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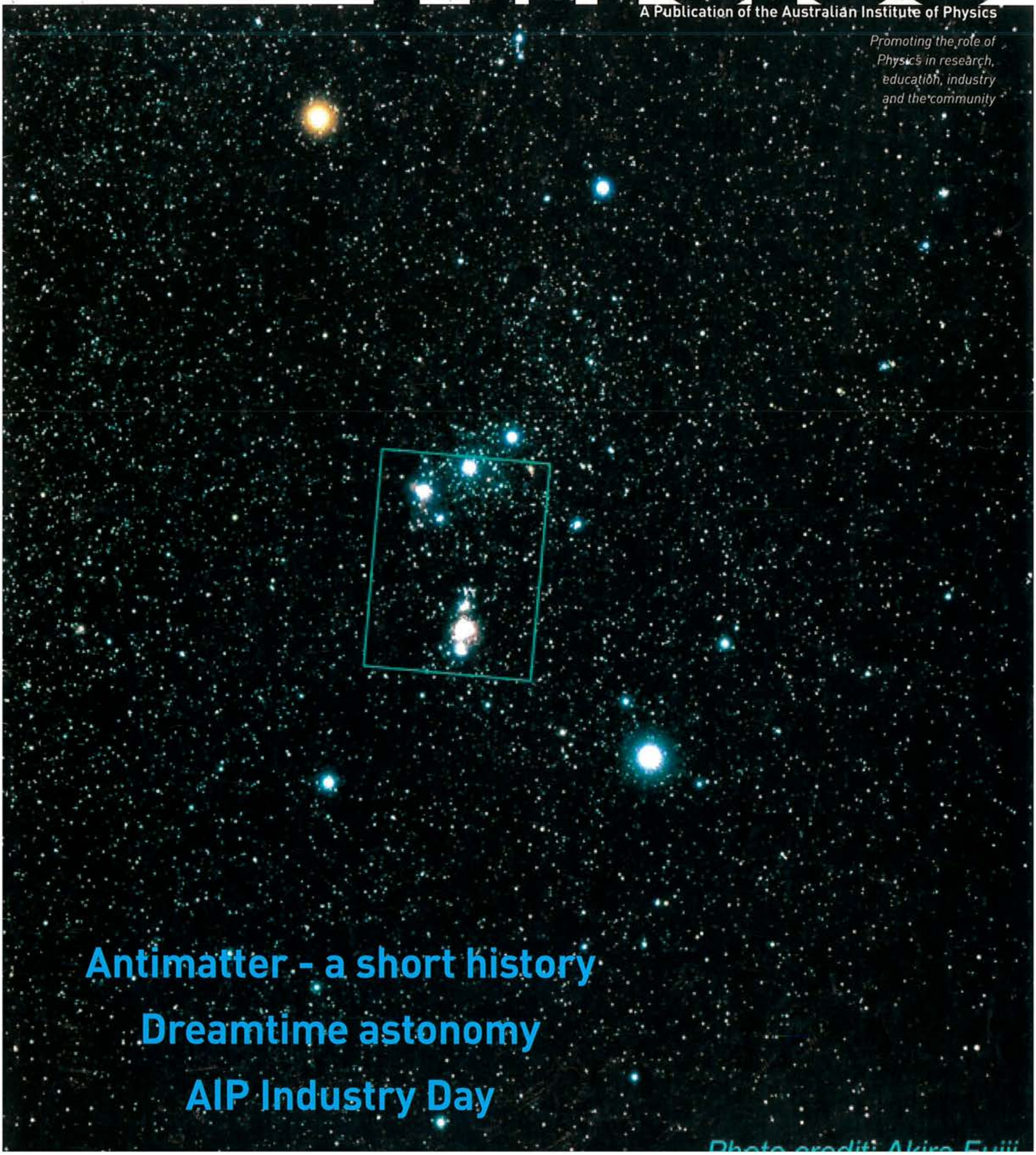
Promoting the role of Physics in research, education, industry and the community



Antimatter - a short history
Dreamtime astonomy
AIP Industry Day

Photo credit: Akira Fujii

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Cover image: Orion, one of the most recognized constellations, is visible high in the night sky during winter. It includes several prominent, bright stars including the red giant Betelgeuse (Alpha Orionis) at upper left and blue giant Rigel (Beta Orionis) at lower right. In the center is Orion's "belt" consisting of three bright blue stars. The Orion Nebula is in his "sword" below the belt, just visible to unaided eyes in very clear, dark skies.
Photo Credit: Akira Fujii/David Malin Images

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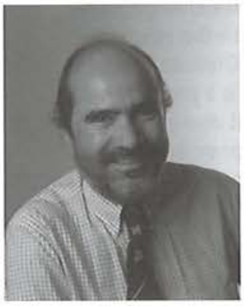
President's Column



Australian Bureau of Statistics data reveal that the Australian Physics community has an annual budget of more than 160 million dollars to spend on their research, or more than 245 million if applied physics is also factored in.

