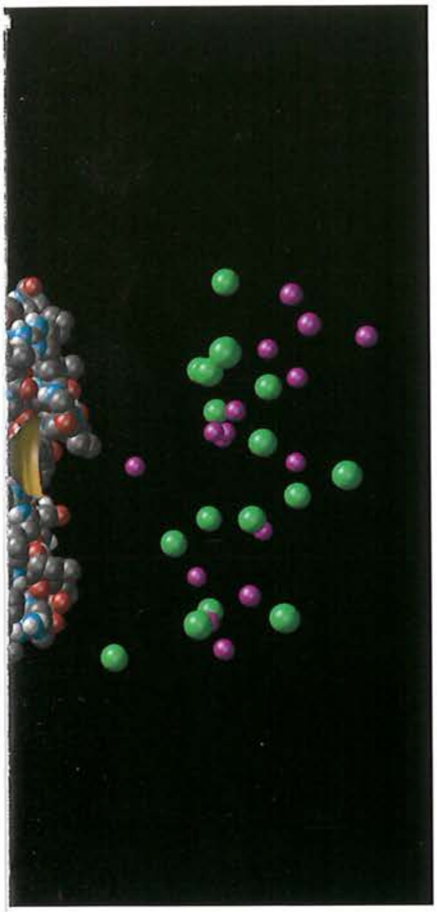
Structure of a potassium channel in a cell membrane, with the intracellular end to the left and the extracellular to the right. K^+ ions are shown as purple, and Cl^- ions as green. The narrowest segment of the conduit is known as the selectivity filter, and is only wide enough for water molecules and K^+ ions to form a single file. Dipoles formed from charged amino acid residues guard the inner and other channel gates.

In providing a comprehensive physical description of biological ion channels, theoretical biophysicists are using a judicious combination of molecular dynamics and stochastic dynamics. In classical molecular dynamics, trajectories of N particles – ions, water molecules and atoms forming the channel – interact via a many-body potential $U(\boldsymbol{r}_1, \boldsymbol{r}_2, \ldots, \boldsymbol{r}_N)$ and are followed using Newton's equation of motion,

$$m_i \frac{d^2\boldsymbol{r}_i}{dt^2} = -\nabla_i U(\boldsymbol{r}_1,\ldots,\boldsymbol{r}_N), \qquad i = 1, \ldots, N \qquad (1)$$

where m_i and r_i denote the mass and position of the i-th particle and where the force on it is given by the gradient of the potential U.

At every time-step, the potential function is recalculated using the new position of the particles and this determines their positions a short time later. This process is iterated over a large number of steps until a statistically satisfactory data set is generated. Although it is not tractable to simulate, through molecular dynamics, the current flowing across the model channel, we can use this technique to see how the ions and protein of the ion channel interact over small segments of the ion channel.



To compare measured channel conductances with those determined experimentally, we make use of Brownian dynamics. Here water molecules that form the bulk of the system are integrated out and only the ions themselves are explicitly simulated. The algorithm for performing Brownian dynamics simulations is conceptually simple. The position and velocity of each individual ion evolves according to a continuous-time stochastic dynamical system. The velocity of an ion with mass m and charge q located at a given position is determined by the force acting on it at time t. This velocity is computed by integrating the equation of motion, known as the Langevin equation:

$$m_i \frac{dv_i^{(i)}}{dt} = -m_i \gamma v_i + F_R + qE \qquad (2)$$

The first two terms on the right-hand side of the equation, the friction force and the random force, represent the effects of collisions with the surrounding water molecules. The last term denotes the total electric field arising from other ions, fixed charges in the protein, the membrane potential, and induced surface charges.

Together, these two computational tools play important roles in understanding ion channel permeation. They have proven to give a good picture of the relationships between the atomic structure of a channel and its experimentally measured properties. The figure shows the structure of an ion channel that selectively allows the passage of K^+ ions across the cell membrane. This is the first biological channel whose high-resolution x-ray structure has been determined.

The channel is composed of 396 amino acid residues, or 3504 atoms excluding polar hydrogens. Making use of this structural information, we have used Brownian dynamics to determine how ions permeate through the conduit formed by the protein wall. We have also able to calculate the currents flowing through the channel under various conditions.

Because many negatively charged residues line the ion-conducting pathway, an attractive potential well for K^+ ions is created. Two K^+ ions are attracted by the energy well and form a stable equilibrium. When a third ion enters the pore under the influence of the membrane potential, the equilibrium of the resident ions is disrupted and the outermost ion is expelled from the channel through a rapid multi-ion shuttling process within the narrow segment of the pore. The magnitude of the currents flowing through the model channel, which we calculate from our Brownian dynamics, are directly comparable to the physiological measurements, giving some indication of the reliability and predictive power of the method.

Molecular dynamics calculations also have uncovered important aspects of ion permeation through the K^+ channel. They have shown (i) how the properties of water and ions change when they enter narrow channels from bulk; (ii) the way in which small molecules and toxins interact with ions channels; and (iii) how the channel allows K^+ ions to pass across while preventing smaller Na^+ ions from entering the pore.

The calculations reveal that the energetic cost of dehydrating K^+ ions is repaid by ion–protein interactions, whereas these interactions are too weak to balance the cost of dehydrating Na^+ ions. Molecular dynamics also provides the numerical values of the parameters that can be used for coarse-grained simulation techniques, such as Brownian dynamics and Poisson–Nernst–Planck theory.

As we attempt to further understand membrane channels in terms of fundamental molecular physics, we are finding that there is an increasing interplay between experiment and theory, the former providing hints and clues for building and refining models and the latter making testable predictions.

Shin-Ho Chung is leader of the Computational Biophysics group at the ANU's Research School of Biological Sciences in Canberra. Email: shin-ho.chung@anu.edu.au.

Branch news

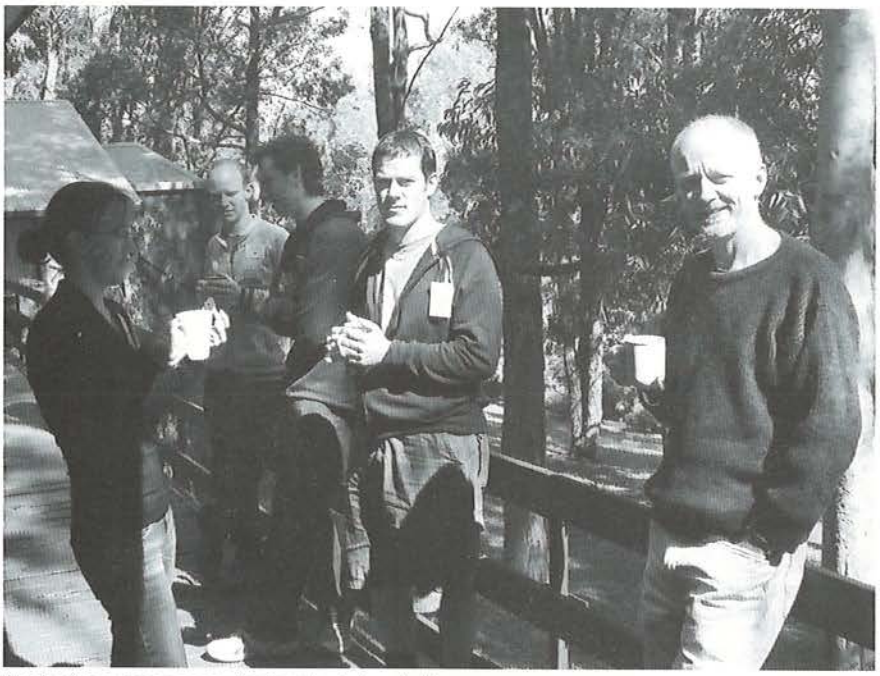
Western Australia

Jarrahdale postgraduate research conference

A long-standing tradition of our branch is to enthusiastically invite physics post-grads at all WA tertiary institutions to attend a biennial conference held somewhere outside the metropolitan area. The tradition started in 1987 with a conference at Yanchep National Park around 100 km north of Perth; however, for the last 15 years the conference has been mostly held at Jarrahdale in beautiful bushland around 100 km south of Perth, and this was the venue last year from 23–25 August.

Each of the cottages here has a pot-belly stove fired by jarrah (the wood that gives the town its name). The warmth is welcome, as it can get very cold at Jarrahdale in the depths of August.

The conference is intended to cultivate the students' ability to deliver their work in an interesting and comprehensible way. The idyllic and relatively isolated bush location engenders a relaxed and accepting atmosphere. The informal connections made between students late into the evening are also important.


A relaxing cuppa among the jarrah at Jarrahdale.