Since the last issue of Australian Physics went to press, the outcomes of the Australian Research Council (ARC) Discovery programs have been announced. This announcement was very early in the year compared to past practice. Indeed Minister Julie Bishop has directed that all ARC Discovery and Linkage grants be announced in the first 2 weeks of October. This is an excellent initiative that will make a huge difference to the legions of early career research fellows that are employed under ARC programs. They can now get on with planning their lives on a more humane timescale. The Federation of Australian Science and Technological Societies (FASTS), of which the AIP is a member, has been lobbying for early release of the ARC outcomes and can take some of the credit for the new policy the minister has announced.

Although the ARC panels have done their usual excellent and difficult job, the news is not great. Of the 4,080 proposals submitted only 20% were awarded a share of funding from the $365M available for the Discovery program. If you were one of the minority who were awarded funding, my congratulations. You have clearly prepared an outstandingly high quality application in a very competitive field. If you missed out, my commiserations, you are in excellent company.

It is regrettable that the success rate is so depressing. Even worse is the very low return on the investment of time in the preparation of the proposals. There are several ways of looking at the dismal return on investment. But consider the considerable costs of preparing 4,080 proposals. Let us assume that the average applicant is employed at the level equivalent to an Associate Professor (Level D) at a University and that the applicant spends two weeks preparing the application (surely a conservative estimate). Then we have to allow for the standard institutional overheads of housing and supporting the applicant that typically multiply the costs by about 2. This means that the 4,080 proposals cost a staggering $38M to prepare. If two people laboured on each proposal (which is more likely), then the cost is an even more staggering $76M! In this case the research sector could save a mind boggling $60M if only we could find a way of not preparing the unsuccessful proposals!

Perhaps it is time to move to a "white-paper" system common in the USA. In this system, a short proposal is submitted - just a few pages - and these are assessed to select finalists who are invited to submit full proposals. This system has its flaws, but we cannot continue to waste so much time and energy with success rates of only 20%. Of course another solution to the problem is for the Government to increase the size of the ARC pool. As pointed out by Australian Academy of Science President, Professor Kurt Lambeck, in his press release of October 11, "Think of the huge additional benefit to all Australians if even another 20 per cent of the unsuccessful projects had received funding". I could not agree more, except I would aim for another 30% to bring the success rate to 50%. This extra investment in the ARC scheme could have a considerable beneficial multiplier effect on our economy and society. A report[1] commissioned by the Department of Education Science and Training showed that investment in the Cooperative Research Centre Program resulted in a return to the Gross Domestic product of more than 2 to 1 for the money invested in the scheme. While the Discovery Program is likely to have longer term and less easily quantifiable returns, **the unfunded proposals at the margins represent a significant resource presently being wasted**. A higher success rate will also bring a huge benefit to non-Go8 institutions, especially those in regional areas.

I have not yet had an opportunity to analyse the proportion of ARC Discovery funding that has gone to Physics, but research done by FASTS from Australian Bureau of Statistics data reveal that the Australian Physics community has an annual budget of more than 160 million dollars to spend on their research, or more than 245 million if applied physics is also factored in. These figures are from research dollars spent on R&D in higher education institutions reported by both Research Fields, Disciplines, Courses (RFDC) and Socio-Economic Objectives (SEO) codes for 2000, 2002 and 2004. This budget has been expanding at more than 14% per year over the past 5 years. The Physics research "industry" is big! Astute suppliers of high-tech equipment please take note.

extra investment in the ARC scheme could have a considerable beneficial multiplier effect on our economy and society.

The voice of FASTS in parliament was loud enough to help bring about the highly desirable early announcement of ARC outcomes. In this way AIP members have had their voices heard in the corridors of power. But our voice is only as loud as the number of members who join us. At present the AIP represents our 1,500 members in the arena of national, international, and governmental affairs. The AIP also underwrites national and international conferences being planned and organised by our members. "Australian Physics" provides a bimonthly mouthpiece for issues in Physics – look out for the special issues next year on the new reactor and the new synchrotron. The AIP continues to recognise excellence in Physics though an extensive program of scholarships, medals and awards. In fact a special session has been set aside at the Congress, *RiverPhys*, on Wednesday December 6 to present the medals. But the most important asset of the AIP, that has produced these outcomes, is our body of members. All the medal panels, the AIP Executive, branch committee members, authors of submissions to FASTS and other bodies, are volunteers. Membership renewal forms are landing in your mailboxes. Please join us and help us to help you to support Physics in Australia.