Bonding between individuals is enhanced by the setting, which calls for students to work with each other and with academics. Jobs are allocated at the professional level (convening sessions) and at the mundane (cleaning up after meals). A stout tradition is the formal dinner, which leads on to lively activities late into the night (followed by a call to rise at some incredibly early hour for talks the next morning). All good practice for future attendees of international conferences!

We had over 40 attendees and 22 students delivered presentations. I liked the savvy and appropriate use they made of technology, and the confident presentations would easily be at home in an international conference. The other wonderful thing was the broad range of subjects: we heard talks on lead isotopes in the Himalayas, magnetic susceptibility of blood cells, quantum field theory, Lorentz invariance tests, vibrating string magnetometry, and snapping shrimp noise. I also now know more about spin waves, radioastronomy, laser cooling, and positron physics.

We rewarded the best talks with prizes (kindly donated by Analytica International and Coherent Scientific). The winner was Karen Livesey who won a copy of Mathematica and joint membership of the AIP/IOP for her talk on 'Parametric excitation of spin waves in thin magnetic films'. Joint runners-up were Aman Chauhan (microwave measurements of oil and gas mixtures) and Paul Stanwix (Lorentz invariance tests with cryogenic resonators). Anne Dinh, Peter Metaxas, Tegan Rourke, and Sam Dawkins were given honourable mentions for clarity and interest.

I am sure the conference succeeds at increasing the interest of students in membership of the AIP, and at strengthening the bonds between students and staff. Jarrahdale generates a tangible air of excitement and camaraderie, and the students show improved confidence in oral presentation. We organise the event so that food, drink, and accommodation costs are largely met by the departments and the WA branch of the AIP, leaving only a small amount to be contributed by students. I recommend that other AIP branches hold similar events.

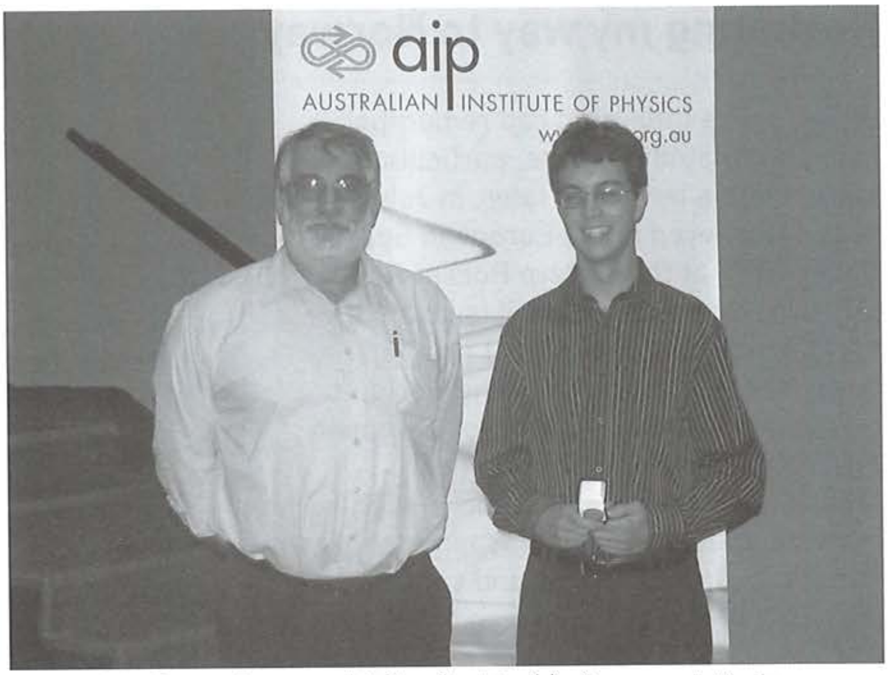
Andre Luiten
Physics Department
University of Western Australia

South Australia

The SA branch presented its Bronze Bragg medal to Glen Sneddon, the best student in the 2006 year-12 physics exam, at a ceremony on 15 February this year. The presentation was done by Dr Robert Loss, of Curtin University, who also handed certificates to 16 other students who had received 20/20. After the ceremony, Dr Loss then treated all of us to a public lecture on 'Out of Africa: a 2 billion year old nuclear reactor'. The lecture included a description of the natural reactors at Oklo in central Africa, as well as an introduction to nuclear power and the analysis of radioisotopes.

We learnt that the uranium isotopes found at Oklo strongly resemble those in the spent nuclear fuel rods of today's fission reactors. Perhaps nature had beaten us to the punch!

The following month, on 8 March, the branch held its annual student night. Three physics postgrads, each representing the three South Australian universities, gave a talk on their research. Clancy James from the University of Adelaide talked about simulating the radio-detection of UHE neutrino interactions in the Moon, Hong Ji from the University of South Australia conveyed how a fiber Bragg grating based optical touch trigger probe might be useful for down-scaled 3D coordinate measuring machines, and Jingxian Yu from Flinders University informed us about direct attachment of well-aligned single-walled carbon nanotube architectures to silicon (100) surfaces, describing a simple approach for device assembly. As well as members, the branch invites physics students to these talks, allowing young students to see something of what is involved in postgraduate research. Before the lectures, Silver Bragg medals, awarded to the best 3rd-year physics student in 2006 at each university, were presented to Samuel Stranks of the University of Adelaide and Nadine Pesor of Flinders University.



Winner of the Bronze Bragg medal, Glen Sneddon (r), after presentation by Dr Robert Loss of Curtin University.

Laurence Campbell
School of Chemistry, Physics, and Earth Sciences
Flinders University

Rocketing my way to Norway

Since I was a little girl I can remember being fascinated by space, particularly the stars. Quite a few years later, in July last year, I journeyed to the European Space Camp (ESC) at the Andøya Rocket Range (ARR) in Norway. At 69°N, it is inside the Arctic Circle, and is the most northern permanent rocket range in the world. It is from Andøya that a variety of European Space Agency sounding rockets are launched. Andøya is rather like a slightly more populated version of Woomera, except that it's cold, with whales and snow.

I was the first Australian to attend the week-long camp, and I was very proud to represent my country on an international level. There were 20 other students from 6 countries: Wales, Portugal, Denmark, Germany, Norway, and Australia. We all had studied physics and mathematics, and were in our final year of high school or first year of university.

It was a fantastic group of students, and we worked well together to achieve our goal of the week, to launch a real sounding rocket.

We attended lectures by some of Europe's most eminent scientists. Topics included "Is a vacuum really empty?", "Rocket aerodynamics and stability", and "The plasma universe". I enjoyed being with like-minded people, and not being "talked down to", although some of the maths was a little beyond me. I learnt more about astrophysics and astronomy than I ever would at school. The regular breaks from learning and the ability to engage with unfamiliar concepts made for an unforgettable experience.

Amelia soldering a circuit board for the payload.

Before the final countdown, I was involved in a variety of tasks, the main one being the soldering of circuit boards for the payload of our rocket, Ikarous. I was in the instrumentation group that made the circuit board sensors for the payload of the rocket. We made the boards from scratch, etching, soldering, and finally testing them – a challenging but rewarding task.

The rocket was 1.7 m high, weighed 14 kg, and went 9 km up into the atmosphere taking readings at beyond mach 1. The whole flight lasted 84 seconds, during which Ikarous changed spin direction 3 times. My group's job was to decipher the readings and create a presentation on the results and our work, which made for an enjoyable finale to the week. I was proud that an object I had made was responsible for high quality data received by the telemetry station.

Of course, the camp not only involved science but also social activities. These included beach volley ball under the midnight sun and a very invigorating, if a little chilly, "swim" in the Arctic Circle sea. The Norwegian brown cheese was ... interesting. My group also went on a whale-watching tour, where we did see a whale. Although an exciting excursion, it was ultimately decided that, to put it politely, the stable dry land was more desirable than the swirling seas.

I have returned from the ESC with a renewed interest in the space sciences, especially cosmology and astrophysics, and a slightly lowered desire to do any more swimming in the Arctic. I am now the Australian representative for ESC, a job whose main aim is to encourage more Australian students to attend the camp. I also coordinate media releases and attempt to find Australian sponsors for Australian students.

I want to thank my sponsors, Telstra, Lovatts Crosswords and Puzzles, Mornington Bay Rescue, and Mornington Peninsula Shire Council.

The camp was a fantastic experience. For more information please contact me at amelia@spacecamp.no or look at the web sites www.spacecamp.no and www.rockettrange.no. As they say, "The sky is not the limit, it's where the fun begins."

Amelia Travers
amelia@spacecamp.no

A uniform national Year 12 curriculum

Currently there is much national debate about the pros and cons of uniform national syllabuses for core senior high school subjects. In January 2007, federal Minister for Education, Julie Bishop, released a report prepared by the Australian Council for Educational Research (ACER) entitled 'Year 12 Curriculum Content and Achievement Standards.' Since then, a meeting in April of all education ministers agreed in principle to work towards a uniform curriculum across all years, although they did allow for regional variations.