My best wishes for the season.

Prof. David Jamieson

[1] Available from http://www.crc.gov.au

Editorial

The causes and consequences of climate change have certainly been in the news recently. With the release of the Stern Review on the Economics of Climate change, governments have admitted that there's a problem that needs to be dealt with, though they still disagree on the best way to go about this. This is good response and hopefully some long-term positive action will result from all the recent public discussion.

However, I find one aspect somewhat disheartening. Scientists have been saying for many years that global warming and climate change are real and that action needs to be taken immediately in order to minimise the effect of these. They have mentioned not only the effects on climate, but also the likely economic and social effects. They have offered advice, they've given warnings, they've written articles and papers and they've given talks. For the potential seriousness of the problem, these warnings have had little effect on government and industry.

Now this new report has been published on about the effects of climate change and has really made a noticeable splash and caught the attention not only of the media, but of governments worldwide. In it there is very little about the science of climate change. One of the opening sentences is "The scientific evidence is now overwhelming: climate change is a serious global threat and demands urgent global response."[1] So climate change is taken as read and only the consequences examined.

So why has this review attracted so much more attention than all the warnings given by eminent scientists over the years? It was carried out by an eminent economist, Sir Nicholas Stern, Head of the Government Economic Service and former World Bank Chief Economist. I've only so far read the short Executive Summary, but he has obviously consulted widely with scientists as well as economists and the conclusions are obviously sensible. What is disheartening is that it takes an economist to point out the obvious before governments take notice. What have scientists been doing wrong?

It's easy to assume that this is because our society currently places so much emphasis on economic growth and prosperity and that therefore the opinions of an economist carries more weight than that of a scientist. While this may be a factor, I'm not sure it's the only one. As scientists we're used to thinking about uncertainties in measurements and observations, but when we talk to non-scientists it can sound as if we are unsure of our ground. We also look for other possible causes of observed effects. Once again, we can sound unsure.

In the final analysis, though, it's more important that the message gets across – n matter who the messenger is. The whole of the Stern Review is downloadable from *www.hm-treasury.gov.uk/Independent_Reviews/stern_review_economics_climate_change/sternreview_index.cfm*

In this issue: History seems to be a bit of a theme this time. Stuart Tovey looks at the history of antimatter research while Ragbir Bhathal looks at astronomy in Australia before European settlement. There's also a report on the AIP Industry Day held at CSIRO Industrial Physics. As well as the usual regular items there is also a 'Memoriam' for ElizabethEssex-Cohen.

Corinna Horrigan

1. Stern Review, Executive Summary, short version.

Deadline for next issue: 18th December 2006

Submission guidelines

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

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

Letters

I read with interest David Jamieson's discussion of presentation methods in the July/August edition of *Australian Physics*. He points out that presentations at the July nanoscience conference in Brisbane were all electronic, while those at another conference on fundamental physics were hand-written transparencies, which struck him as quite archaic. He suggests that perhaps many presenters worry about the dominance of PowerPoint in presentations. I certainly do, but I also find PowerPoint not up to the task of creating a good physics presentation in finite time. However, I don't use transparencies either. I am curious to know of what middle roads physics presenters might choose.

Here are some alternatives that I have tried; perhaps readers can suggest others. Some users prefer the latex package Prosper, which makes a very slick PDF-format presentation that incorporates mathematics properly. But in contrast to writing papers, many academics do prefer the what-you-see-is-what-you-get approach to designing a presentation.

PowerPoint can incorporate latex-quality maths with add-ons such as TeXPoint and TeX4PPT, which format raw latex snippets within the presentation. I've not experimented with these.

An alternative for Mac users is Apple's very smooth Keynote software combined with the small free Mac program LaTeXiT (though you need to have latex installed). LaTeXiT converts latex snippets into PDF files of the formatted output. These can then be dragged into Keynote. Keynote is the Mac equivalent of PowerPoint, except I find it much easier to use, and I don't need to constantly battle with it to do the simplest things, as is the case with PowerPoint. Plus, since Macs use PDF extensively under the bonnet, Keynote accepts any PDF file quite happily.

Of course, none of these choices make it easy to spice up a physics presentation with pictures, with the result that presentations across the board have grown very uniform in recent years. Boring bullet points are de rigueur, interweaving pictures and text is virtually non-existent, and the result is a very linear presentation. So much for high technology. But we are not all graphic-design artists either.