The ministers supported the idea that no child should be disadvantaged by moving interstate, even though there is still no agreement on a common school starting age. The key point was to move first towards consistency in the higher years, with an initial focus on physics, chemistry, mathematics, history and English.

Some extracts from the executive summary of the ACER report, relating particularly to physics, chemistry and mathematics, are reproduced below. The full 151 page report is available at the web site listed at the end.

Curriculum content: What is common?

Physics and chemistry are subjects with a very high degree of national curriculum consistency. Each state and territory offers subjects called physics and chemistry, and an analysis of the curriculum in these subjects shows that 85–95% of curriculum content – both subject matter and intended skills/understandings – is common to all eight jurisdictions.

In mathematics, 27 different TER (tertiary entry rank) courses are offered across Australia. Results in these courses/subjects can be used in the calculation of a student's TER. These courses are designed for different purposes and for students with different abilities and interests. Within these 27 courses, each state and territory offers a course that is identifiable as high-level mathematics. An analysis of these high-level mathematics curricula reveals a high degree of consistency across the eight jurisdictions. About 90% of the content of these high-level courses is common across states and territories.

Curriculum content: What is essential?

As well as analysing what is currently taught across Australia in these five senior subjects, this project also sought opinions on what should be taught in these subjects from selected experts (teachers, teacher-educators, university discipline specialists, and community members). These experts were asked to review and rate the importance of current curriculum content and to identify other content that they considered important but missing from current curricula.

In physics, almost all topics identified as 'essential' by the majority of reviewers are present in all state and territory curricula. The only exception is the topic Static electricity and electronics, which was judged essential by the majority of reviewers but is not included in all state/territory curricula.

In chemistry, the same topics appear in almost all state and territory documents and almost all were considered essential by the majority of reviewers. Two exceptions are Analytical techniques and Gases in the atmosphere, which appear in only some curricula. Analytical techniques was rated 'essential' by almost all reviewers. On the other hand, while all states and territories include in their chemistry curricula the historical development of atomic theory, none of the reviewers considered this topic essential.

What is the necessity and efficiency of developing curricula seven times?

In mathematics, a list was developed of all topics covered in senior mathematics courses, and reviewers were asked to rate how essential each topic was for inclusion in the highest-level mathematics course. Almost all mathematics topics judged 'essential' by the reviewers appear in almost all state and territory highest-level mathematics curricula. The exceptions are The binomial theorem, Logic proof, and Sequences and series, which most reviewers considered 'essential' but are mentioned in a minority of advanced courses. (It is possible that, in some states, advanced mathematics students are exposed to these topics in other, complementary, mathematics courses). One topic, Application of calculus to conics, is mentioned in all advanced courses but was not considered essential by the majority of reviewers.

Achievement standards: Are they comparable?

This study also considered the standards of achievement expected of students in each state and territory as reflected in jurisdictions' descriptions of what students must do to be awarded the highest possible grade (e.g. Band 6 in New South Wales, Very High Achievement in Queensland). This analysis included an inspection of readily available assessment materials (school-based and externally set). Across Australia, in all five subjects, there is a degree of consistency in what is looked for when assessing

students' achievements. In any given subject, states and territories tend to pay attention to the same kinds of achievements and features of student work (e.g. a student's ability to 'use evidence to support a point of view').

In chemistry and physics, there is a high degree of consistency in the kinds of achievements and features of student work that are assessed in the senior school, consistent with the high degree of commonality in chemistry and physics curriculum content.

In mathematics, despite the commonality of curriculum content in high-level courses, there are some significant differences in what is required to achieve the highest available grade in advanced mathematics. Some jurisdictions require students to demonstrate mastery of a broader range of mathematical content; some appear to require higher levels of mathematical sophistication.

Questions raised by this study

This study has shown that, in some senior subjects such as chemistry and physics, there is already a very high degree of curriculum consistency across Australia. The selected experts asked to review the chemistry and physics curricula provided strong support for the current content of these subjects, while individually questioning the current relevance of some particular topics and proposing other topics that might be given more emphasis. Given that at least 85% of the curriculum in these subjects is common across Australia, a question remains about the necessity and efficiency of developing curricula and their accompanying assessment processes for these subjects seven times in seven different jurisdictions (for use in eight jurisdictions). In these subjects, and perhaps others such as economics, it should be a straightforward matter to reach Australia-wide agreement on a core of essential curriculum content (including both subject matter and essential skills/ understandings).

A similar question can be asked about the need for 27 different TER mathematics courses across Australia. Different mathematics courses are required for students of different abilities and interests, but it is difficult to imagine that 27 different courses are necessary. Among the seven high-level mathematics courses which go by a variety of names there is a high degree of consistency of curriculum content, again suggesting that the identification of a core of essential content should be straightforward. The group of expert mathematics reviewers was supportive of current course content but felt that some essential topics were missing from some state curricula.

Going forward on the basis of the study

On the basis of this study, we believe it would be desirable to:

1. identify, for each of some nominated senior school subjects, a curriculum 'core' that clearly specifies what all students in Australia taking that subject are expected to learn, regardless of where they live in Australia; and

2. develop a set of achievement standards as a nationally consistent description of how well students are expected to learn the core in each subject.

Curriculum 'core' in a subject could be expressed in terms of subject matter (e.g. topics, text types, big ideas and concepts) and skills (both subject-specific and generic). It should:

- ensure sustained engagement with central concepts and principles in order to develop deep understanding;
- relate these central concepts to the world that students understand;
- express central concepts in language that is familiar to students;
- be developed to minimise overlap or duplication of core content across subjects;
- ensure the integration of academic content with the teaching and learning of higher-order thinking skills (i.e. not privilege generic skills over conventional knowledge categories);
- require the development of factual (or declarative) knowledge. Students must learn facts, concepts and procedures and must be able to demonstrate and apply this knowledge (e.g. to problems, performances); and
- respect domain-specific knowledge (i.e. strike a balance between everyday relevance and application and more esoteric knowledge).

Curriculum documents should identify core content and standards in clear and precise language, even if the concepts (e.g. in Atomic theory) are not widely understood by the public. This does not necessarily mean avoiding technical and specialist terms: these are required for precise communication among teachers. A lack of clarity in curriculum documents sometimes arises from attempts to be inclusive and positive. Terminology for describing the subject matter of the core curriculum should be consistent across Australia, there should be a common language for talking about theoretical and practical aspects of curriculum and assessment (including moderation), and common symbols should be used for codifying results on certificates.

The full report is available at: *http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/y12_curriculum_standards.htm*

Alan Harper: father of metric conversion

Who is...? Great people in AIP history

Alan Harper

In September 1989, the AIP established the AFA (Alan) Harper Scholarships which provide monetary support to the students representing Australia in the Physics Olympiad. This month, the AIP has renewed our commitment to this scheme, and in so doing we have renewed our interest in Alan Harper.

So who was Alan Harper and why does he have this scholarship named after him?

Alan Harper was the driving force behind the successful Australian conversion to the metric system in the 1970s. Born in 1913 in the Gloucester-Barrington area of the UK, the son of a Methodist minister, Alan became a brilliant physicist – graduating from the University of Sydney with a university medal in 1934.

He first worked at the University of Sydney as the first state physicist to hospitals, mainly concerned with the measurement and control of radiation associated with the use of radium and X-rays in cancer treatment. When he joined the National Standards Laboratory (NSL) in 1939, he took charge of temperature measurement and standards, displaying a taste and aptitude for administrative and legal detail. Because of this, he was appointed with John Norgrad to be Executive Officer of the Metric Conversion Board. By studying closely the experiences of many countries, including South Africa, Kenya, Britain, France, USA, Canada, New Zealand and Japan, Harper and Norgard recommended to the government that metrification should be undertaken.

They based their recommendation on the following two principles. (1) The process of conversion should be pushed and not allowed to meander; while voluntary it would employ strong forms of pressure and possibly additional legislative measures to meet the goal of sole use of metric units by 1980. (2) The metrication process should proceed on all fronts in unison, creating the multiplying effect of a general metric environment and minimising the transitional juggling of metric quantities in one area and imperial measures in another. By 1980 most of the metric system had been adopted and Australia's metrification was one of the world's fastest and most successful.

Alan was also one of the founding members of the AIP. He was the first Honorary Secretary from 1964 to 1967, Vice President in 1968, and finally the 4th AIP President from 1969 to 1970. Alan also drafted the first AIP constitution (lasting without amendment until 2004) and was instrumental in manoeuvring the Australian Branch of the Institute of Physics (UK) to become independent in its own right as the Australian Institute of Physics in 1964.

Alan died in 1991. As a point of reference, Alan's work is documented in J. Todd, *For Good Measure* (Allen and Unwin, Crows Nest, 2004) p. 180.

Cathy Foley and Brian James

The 2007 Bragg Gold Medal for Excellence in Physics

State branches and physics departments are now invited to nominate candidates for the award of the Bragg Medal

Aim

The purpose of the prize is to recognise the work done by a PhD student in Australia that is considered to be of outstanding quality.

Background to the Award

The Bragg gold medal for the best PhD thesis by a student from an Australian University was established in 1992 as an initiative of the South Australian Branch, to commemorate Sir Lawrence Bragg (whose picture is inscribed on the medal) and his father Sir William Bragg. The medal is awarded annually to the student who is judged to have completed the most outstanding PhD thesis under the auspices of an Australian university.

Nominations

Each Australian university may nominate one candidate. These nominations are submitted to the State Branch committee. The committee selects the best thesis from their state (two for NSW and Vic.) and three copies of the selected thesis are then forwarded to the honorary secretary. Nominations from the universities should reach the secretary of the local State Branch by Monday 16 July 2007.

Further information about this award can be obtained by email from *secretary@aip.org.au* or by phone to (08) 9332 1513.

Ian Bailey, Honorary Secretary

Press Room Science-related Government media releases

$67 million for Centres of Excellence

In March the Australian government committed an additional $67 million over 3 years to 14 Australian Research Council (ARC) Centres funded under the Centres of Excellence scheme.

A Review Committee chaired by consultant and former BHP Billiton Chief Scientist Dr Bob Watts recently assessed the performance over the past 3 years and future research plans of ARC Centres of Excellence and ARC Centres first funded in 2003, and made recommendations regarding further investment.

The scheme supports collaborative approaches to challenging research problems, builds on Australian research strengths and supports the establishment of first-class training environments for the next generation of researchers.

The ARC Centre of Excellence for Advanced Silicon Photovoltaics and Photonics at the University of New South Wales (UNSW) was positioned as a world leader in solar power research. The Centre holds the world records for the most efficient silicon solar cell and the most efficient silicon solar power module. It has successfully commercialised or is in the process of commercialising eight solar power technologies.

Similarly, the ARC Centre of Excellence for Quantum Computer Technology has become a focal point for worldwide research in quantum computing.

The ARC Centres of Excellence and ARC Centres that will receive funding extensions are conducting research in the National Research Priority areas of Promoting and Maintaining Good Health and Frontier Technologies for Building and Transforming Australian Industries. The Centres are funded under the ARC's National Competitive Grants Program, a component of the Government's 10-year $8.3 billion commitment to innovation, Backing Australia's Ability.

ARC Linkage International Awards

In March, the Minister for Education, Science and Training announced Australian Government funding of $801,300 over 3 years to support 252 postgraduate and postdoctoral researchers in the final round of Australian Research Council (ARC) Linkage International Awards for 2006. This brings total funding for the Awards scheme for 51 collaborative research projects beginning in 2006 and 2007 to more than $1.6 million.

Thirteen Australian universities have been awarded Linkage International Awards Round 3 funding to enable promising new researchers to tap into international networks.

New Chairman for ANSTO

In March the Minister for Education, Science and Training announced the appointment of Dr Zygmunt (Ziggy) Switkowski as the new Chairman of the Board of the Australian Nuclear Science and Technology Organisation (ANSTO).

"Dr Switkowski's extensive experience in business, public company and corporate governance, coupled with his nuclear physics qualifications, provide him with excellent credentials as the Chair for ANSTO, Australia's only research organisation devoted solely to nuclear science and technology," Minister Bishop said.

"This important appointment takes place at an exciting time for ANSTO, with the construction of the new OPAL reactor now complete and commissioning proceeding successfully. The Board will play an important role in ensuring that ANSTO is positioned to capitalise on the significant new opportunities that OPAL provides.

Dr Switkowski chaired the Uranium Mining, Processing and Nuclear Energy Review Taskforce which reported to the Government in December last year. One of the key findings of the Taskforce was that Australia needed to boost nuclear science and engineering education and training if Australia decides to expand its role in the nuclear fuel cycle and in nuclear research.

ANSTO announced recently that it has initiated a graduate program to recruit and train 15 graduates per year.

Dr Switkowski's appointment coincided with the commissioning of the new OPAL reactor that is claimed will place ANSTO among the top three nuclear research facilities in the world.

Research Quality Framework committee announced

Membership of the Research Quality Framework (RQF) Reference Committee has been announced. The RQF is an Australian Government initiative that aims to ensure that public money is invested in research of the highest quality and relevance, according to the Minister who made the announcement in February.

The committee will contain 9 committee members from Australian academic institutions. A list of them can be found at *www.dest.gov.au/research/rqf*. The Australian Government will provide $87 million to implement the RQF, $42 million of which will be provided directly to universities for data gathering and pre-implementation trials.

The Committee will provide advice on pertinent RQF matters, including the development of RQF specifications, the moderation and validation process, IT requirements, and development of an RQF Information Management System, which will support data-gathering and assessment.

"The Government is committed to providing a strong, vibrant and innovative research sector that will positively impact on Australia's economic and social growth," the Minister said. "While the assessment of quality will identify research excellence, the assessment of impact will assist business and industry to identify areas for potential collaboration.

"The measurement of impact will also support increased commercialisation of the results of research at Australian universities."

Awards promoting science in primary schools

Five hundred new awards will be offered to student teachers to promote the teaching of science in primary schools in new and stimulating ways.

In February the Australian Minister for Education, Science and Training announced that the Primary Pre-service Teacher Awards for Excellence in Science Education, valued at $2000 each, will be offered to exemplary student teachers in the final stages of their pre-service primary teacher courses in 2007.

The initiative is designed to strengthen the scientific literacy of qualifying primary teachers, as well as their enthusiasm for science. It should lead to marked improvements in primary students' interest in and learning of science, the Minister said.

Decreasing standards of literacy and numeracy

Results recently released of literacy and numeracy tests conducted in 2005 show that the number of students failing to meet benchmarks increased the longer they were at school.

In 2005, the percentage of students not meeting the benchmarks in numeracy in Year 3 was 6%, however, by Year 5 this had increased to 9% and by Year 7, 18% of students were not meeting the benchmark. Results for Year 7 students also show that 10% did not meet the reading benchmark and 8% did not meet the writing benchmark. Although the Australian Government provided an additional $1.8 billion over 2005-2008 to State Government and non-government schools to specifically lift standards in literacy and numeracy, the minister for Education, Science and Training expressed concern that this money is not being used to good effect.

"It concerns me that too many students are still failing to meet these minimum standards. Reading, writing and mathematics are fundamental life skills that every person needs for further education, employment and participation in society", she said.

Further information and the full report is available at: *www.mceetya.edu.au*

Product news

Warsash Scientific

'Cobalt' lasers with higher power

Cobalt of Sweden has released higher power versions of its Calypso continuous-wave solid-state lasers. The single-line Calypso is now available with up to 100 mW at 491 nm and the Dual Calypso with up to 50 + 50 mW at 491 + 532 nm, both maintaining the same compact package and optical performance as previous models.

All Cobolt lasers are single-frequency lasers with very narrow spectral bandwidth (typically <30 MHz). Built on a robust platform they feature low noise (rms noise <0.3%; peak-t o-peak noise <3%), e xcellent beam quality (M2<1.1), and l ow power consumption (the full system consumes <40 W). Wavelengths and beam characteristics are comparable with Ar-ion lasers and the laser housing has a mechanical outline compatible with the current industry standard for blue solid-state Ar-ion laser alternatives.

The higher power levels make the lasers particularly attractive for cell sorting, spinning-disc or line-scanning confocal microscopy, high through-put bioanalysis, and laser Doppler velocimetry.

Warsash distributes Filmetrics products

Warsash Scientific are now the exclusive Australian and New Zealand representatives of Filmetrics Inc. of California. Founded in 1995, Filmetrics is a leader in affordable and easy-to-use instruments for measuring film thickness (30Å to 450μm), refractive index, and deposition rates.

Filmetrics designs affordable purpose-built miniature spectrometer systems and combines them with sophisticated software to bring advanced thin-film expertise to a simple Windows interface.

Further information on either of these two items is available from WARSASH Scientific at (02) 9319 0122 or *sales@warsash.com.au.*

Lastek P/L

WS Ultimate wavelength meter

The HighFinesse WS Ultimate is a highly sensitive wavelength meter for pulsed and continuous laser sources. Both optical elements and electronics are housed in a compact, thermally insulated casing. Absolute and relative accuracy is sufficient to meet the highest application requirements. The high precision of the WS Ultimate is achieved by using two special multiple interferometer arrays in a unique geometric configuration.

The WSU is connected to a PC via a USB interface. It is ready for use as soon as the software is installed. There is no warm-up time under constant ambient conditions. Its design enables the integration of additional options, allowing customised solutions to specific applications.