Currently my fix for this is to present hand-written pages scanned into one PDF file. This combines ease of graphics creation (by hand!) with ease of presentation (a single PDF). I write on A4 paper in ballpoint and can draw all the boxes, loops, arrows, and pictures required. Each page is scanned into a separate PDF; I then combine these by inserting each into Keynote and exporting the lot to one PDF file. Presumably Keynote is not really needed for that, but it does allow the freedom to add photographs.

This approach combines the best of projection technology with the best of text-picture integration. After all, we are really not obliged to use sophisticated graphics packages to draw stick figures. And conference presentations aside, as part of their education students need to see, in lectures, how physics is written *by hand*, something that glossy presentations fail to do. On that note, it's a sorry day when the good old blackboard is removed from universities to be replaced by that abomination, the whiteboard. Lacking good pressure feedback, combined with wasteful markers that never work properly, whiteboards do nothing for a presenter's handwriting. Compare them to blackboards, whose natural tendency to put a calligraphic edge on the chalk can really bring out some good handwriting, and be a pleasure to use. And chalk never leaves ink marks on hands and clothing! Conferences have different needs of course, but there is a place for projected handwritten presentations in these. I think physicists should resist the corporate idea that glossier is better when it comes to presenting their work. In my experience, corporate presentations often trade off content for gloss.

Finally, a comment on David's closing remark about the difficulty of judging quality in physics: for those who wish to ponder the matter, the book *Zen and the Art of Motorcycle Maintenance* by Robert Pirsig makes very good reading.

Don Koks,
DSTO, Adelaide

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AIP News

South Australian Branch

Prof. Michael Gore and Dr Olivia Samardzic present John Debs with the Silver Bragg medal, awarded to the best 3rd-year Physics student at Flinders University in 2005

The SA branch of the Australian Institute of Physics has had a busy time in July to September, putting on 9 events. On July 12th. NASA astronaut Dr Robert Satcher Jr gave a public lecture in which he described the training of astronauts and his special interest in bone loss. On July 21st. Professor Sylvester James Gates Jr gave a public lecture on supersymmetry, with his explanations illustrated by excellent graphics.

On July 27th the branch held its annual Student Night. Sean Manning of the University of Adelaide spoke on *Thermal poling of soft glass micro structured fibers (developing visible band fibre lasers)* and Alec Deslandes of Flinders University spoke on *Modifying Surfaces to Build Better Sensors*. The Silver Bragg medals for the best 3rd year Physics students in 2005 were presented to Samuel Edwards of the University of Adelaide and John Debs of Flinders University (as shown in the photograph).

On August 11th. Professor David Jamieson gave a public lecture on *Einsteins's Revolution: Quantum and Relativity Technology for the 21st Century*. Professor Jamieson described the role of Quantum Physics and Relativity in modern technologies, such as the global positioning system, then described developments in Quantum Computing.

On August 17th and 18th the branch presented a theatrical production by Professor Mike Gore on *The Life, Science and Times of Galileo*, with many demonstrations including the giant bowling ball pendulum, the falling chimney paradox and "The Monkey and the Hunter". Also on August 18th the branch conducted its annual Super Science Quiz for High School students.

On September 6th the branch held its annual joint meeting with the Astronomical Society of South Australia, with a lecture by Prof. Fred Watson on *What's happening to gravity?* On September 28th, in a second joint meeting with the Faculty of Engineering, Computer and Mathematical Sciences of the University of Adelaide, and the Adelaide Section of the American Institute of Aeronautics and Astronautics, Prof. Rod Boswell gave a public lecture on *The Hydrogen Economy*.

Laurence Campbell

Tasmanian Branch

On 26th September Prof Deb Kane, the AIP Women in Physics lecturer for 2006, commenced a statewide lecture tour. Deb arrived on the North-West coast of Tasmania and delivered a talk to about 40 year 11 and 12 students in Devonport before traveling to Launceston for an overnight stay. In the morning she repeated the talk at Launceston College to more than 100 students from various schools. A pleasant drive to Hobart in the pouring rain for two and a half hours was followed by dinner with members of the Branch committee before a public lecture at the University of Tasmania. Unfortunately it was a bitterly cold and wet night and so the turnout for the lecture was smaller than is usual for AIP lectures. The next morning Deb addressed a further 50 students at Elizabeth Matriculation College. Finally, Deb gave a professional seminar to Physics staff at the University before a short scenic tour around Hobart and a flight out from Hobart airport. The Branch is really grateful for the time that Deb put into her tour and her encouragement of young people interested in the physical sciences.