An optional second fibre input provides automatic, continuous calibration with any well known calibration wavelength standard. The measurement counts or time period between calibrations is adjustable. A recent test, without temperature control, showed the stability of the WS Ultimate can be better than +/- 2 MHz over more than 11 hours.

USB temperature logger

The Lepta USB thermometer-logger is a tiny plug-and-play USB device which measures the ambient temperature and sends the result to the PC. Absolute accuracy is 0.5°C and relative resolution is 0.05°C. Sample rate is as short as 1 per second. The temperature is displayed in the Windows system tray and is also presented in the application window as a chart with selectable time axis. It can be connected directly to any USB port or via a USB hub or extension cable (supplied). Measurements can

be saved to an Excel-compatible data logging file and transferred to other applications. The device might be useful in informing you of temperature excursions in your work environment.

For further information on either of the above two devices contact:
Lastek Pty Ltd
Adelaide University, Thebarton Campus
10 Reid St, Mile End, SA 5031
Tel: (08) 8443 8668
email: sales@lastek.com.au
web: www.lastek.com.au

Coherent Scientifi c

Hysitron Tribolndentor for nanoscale mechanical testing

Hysitron is a world leader in nanomechanical testing, providing instrumentation to analyse materials at very small scales and high resolution. This opens the door for a better understanding of materials and ultra-thin coatings.

Product news

The Hysitron TriboIndenter is a complete automated nanomechanical test system, ideal for measuring the hardness and elastic modulus of thin films and coatings as well as for performing dynamic analysis on soft materials such as polymers. Available in normal and lateral force loading configurations, the TriboIndenter redefines the sub-micron scale testing arena with real-time data collection and nanometre-resolution in situ SPM imaging.

Hysitron is well known for excellence in load resolution due to a patented transducer design. At the heart of all Hysitron nanoindentation products, it features an unprecedented low noise floor (< 100 nN), enabling the highest possible resolution in nanoindentation studies.

For further information on the Hysitron product range please contact
Coherent Scientific
116 Sir Donald Bradman Drive
Hilton, SA 5033
Ph: (08) 8150 5200
sales@coherent.com.au
www.coherent.com.au.

NewSpec P/L

Newport Agilis motorised optical mounts

Newport's new piezo-driven optical mounts take a new approach to adjusting laser setups. Agilis mounts provide ultra-high adjustment sensitivity and convenient remote operation of a motorised component at the price and size of a manual mount.

Newport's new, proprietary, non-resonant piezo motors directly couple to the moving platen. When idle, spring forces lock the mirror and provide long-term stability. Agilis mounts have a faster adjustment speed than screw-driven designs and are free from backlash or hysteresis. Compared to ultrasonic motors, the Agilis motor makes small adjustments more predictable, with 50 nm incremental motion capability - ideal for ultra-sensitive optical alignments.
The optical mounts are manually operated via a battery-powered, 2-axis remote controller. For each axis, there are two rows of push buttons for step-size settings, allowing precise low-speed adjustments and fast coarse motion.

Agilis optical mounts are the first members of an entire family of piezo motor, remote controllable components that will be introduced by Newport over the coming months. A network-enabled computer controller is in the design stage.

Newport's PulseScout autocorrelator

A versatile, easy-to-use diagnostic for measuring ultrafast pulses, the PulseScout is capable of measuring pulse widths from both high repetition rate (MHz) oscillators and low repetition rate (kHz) amplifiers in the visible and IR wavelength range.

The device features <50 fs t o >3.5 ps pulse width capability (with optional capability of 20 fs), four different wavelength ranges covering 420–1600 nm, and small size (16 x 16 x 16 cm). It is CPU addressable and has on-board electronics, so that no oscilloscope is necessary.

In the past, measuring ultrafast pulses from ultrafast lasers required separate autocorrelation technology: low repetition rate amplifier pulses were measured using single-shot autocorrelators, high repetition rate oscillator pulses were measured using a spinning glass block. With the PulseScout, separate autocorrelators are no longer necessary. The unit comes equipped with either a photodiode detector module to detect and measure high-energy amplified pulses, or a photomultiplier-based detector to measure low-energy oscillator pulses. Conveniently, these detector modules use the same autocorrelator optical head and are fully interchangeable. Alignment is quick and straight-forward, making the PulseScout an ideal diagnostic tool for ultrafast applications.

Newport collimation tester

This 50-mm diameter collimation tester is a wedged window of fused silica that allows for quick testing of beam collimation by utilising shearing interferometry. When aligned at a 45 degree angle of incidence with respect to the incident beam, two wavefronts are formed - one from the front surface of the wedge and one from the back. Where these two wavefronts overlap, the user will see interference fringes. When the fringe pattern is horizontal then the collimation of the input beam is considered well collimated.

This optical element is also a good teaching tool for shearing interferometry. An application note (#25) that sets out shearing interferometry theory and an outline of the method of test is available as a free download from Newport's web site *(www.newport.com)*.

For further information on Newport equipment, contact Neil McMahon at NewSpec: *sales@newspec.com.au,* 08 8273 3040.

Prompt critical Reviews

Of physics, ecology and life

Living organisms survive on an energy gradient. No gradient means equilibrium and that means death. So a study of non-equilibrium thermodynamics (NET) is essential to an understanding of ecology – the scientific study of our living environment. Its relation to physics is the subject of a new book from the University of Chicago Press: *Into the Cool: Energy Flow, Thermodynamics and Life*, by Eric Schneider and Dorion Sagan.

Although its fresh concepts were highly challenging to a non-biologist, the book was a pleasure to read, despite having to catch up on the jargon of ecology.

Essentially, living entities efficiently degrade their supply of input energy through a series of delaying cycles between several members of an ecosystem. The energy and vital elements, such as water, residing within an ecosystem are greatest for a tropical rainforest and least for a desert. The forest recycles its resources many times before discharging its energy as useless entropy. Digesting this information led me to wonder whether climate change might be more due to land-clearing than an excess of CO_2.

The scope of the book is astonishing, for example attacking creationism and intelligent design on one hand while on the other discussing cosmology and black holes! There are some errors, such as the use of base-10 logs in Boltzmann's entropy relation and confusing biologist David Currie with Madame Curie in the index, which is otherwise very good, like the extensive reference section.

Into the Cool is great brain food and I thoroughly recommend it to any physical scientist wanting to get to know the essential role of NET in explaining how we work and hinting at why we are here. Order it through its ISBN-13: 978-0-226-73937-3.

Colin Keay
Reviews Editor

Exploding Disk Cannons, Slimemobiles, and 32 other projects for Saturday Science

NA Downie
Johns Hopkins University Press, Baltimore MD, 2006
xii + 295 pp., US$19.95 (paperback)
ISBN 0-8018-8507-8

This interesting 'how-to' guide is the third in a series of project-based science books from UK physicist and science writer, Neil A Downie (a fourth book is promised). There are 34 well-organised chapters/projects in 12 groups covering a diverse range of topics including lasers, optical illusions, demolition and interesting vehicles.

Each group of chapters starts with a line drawing, relevant quotation (there are wonderful quotes and anecdotes sprinkled right through the book), and a page or two of introduction. For each project Downie carefully specifies 'What You Need', 'What You Do', (sometimes a section entitled 'How It Works'), 'The Science and the Math', and finally some extension activities. He also provides references, plus a useful index and a 'Hints and Tips' section at the end of the volume.

A minor criticism: The numerous line drawings used throughout the book are very clear but they are also very plain, and none are captioned.

While I have not closely analysed all the 'Science and the Math' sections, they appear to be very complete – expanding and complementing the foregoing material very well. This is a book for 'inveterate tinkerers and amateur scientists' [back cover] but not, in my opinion, for 'kids as young as 9 or 10' [p. ix]. Some of the projects would be dangerous in the hands of young, unsupervised or inexperienced experimenters. If you are a science teacher, engineer or research scientist, and you want to share your passion for science and engineering with others, you'll love this book.

TW Burns
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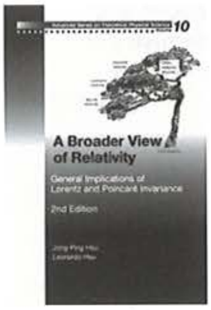


A Broader View of Relativity (2nd ed.)

Jong-Ping Hsu and Leonardo Hsu
World Scientific, Singapore 2006
xx + 516 pp., US$78.00 (hardcover)
ISBN 981-256-651-1

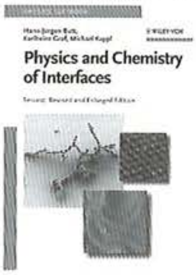
How much does relativity require a constant light speed in all reference frames? Here, the authors assert that, as it only calibrates our experience of the passage of time, constant light speed can be abandoned when formulating relativity. With this, the authors present both taiji relativity, where the speed of light is eliminated by treating ct as a spatial length, and common relativity, where allowing the light speed to change results in a synchronisation of all coordinate times. Given that the resulting frameworks match that of standard relativity, it is no surprise that such coordinate manipulation does not change the predictions for classic tests of special relativity.