Following the encouraging changes to high school science and mathematics syllabuses by the state Minister for Education that were reported in the last Branch News, the Chair of the Branch wrote to the Minister congratulating him on his new direction. The Branch was subsequently invited to take an active role in the development of the new curriculum. The first step in this process will be the two day annual teachers development program (in early December) run by the AIP and staff from the School of Chemistry at the University of Tasmania at which there will be sessions on the new curriculum. It is encouraging to find that the AIP has been given the opportunity to have a genuine input into such an important development in the state's education system.

Marc Duldig

AIP News

Australian Institute of Physics Annual General Meeting

The 44th Annual General Meeting of the AIP is to be held in the Hercus Lecture Theatre, University of Melbourne, at 1800 on Monday 19th February 2007.

Agenda

1. Apologies, recording of proxies
2. Minutes of 43rd Annual General Meeting
3. Business arising from the minutes
4. President's report
5. Treasurer's report
6. Election of Office Bearers for 2007/2008
7. Appointment of auditor.
8. Any other business.

Ian Bailey
Hon. Secretary

CALL FOR NOMINATIONS

IUPAP Young Scientist Prize in Atomic, Molecular and Optical Physics 2007

Nominations are being sought for the Young Scientist Prize in Atomic, Molecular and Optical (AMO) Physics which will be awarded by the International Union of Pure and Applied Physics through the Commission C15 (AMO Physics) for the first time in 2007. The prize will be awarded during the XXV International Conference on Photonic, Electronic and Atomic Collisions (XXV ICPEAC) to be held in Freiburg, Germany, July 25 – 31, 2007. The Prize includes a medal, a $1000 award and an invited presentation at XXV ICPEAC.

The nominee is expected to have made original and outstanding contributions to the field of AMO physics. The leading personal contribution of the recipient to the achievement must be clearly indentifiable when the work was performed in collaboration. Nominees for the prize should have a maximum of 8 years of research experience (excluding career interruption) following the PhD on January 1, 2007.

Nominations should include:

- A letter of not more than 1.000 words evaluating the nominee's achievements and identifying the specific work to be recognized.
- A curriculum vitae including all publications.
- A brief biographical sketch not exceeding two pages.

Self-nominations will not be considered. Nominations should be sent to the chair of IUPAP- C15:
Prof. J. Burgdörfer, Institute for Theoretical Physics, Vienna University of Technology, Wiedner Hauptstraße 8-10/ E136, 1040 Vienna, Austria, EU or *iupap@tuwien.ac.at*.

Deadline is February 1, 2007.

Samplings

People

NASA scientist John C. Mather wins 2006 Nobel Prize for Physics

The Nobel Prize Committee announced Tuesday that NASA scientist and Goddard Fellow Dr. John C. Mather is this year's recipient of the Nobel Prize for Physics. Mather is currently serving as senior project scientist for NASA's James Webb Space Telescope program.

Mather shares the prize with George Smoot of the Lawrence Berkeley National Laboratory in Berkeley, California. They received the award for their work that helped cement the Big Bang theory of the universe and deepened our understanding of the origin of stars and galaxies.

Mather and Smoot's work was based on measurements performed with NASA's Cosmic Background Explorer (COBE) satellite, launched in 1989. Together, the scientists could observe the universe in its early stages about 380,000 years after it was born. Ripples in the light they detected helped demonstrate how galaxies came together over time.

NASA media release

Short Notes

Japan launches satellite to study the Sun

A satellite designed to collect vital information about the Sun's magnetic field successfully took off from Japan's Uchinoura Space Centre early on Saturday local time. The Solar-B mission will attempt to understand how the field triggers solar flares and coronal mass ejections, which can cause communications blackouts on Earth. Data from the mission could even be used to predict when these massive explosions occur.

PhysicsWeb

Elements 116 and 118 discovered

At the Joint Institute for Nuclear Research (JINR) in Dubna, Russia, physicists (including collaborators from Lawrence Livermore National Lab in the United States) have sent a beam of calcium-48 ions into a target of californium-249 atoms to create temporarily a handful of atoms representing element 118. The nucleus for these atoms have a total atomic mass of 294 units.

In fact, only three of these atoms, the heaviest ever produced in a controlled experiment, were observed. After sending 2 x 1019 calcium projectiles into the target, one atom of element 118 was discovered in the year 2002 and two more atoms in 2005. The researchers held up publication after seeing their first specimen in order to find more events. According to Livermore physicist Ken Moody, speaking at a press conference today from Livermore, the three events have been well studied and the odds of a statistical fluke at work here are less than a part in 100 thousand.

Physics News

Invisibility cloak unveiled in the US

A mainstay of science fiction and prized possession of the young wizard Harry Potter, the invisibility cloak is also of great interest to the defence and intelligence communities. As a result, a great deal of research (both secret and public) has gone into the development of materials that can hide objects from prying eyes – or at least radar systems. Now researchers in the US and the UK have claimed the first public success (*Scienceexpress* 1133628).

David Smith and colleagues at Duke University in North Carolina have used specially-structured materials called metamaterials to create a device that can make an object almost invisible to the microwave radiation used in some radar systems. Based on a design by the physicist John Pendry of Imperial College, the cloak bends microwave radiation around the object, like water flowing around a smooth stone. This makes both the cloak and object invisible to an observer because the radiation does not appear to be scattered or absorbed by cloak or object.

PhysicsWeb

GeV acceleration in only 3 centimetres

Much of particle physics over the past century was made possible by machines that could accelerate particles up to energies of thousands of electronvolts (keV), then millions of electronvolts (MeV), and then billions (GeV). Possessing such high energies, beam particles can, when they smash into something, recreate for a short time a small piece of the early hot universe. Now the effort to impart more acceleration to particles over a short haul has taken a notable step forward. Physicists at the Lawrence Berkeley National Laboratory and the University of Oxford have accelerated electrons up to an energy of 1 GeV in a space of only 3 centimetres. The device used is called a laser wakefield accelerator since it boosts the electrons using potent electric fields set up at the trailing edge of a burst of laser light traveling through a plasma-filled cavity. Previously gradients as high as 100 GeV per meter had been attained, but the acceleration process could not be sustained to energies much above 200 MeV. Leemans *et al.*, *Nature Physics*, October 2006.

Physics News

Splashing out against tumours

Similarities between tumour growth and the physics of splashing water drops have been used by researchers in the US and Italy to predict how cancer invades healthy tissue. This has led them to propose clinical management strategies for the treatment of invasive tumours (*arXiv.org* physics/0610040).

Physics News

NASA approves return to Hubble

Shuttle astronauts will make one final house call to NASA's Hubble Space Telescope as part of a mission to extend and improve the observatory's capabilities through 2013.

NASA Administrator Michael Griffin announced plans for a fifth servicing mission to Hubble Tuesday during a meeting with agency employees at NASA's Goddard Space Flight Center.

"We have conducted a detailed analysis of the performance and procedures necessary to carry out a successful Hubble repair mission over the course of the last three shuttle missions. What we have learned has convinced us that we are able to conduct a safe and effective servicing mission to Hubble," Griffin said. "While there is an inherent risk in all spaceflight activities, the desire to preserve a truly international asset like the Hubble Space Telescope makes doing this mission the right course of action."

The flight is tentatively targeted for launch during the spring to fall of 2008.

For more information about the mission and the Hubble, visit: *www.nasa.gov/hubble*

NASA media release

"Smust" soaks up ethane on Titan

The mystery of the missing ethane ocean on Saturn's largest moon Titan could be explained by dusty smog particles called "smust", claims an American physicist. Planetary scientists had believed that the entire surface of Titan was engulfed in an ocean of liquid ethane one kilometre deep. That is until the European Space Agency's Huygens lunar probe landed on Titan in 2005 and found a surface covered in a sand-like material – not liquid ethane. Recent calculations by Donald Hunten from the University of Arizona, USA suggest that instead of accumulating in liquid form after being produced in Titan's upper atmosphere, the ethane condenses onto thick smog that envelops the moon's surface (*Nature* 443 669).

This process forms a smog-and-dust-like material that Hunten calls "smust". The idea came to Hunten while he was analysing the vertical distribution of ethane in Jupiter's atmosphere. "Jupiter has smog particles too, and it occurred to me that they are very spongy and have lots of sites that would be good for ethane to adhere to. The same process should work on Titan." Indeed, Hunten has calculated that Titan could be covered in a layer of smust 2.6 km thick that could support dune-like structures. Such dunes have been observed on Titan by the ESA's Cassini planetary probe, which launched Huygens and continues to monitor Titan.

PhysicsWeb

Changing blood-cell shapes provide clues for fighting disease

Living cells are not constant little balls. Responding to various chemical and temperature changes, cells change their shape and their volume. The outer layers (membranes) of red blood cells, for example, can change by tens of nanometers on time scales of tens of milliseconds. At the recent Optical Society of America annual meeting in Rochester, N.Y., an MIT group showed how they measured such tiny, quick fluctuations, and how they are related to the cell's osmotic behavior -- that is, to the cell's ongoing effort to maintain a balance in the concentration of ions between itself and its surroundings. It can do this, for instance, by admitting or expelling water.