But this book goes further, applying the revised relativistic formalisms to many-body problems and quantum field theory, deriving invariant forms of quantities such as entropy and temperature. While the veracity of some of these applications are beyond my expertise, I was surprised to see the authors conclude that the CMB dipole is not due to Earth's relative motion, but to 'a new phenomenon on a cosmological scale', a far from orthodox view. Such unorthodoxy continues as, with a constant speed of light abandoned, the authors conclude that the fine structure constant is the only truly fundamental constant.

In general, the text and figures are poorly formatted, and the discussion gets confusing with the introduction of new quantities such as 'ligh' [sic] and 'genergy' [sic]. However, it does provide a novel viewpoint of relativity and would be interesting for anyone looking beyond a standard textbook presentation.

Geraint Lewis
School of Physics
University of Sydney

Reviews



Physics and Chemistry of Interfaces

H-J Butt, K Graf and M Kappl
Wiley-VCH Verlag, Weinheim 2006
x + 386 pp., EUR 59.00 (softcover)
ISBN 0-471-49083-0

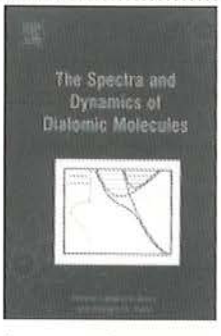
The physics and chemistry of surfaces and interfaces is an area of study that generates an ever-increasing level of interest from researchers across a wide range of disciplines. This is largely due to over 50 years of growth in micro- and nano-scale research, where the properties of the interface often play the dominant role. This book provides a good introduction to interface science for students and researchers in physics, chemistry, materials science, biology and engineering. While not specifically targeting nanoscience research, this broad-based reference material will be particularly useful for researchers in this inherently interdisciplinary field.

The book has 13 chapters covering a diverse range of topics, including: thermodynamics of interfaces; surface forces; liquid surfaces; wetting; charged solid surfaces in liquids; crystalline solid surfaces; adsorption; self-assembled monolayers; polymer deposition and lithography; friction; surfactants (including biomembranes); and thin films on liquid surfaces.

Fundamental concepts are explained in a concise and easily readable way. The authors do not shy away from equations – either mathematical or chemical – giving a good balance between readability and detail. At the end of each chapter there is a selection of exercises that are few and not comprehensive. Nevertheless, they are directed at key points and help indicate where further reading may be required. The book is well referenced, containing 682 citations to books and material published in leading research journals.

This book will be of most use to beginning students, and researchers who are branching out into new areas of interface science. In such cases, this book will provide a concise, well referenced overview, and a starting point for further reading.

Steven R Schofield
School of Mathematical and Physical Sciences
University of Newcastle



The Spectra and Dynamics of Diatomic Molecules

Robert W Field and Hélène Lefebvre-Brion
Elsevier Academic Press, San Diego 2004
xxvii + 766 pp., UK pounds 57.00 (paperback)
ISBN 0-124-41456-7

This book not only contains updates on their earlier volume Perturbations in the Spectra of Diatomic Molecules (Academic Press, Orlando, 1986) but it also takes a broader look at diatomic spectra. It is aimed at the graduate student who is just beginning research and assumes an understanding of undergraduate quantum mechanics. It begins with a very concise overview of standard experimental techniques, replete with definitions of the traditionally used terms, symbols and constants, which should be very handy for the person entering the field. On the theoretical side it covers the construction of structural models, angular momentum theory, Born–Oppenheimer basis sets and deperturbation methods.

Grinding through this background material should adequately equip the newcomer to the physics of diatomic spectra. It also describes more interesting topics such as Rydberg transitions, multiphoton transitions and dynamical effects such as quantum beats and pump-probe experiments.
I found its relaxed writing style quite adept at drawing out and emphasising important issues. For example, in Chapter 1 there is a section titled 'What and How Much?' which discusses how one can 'figure out' the relative contribution to a spectrum from different molecules in a sample. This style, which is becoming more common these days, gives a rich flavour of physics to the formal mathematical analysis. But the most useful aspect of the book I found is its comprehensive list of references littering every chapter. This is a very comprehensive text which I think would be a valuable up-to-date resource for everyone working in this field.

Joan Vaccaro
Centre for Quantum Dynamics
Griffith University

Explorations in Mathematical Physics

Don Koks
Springer, New York 2006
xv + 544 pp., A$91.00 (hardcover)
ISBN: 0-387-30943-8

This truly is a book of explorations, covering many topics. The presentation is at its best in the fields of linear algebra and transformations, tensors, curvature and the geometrical insights. A number of standard tools, e.g. the variational calculus or Green's functions, are carefully explained and introduced. This is also true for some less known but useful topics, like the Gauss–Bonnet theorem. The applications to special and general relativity are particularly valuable.

Overall the text is very uneven in the coverage or the level of difficulty, and some topics receive only fragmentary presentation. For example, widely used methods of wavelet expansions or singular spectral analysis are not included into the signal processing sections.

The text typically explains to the reader the logic behind the development of particular mathematical tools, their relationships and interdependencies and the reasons why such elegant mathematical forms facilitate physical understanding. The publisher suggests advanced undergraduate and graduate students and researchers as the readership. But the latter groups will normally seek more specialised sources and advanced undergraduates should be the natural audience. Seeking deeper understanding of standard and less standard topics is important, as the efficiencies of teaching often neglect thorough exploration. I believe the book is an interesting supplement to standard texts for teaching mathematical methods in physics, as it will add alternative views that could serve as additional material. As many explorations are not complete without historical and modern references, this deficiency could easily be corrected with an online supplement.

S Marcelja
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Reviews

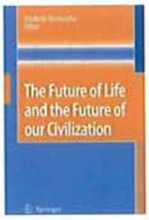
Astrobiology: A Multidisciplinary Approach

Jonathan I Lunine
Addison Wesley,
San Francisco CA 2004
xiv + 586 pp., US$79.20 (softcover)
ISBN 0-8053-8042-6

This book is aimed at 'upper-level undergraduate students and beginning graduate students'. Astrobiology is one of the most multidisciplinary subjects imaginable (so the subtitle of this book is redundant). It deals with the origins, distribution and, for some, the future of life in the Universe. It ranges from the Big Bang to molecular biology, from the early Earth to extrasolar planets, from the oxygenation of Earth's atmosphere to the concept of multiverses, and more. So to write a textbook on this subject must be a daunting prospect. I teach the subject and have avoided the textbook problem by not using one, attempting to work from primary sources instead.

There are other recently published texts in this field but none so comprehensive, detailed and beautifully illustrated. It fills a need and will be widely used, mostly by post-graduate students and teachers of astrobiology (a very small market in Australia but one that is growing elsewhere).

Malcolm Walter
Centre for Astrobiology
Macquarie University



The Future of Life and the Future of our Civilization

Vladimir Burdyuzha (editor)
Springer-Verlag, Dordrecht 2006
xvii + 495 pp., EUR 181.85 (hardcover)
ISBN 1-4020-4967-6

This is a noble effort that has failed dismally. It is an edited collection of seemingly all presentations at the symposium 'The Future of Life and the Future of Our Civilisation' that was held in Frankfurt in 2005. However, the word 'edited' is used recklessly. There has been no quality control, of either the content or the language. There are innumerable spelling mistakes and almost unintelligible sentences. Dubious and downright wrong statements abound. I feel sorry for those authors who produced good manuscripts, and there are quite a few. Their work has been buried. Many of the 'chapters' are only abstracts, one only four lines long. This book does the publisher no credit.

It was, I say again, a noble effort. It is incumbent on us to look to the future, especially with the perspective of the past. No thoughtful person doubts that we face daunting challenges. Many are confronted in this book: energy supply, emerging medical problems, the preservation of biodiversity, the roles of different religions, climate change, and so on. These issues are faced and set in the context of cosmology and the origins of life.

I can recommend this book only to those with time on their hands and a stubborn determination to find the gold amid the dross.

Malcolm Walter
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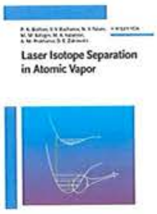
Macquarie University



Laser Isotope Separation in Atomic Vapor

PA Bokhan, VV Buchanov, et al.
Wiley-VCH Verlag, Weinheim 2006
xiii + 185 pp., EUR 99.00 (hardcover)
ISBN: 3-527-40621-2

The first major use of isotope enrichment was in the production of uranium-235 in the Manhattan Project. Many physical and chemical methods of enrichment have been developed since then, and the use of lasers to separate isotopes, known now as Laser Isotope Separation (LIS), is one of the most recent.