If the osmotic imbalance becomes too great, however, the cells can burst, an action called lysis. Often diseased cells are more prone to lysis, which in turn is signaled by changes in the way the membrane flickers (a swelling cell flickers less), hence the interest in numerically monitoring activity at the cell's boundary.

Gabriel Popescu (gpopescu@mit.edu), a researcher in the MIT laser spectroscopy lab of Michael Feld, says that their optical microscopy measurements of the role of osmotic pressure in red blood cell flickering are likely to help in understanding clinical problems such as the effects of the malaria parasite on the red blood cell membrane and changes in the mechanical properties of the cells during sickle cell disease. Such basic knowledge, largely unknown until now, paves the way toward better understanding and strategies for treating those and many other diseases involving red blood cells.

Physics News

Busted! Astronomers nab culprit in galactic hit-and-run

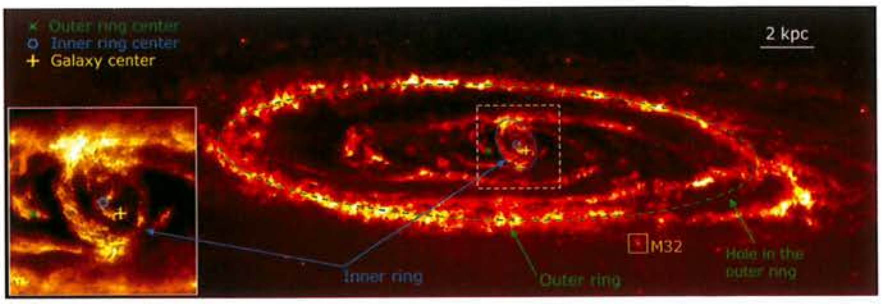
The Andromeda galaxy, the closest large spiral to the Milky Way, appears calm and tranquil as it wheels through space. But appearances can be deceiving. Astronomers have new evidence that Andromeda was involved in a violent head-on collision with the neighboring dwarf galaxy Messier 32 (M32) more than 200 million years ago.

This discovery was reported in the October 19 issue of the journal *Nature*.

Dramatic proof of the galactic smash-up came from images taken by the Infrared Array Camera (IRAC) on NASA's Spitzer Space Telescope. Those images revealed a never-before-seen dust ring deep within the Andromeda galaxy. When combined with a previously observed outer ring, the presence of both dust rings suggests a long-ago disturbance whose effects are still expanding outward through Andromeda.

"These dust rings are like ripples in a pond," said David Block (University of the Witwatersrand, Johannesburg), who is the lead author on the paper. "Plop a stone into water and you get an expanding series of rings or waves. Let a small galaxy collide nearly head-on with a larger one, and you will see waves or rings of gas and dust that propagate outward as a result of the violent gravitational interaction.

Research team members Frederic Bournaud and Francoise Combes (Observatoire de Paris) conducted a series of computer simulations to model the collision between Andromeda and M32. They found that M32 plunged through the disk of Andromeda along Andromeda's polar axis approximately 210 million years ago. Since M32 is much less massive than Andromeda, the latter was not substantially disrupted, but the smaller galaxy lost more than half its initial mass in the course of the collision.



Astronomers have new evidence that the Andromeda spiral galaxy was involved in a violent head-on collision with the neighboring dwarf galaxy Messier 32 (M32) more than 200 million years ago. This infrared photograph taken with NASA's Spitzer Space Telescope revealed a never-before-seen dust ring deep within the Andromeda galaxy (highlighted by the inset). When combined with a previously observed outer ring, the presence of both dust rings suggests that M32 plunged through the disk of Andromeda along Andromeda's polar axis approximately 210 million years ago. Credit: NASA/JPL/P. Barmby (CfA)

Samplings

"To continue the hit-and-run analogy, you could compare M32 to a compact car while Andromeda would be an 18-wheeler," explained Barmby. "In a collision between the two, the truck would be almost unharmed while the car would be wrecked. Similarly, M32 was much more damaged than Andromeda."

This discovery was made with Spitzer's Infrared Array Camera, built primarily at NASA Goddard Space Flight Center in Greenbelt, Maryland. The instrument's principal investigator is Giovanni Fazio of CfA. The Jet Propulsion Laboratory, in Pasadena, California, manages the Spitzer Space Telescope mission for NASA's Science Mission Directorate, Washington. Science operations are conducted at the Spitzer Science Center at the California Institute of Technology in Pasadena.