The present book is co-authored by six leading Russian scientists (including Nobel laureate AM Prokhorov, 1916–2002), four of whom are distinguished members of the Russian Academy of Science, and one a member of a laser company. The book details the physics and photochemistry of LIS. In typical Russian fashion it states very early that 'The fundamentals of LIS, including laser separation in atomic vapours, were discovered in the former USSR'; fortunately, the authors continue with 'Nevertheless, the first promising experimental results on LIS in atomic vapours and considerable quantities of required isotopes were obtained in the USA.' The authors suggest that the reason for overseas success was billions of dollars put into government laboratories in the USA, Europe and Japan.

In the Introduction, much is made of the US program known as AVLIS (atomic vapour laser isotope separation) aimed at commercialising a LIS process for large-scale production of uranium-235. It is not clear when the authors completed their manuscript but there are no references after 2004. Long before that time, all large programs outside Russia had abandoned AVLIS in favour of centrifuge enrichment, but surprisingly the authors make no reference to this development. The only current LIS process being considered outside Russia is by the SILEX Company based in Australia with the recent support of the US General Electric Co.

As a result of the particular expertise of the Russian co-authors, as well as the security classification of much of the detailed work in the USA, the list of references is heavily biased to Russian sources (144 out of 270). Many of the Russian sources are in Russian and difficult to access by western scientists. It is unsatisfactory for readers to be given a brief description of AVLIS and then be told that 'A detailed description of AVLIS can be found in ref. 20', a work only available in Russian.

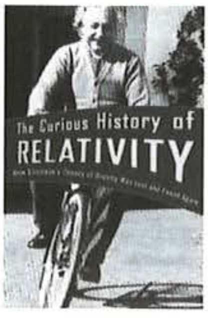
A serious criticism of this book is the completely inadequate index of only 39 entries. There are no entries to boron, lead, palladium, plutonium, silicon, or even uranium-235.

Many readers will be surprised by the complexity of the photochemical processes and equipment involved in LIS. Little wonder then that, despite much effort, no laser process to enrich uranium on a multi-tonne scale has become commercial. Centrifuges have won the day and in a few years will have displaced completely the old gaseous diffusion enrichment process to produce thousands of tonnes of enriched uranium-235 per year, including in Russia.

This book, with all of its limitations and distinct Russian bias, provides a useful explanation of these complex processes.

CJ Hardy
Australian Nuclear Association

Reviews



The Curious History of Relativity: How Einstein's Theory of Gravity Was Lost and Found Again

J Eisenstadt
Princeton University Press, Princeton NJ
2006
ix + 363 pp., US$29.95
(hardcover)
ISBN-13: 978-0-691-11865-9

It is a curious history. Einstein died worshipped by the public and deeply admired by physicists. Yet general relativity was in the doldrums: its predictions few, its mathematics hard, its concepts both bewildering and exciting. Eisenstaedt captures how hesitant relativists were to push Schwarzschild's spacetime past weak field, linear approximations to make it do its real work. Despite Schwarzschild's being the theory's simplest case, it was not until the 60*s that the black hole and its geometry were tackled. This book, for the general reader, tells its story entertainingly. Eisenstaedt also digs back into the past to describe interesting episodes: early attempts to measure the speed of light, Newton's corpuscular theory and its gravitational bending of light, Laplace's dark bodies. The tale of establishing the bending of light after the 1919 expeditions is absorbing. It's entertaining and readable.

Eisenstaedt wants to introduce the general reader to relativity. His performance is surprisingly uneven. The easier parts of the theory sound the hardest. Minkowski diagrams get an intimidating press: they go in Eisenstaedt's 'too hard' box. Yet they are wonderfully helpful and rather easy to grasp. Some crucial points are handled carelessly. We read (p. 99) that tensors are intrinsic and so their components must be invariant. Later (p. 123 and elsewhere), it is implied that all object trajectories are geodesics. By contrast, black holes and Kruskal and Penrose diagrams of them will be easy for new readers to follow.

The hardcover quickly came off my copy. Bad luck?

Graham Nerlich
Department of Philosophy
University of Adelaide

From Physics to Biology
AIP Conference Proceedings 851

J Clemente-Gallardo, et al. (eds)
Springer, New York
2006
xi + 204 pp., EUR 105.50
(hardcover)
ISBN 0-7554-0350-5

This book is aptly titled, as it features several topics on the application of fundamentals from physics to biological systems but not, for example, the spectroscopic topics that one might presume of a biophysics volume.

Nevertheless, a physical biochemist would have the most appreciation for the text, perhaps as an advanced edition of Cantor and Schimmel's Biophysical Chemistry series. However, a physicist will likely be disappointed with language which clearly expects fluency in biological jargon, and a biologist will likely find the physical theory too presumptuous to be accessible.

The text is no more a pedagogical or reference tool than that provided by the usual literature search. Indeed, the content is basically a list of submissions from attendees at the BIFI 2006 conference (including contributions from just five of the eleven headlining invited speakers), ranging from full articles to extracted abstracts presented in article format. Consequently, the peer review of these articles and the editing appears to be minimal (e.g. captions and associated text refer to coloured elements in black and white figures; the English is awkward in places, citation conventions vary, and font and formatting is inconsistent throughout).

Most 'chapters' are more general than regularly published journal articles by the same authors. The lack of coherence between chapters, however, suggests a special journal issue might have been more appropriate, and enjoyed a wider distribution, than a pricey book.

John Gehman and Frances Separovic
School of Chemistry, Bio21 Institute
University of Melbourne

The pinch effect

continued from page 10

instabilities, came later. Bennett's paper does not reference Pollock and Barraclough.

Thus, for quite some time Pollock and Barraclough did not receive due recognition for their pioneering work. This has now been corrected. In a recent article reviewing the use of wire-array z-pinches as x-ray sources, Haines et al [6], acknowledge that "Pollack and Barraclough in Australia proposed the pinch effect to explain the implosion of a copper rod used as a lightning conductor". And at the time of writing the Wikipedia entry for 'Pinch (plasma physics)' notes that 'The phenomenon was not understood until 1905, when Pollock and Barraclough investigated a compressed and distorted length of copper tube from a lightning rod after it had been struck by lightning." [7]

I would like to acknowledge that my interest in looking more closely at Pollack and Barraclough's paper is due to an email from Dr Michael Coppins of Imperial College in early 2006. Michael was seeking biographical information on Pollock and Barraclough for a talk he was giving on the history of the pinch effect. In passing, he asked if we had celebrated the centenary of the publication in 2005. Regretfully, I had to respond in the negative, and to admit that, to my knowledge, it had passed without notice.

1. J.A. Pollock and S.H. Barraclough (1905) *Proc R Soc* NSW, 39, 131

2. V.A. Rakov and M.A. Uman (2003) *Lightning: Physics and Effects* (Cambridge University Press, Cambridge)

3. Geoffrey Walsh, private communication

4. E.F. Northrup (1907) *Phys Rev* 24, 474

5. W.H. Bennett (1934) *Phys Rev* 45, 90

6. M.G. Haines, T.W.I. Sanford and V.P. Smirnov (2005) *Plasma Phys Control Fusion* 47, B1–B11

7. *http://en.wikipedia.org/wiki/Plasma_pinch*

Samplings

Open access and free (for a while)

Now there's a new open access publisher in the physical sciences, with PhysMath Central launching the first of its physics journals at the American Physical Society meeting in Florida on 14 April. *PMC Physics A* covers particle and nuclear physics, gravity, cosmology and astroparticle physics; it also has a special section devoted to instrumentation and data analysis. The new journal emanates from BioMed Central, which has been publishing an expanding number of titles in the biological sciences for some years and has now moved into chemistry as well. There is no publication charge for all articles submitted before 30 June 2007 and subsequently accepted for publication in *PMC Physics A*. Other titles to come are *PMC Physics B* and *PMC Physics C*. Details at *www.physmathcentral.com* .

Angling for the best knot

Why do knots break? Experienced anglers know that some knots are better than others – but exactly why some knots should be stronger than others is far from clear. Now, physicists in Japan have tried to unravel this mystery by carrying out the first experiments into how fishing lines with knots in them actually break. Surprisingly, it turns out that some knots that are strong when made using traditional nylon fishing line are in fact the weakest when made in a more modern material called PVDF.

PhysicsWeb

Quantum mechanics of photosynthesis

How can we convert solar energy into a chemically useful form with sufficiently high efficiency to replace the use of fossil fuels? Of course plants already have the answer. In higher plants and certain bacterial systems, the initial steps of photosynthesis harness light energy with an efficiency of 95% or more – values that we can only aspire to with artificial photocells. Physicists in the US have shown that electrons involved in photosynthesis reactions in the green sulfur bacterium Chlorobium tepidum 'sample' different energy-level routes in much the same way quantum-computer algorithms can (at least in theory) quickly search through unsorted databases. The researchers claim that the discovery could explain how photosynthesis can proceed at efficiencies unparalleled in solar cells.

PhysicsWeb

Spins turn light off

Researchers in Canada and the US have unveiled a new material that can switch a light beam on and off by varying the spin-polarization of electrons. The material is made up of tiny magnetic particles of cobalt that are partially coated with gold. According to the researchers, it could one day be used in devices for processing information that exploit both light and electron spin (*Phys. Rev. Lett.* 98, 133901).

PhysicsWeb

Electron tunnelling seen in real time

The strong electric field from an intense laser pulse can cause electrons to 'tunnel' away from an atom in just an attosecond. Now physicists in Germany are the first to observe this well-known quantum-mechanical process as it proceeds in real time. The breakthrough paves the way for a new technique that can probe short-lived states of atoms or molecules, giving the first direct insight into the dynamics of electron tunnelling.

PhysicsWeb

Physicists take a crack at rocks

Sandstone and granite are very different types of rock, so it might come as a surprise that both materials appear to crack in the same way – at least according to physicists in Canada and Germany who measured the sounds given off by rocks before they shattered. What's even more curious is that sounds from the small samples of rock studied by the group have similar characteristics as those detected after an earthquake, suggesting cracking is a universal process that occurs in many different materials over a wide range of size and time scales (*Phys. Rev. Lett.* 98 125502).

PhysicsWeb

Controlling light at the nanoscale

Physicists in Europe have unveiled a new technique, reported in a recent issue of Nature, that can control the intensity distribution of laser pulses at dimensions much smaller than the wavelength of the laser light. The method combines pulse-shaping techniques with near-field optics and the researchers claim it is a major step forward in the development of laser-based tools for the manipulation of matter on very small length scales.

Diffraction effects normally mean that the position of a light beam can only be controlled over distances greater than half a wavelength. However, theory suggests that this limitation might be overcome by taking advantage of the interference of light on very short length scales – so-called near-field optics. Walter Pfeiffer of Bielefeld University, Germany, together with colleagues in Germany and Spain, have found a way to harness near-field effects by using carefully controlled laser pulses.

PhysicsWeb

Spins take their time to relax

Engineers in the US have discovered that the spin of electrons in organic nanowire 'spin valves' is extremely robust. A team of researchers from Virginia Commonwealth University and the University of Cincinnati have found that the spin-relaxation time in these wires is at least 1000 times longer than that reported in any other system. The result means that these materials could be ideal for use in spintronics, an emerging field that exploits the spin of the electron to encode information in electronic circuits, computers and other devices (*Nature Nanotechnology* doi:10.1038/nnano.2007.64).

PhysicsWeb

Negative index of refraction

Two teams of physicists from the US have independently created the first truly magnifying 'superlenses' using metamaterials with a negative index of refraction. Unlike conventional lenses, superlenses can provide images of almost limitless resolution, and could one day enable the optical imaging of proteins, viruses and DNA.

In 2000, John Pendry of Imperial College in London predicted that the decay of evanescent waves could be offset by amplifying them in a material with a negative refractive index – in other words, one that bends incoming light in the opposite direction to an ordinary material. In theory, such a negative-index 'superlens' could take evanescent waves from a surface, carry them, and convert them into

propagating waves that travel far enough to be captured by a conventional microscope. Since Pendry's prediction, several superlenses have been built that have successfully transmitted evanescent waves. However, none has been able to make the crucial conversion to propagating waves – leaving the evanescent waves with the same fast decay rate as when they started.

Now, two groups have managed to create superlenses that can convert evanescent waves into propagating waves. At the University of Maryland, a team led by Igor Smolyanivov has created a flat superlens consisting of concentric polymer rings deposited onto a thin film of gold (http://www.sciencemag.org/cgi/content/ full/315/5819/1699). Meanwhile, a team led by Xiang Zhang at the University of California in Berkeley has opted for a 3D stack of curved silver and aluminium-oxide layers on a quartz substrate (http://www.sciencemag.org/cgi/content/full/315/5819/1686). Both of these designs are classified as 'metamaterials' – artificial nanostructures made by physicists because substances with a negative index in the optical range do not occur naturally.

For more on applications of meta-materials, see also: http://www.nature.com/nature/journal/v446/n7134/full/446364a.html, an article that quotes Mike Wiltshire, former ANU and CSIRO employee in the 1980's.

PhysicsWeb

Is violation of Newton's Second Law possible?

Alex Ignatiev from the Theoretical Physics Research Institute in Melbourne has come up with an experiment that could potentially reveal a flaw in Newton's law of gravitation. If the flaw exists, it would be the first evidence in support of theories that explain the movement of galaxies without having to introduce 'dark matter' (*Phys. Rev. Lett.* 98 101101).

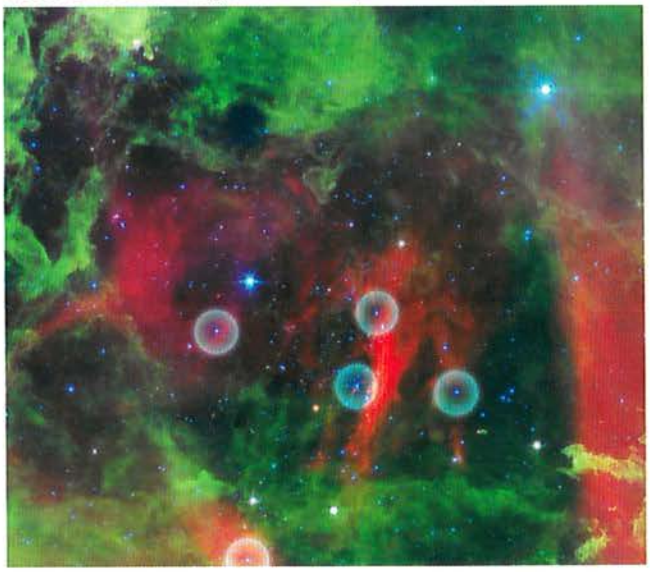
PhysicsWeb

First 'commercial' quantum computer?

A small company in Canada claims to have built the world's first 'commercially viable' quantum computer. D-Wave Systems of Vancouver says that its Orion computer, which is built from superconducting materials, can perform a simple algorithm to search databases. The company says it will start selling a commercial version of the machine in 2008 – but few details of it are available and many physicists are highly sceptical of D-Wave's claims.

PhysicsWeb

Rosette Nebula. Image credit: NASA/JPL-Caltech/Univ.of Ariz.



Danger zones in Rosette nebula

An infrared image from NASA's Spitzer Space Telescope shows the Rosette Nebula, a star-forming region more than 5000 light-years away in the constellation Monoceros. In optical light, the nebula looks like a rosebud, or the 'rosette'.

Lurking inside this cosmic rosebud are so-called planetary 'danger zones' around super hot stars, called O-stars (blue stars inside the spheres), which give off intense winds and radiation. Young, cooler stars that happen to reside within one of these zones are in danger of having their dusty planet-forming materials stripped away.

Knowledge of O-star danger zones is limited. Astronomers have used Spitzer's infrared vision to survey the extent of the five danger zones shown here. The results showed that young stars lying beyond 1.6 light-years of any O-stars are safe, while those within this zone are likely to have their potential planets blasted into space.

Radiation and winds from the super hot stars have collectively blown layers of dust (green) and gas away, revealing the cavity of cooler dust (red).

Nanorods make 'ideal' anti-reflection coatings

Physicists in the US claim to have created the first thin optical film with a refractive index close to that of air. The film consists of an array of obliquely deposited nanorods, which can collectively have a refractive index as low as 1.05.

Fred Schubert and his team from the Rensselaer Polytechnic Institute in New York, have made the materials by depositing silica nanorods at an oblique angle onto an aluminium nitride surface. These nanorods are separate enough to allow air to reside between them, so the effective refractive index is that of the nanorods and air combined. Therefore, by increasing the proportion of air, the refractive index can be lowered towards unity.

The physicists also claim several graded layers of the films can produce an optical coating that 'virtually eliminates' reflection at all wavelengths. The actual value of the refractive index can be precisely tuned by altering the angle of deposition. This enabled the physicists to produce almost perfect anti-reflection coatings by having several layers of graded-index material stacked on top of each other. The grade with a refractive index close to that of the underlying material is deposited first, with successive grades decreasing in refractive index until the final layer – the one in contact with air – has the lowest index.

Schubert and his team are now planning other types of optical material using the same fabrication process such as distributed Bragg reflectors, which would have alternating high/low graded-index layers.

PhysicsWeb

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