Harvard-Smithsonian Center for Astrophysics media release

Stronger hurricanes linked to climate change

A new study of climate data suggests that global warming is causing the Atlantic Ocean to generate deadlier hurricanes. Hurricanes have become stronger in recent decades, in apparent correlation with the rise in atmospheric temperatures. Indeed James Elsner of Florida State University in Tallahassee reports in *Geophysical Research Letters* that there is in fact a clear cause-and-effect link.

Less than three weeks after Hurricane Katrina, a study published in Science showed that, while the number of tropical cyclones had not increased between 1970 and 2004, their strength had surged: Category-4 or -5 hurricanes were more than 50 percent more frequent in the second half of that period than in the first (Webster *et al.*, *Science*, 16 September 2005).

The same period saw a rise in global atmospheric temperatures -- widely attributed to the accumulation of greenhouse gases such as CO^2 -- and in sea-surface temperatures in the Atlantic, where hurricanes are born. Some climatologists believe that global atmospheric warming is causing the oceans' temperatures to rise, and that warmer sea surfaces can in turn add to a hurricane's strength. But others attributed nature's increased wrath to a long-term cyclic fluctuation in sea temperatures called the Atlantic Multidecadal Oscillation. Opinions also varied on whether a warmer atmosphere can significantly make the oceans warmer, and on the extent to which sea temperatures contribute to hurricane strength.

Elsner used an elaborate statistical method (first devised by economics Nobel Prize winner Clive Granger) to answer the first of those two questions. He examined spikes in global atmospheric temperature (using satellite and ground-based data collected by the Intergovernmental Panel on Climate Change) and compared them to seasonal changes in average sea-surface temperatures for the entire northern-hemisphere part of the Atlantic (based on National Atmospheric and Oceanic Administration data). His analysis showed that the spikes in atmospheric temperature mostly tended to come right before hurricane-season spikes in oceanic temperature, suggesting that the first were causing the second. Global warming could indeed be causing stronger hurricanes. Elsner, *Geophysical Research Letters*, 23 August 2006.

Physics News

Room-Temperature Spin Hall Effect

A new experiment by David Awschalom and his colleagues at the University of California, Santa Barbara, plus collaborators from Pennsylvania State University, shoots a stream of electrons through a sample of a non-magnetic semiconductor, and segregates the electrons in such a way that those with spins pointing up are steered to the left while those with downward pointing spins deflect to the right. They also demonstrated that they could polarise the electrons using only electric fields at room temperature as well, a great boon for prospective spintronics circuitry that would fashion a new form of electronics in which both charge and spin provide ways of storing and processing data.

Strangely, Awschalom's new results -- showing a spin current all the way up to room temperature -- is conducted not in Gallium Arsenide, where most previous observations of the spin Hall effect have been made, but in Zinc Selenide, which should not be as efficient at electrically polarizing spins.

Awschalom says that the evidence that the spin Hall effect is strong even in a material where it should be weak will kindle further an interesting controversy swirling around interpretations of the spin Hall effect. The new experiment is a spin equivalent of the conventional Hall effect known since the 19th century.

In the old Hall effect electrons, moving longitudinally through a sample under the force of an applied electric field will, if exposed to a vertically oriented magnetic field, be deflected slightly to one side of the sample. Two years ago physicists showed that a kind of Hall effect could be used to steer spins (to be more exact, electrons polarized with spins up or down) so that even while no pileup of electric charges at the edge of the sample would occur a net pileup of spins would occur (see Physics Today, February 2005).

In another recent experiment, Awschalom and colleagues showed that the spins wouldn't just pile up; they could be led off into a wire and constitute a polarized current, where they would be to a spintronic circuit of spin transistors what an ordinary current is to ordinary electronics. Two articles in *Physical Review Letters*: Sih *et al.*, in the 1 September 2006 issue, and Stern *et al.* in the 22 September 2006 issue

Physics News

Physics Industry Day

Eighty physicists from University departments, government organisations and private companies gathered at the National Measurement Laboratory at Bradfield Park on the 27th September this year for the fifth Physics Industry Day organised by the NSW Branch of the Australian Institute of Physics (AIP) and sponsored by CSIRO Division of Industrial Physics, AusIndustry and the National Measurement Institute (NMI). The theme of the day and the major topic addressed by all thirteen presenters of talks in the Lehany Theatre was "***Is manufacturing in Australia viable?***" A question that was answered with a definite YES, if correct decisions are made regarding the kinds of manufacturing that are to be done. Various posters, including sixteen student posters, describing particular topics in Applied Physics research were displayed in the Foyer area outside the Lehany Theatre. An important part of each Physics Industry Day has been the Postgraduate Poster Competition for students who are reading for a M.Sc or Ph.D degree on a topic in Applied or Industrial Physics. Prizes of $1000, $500 and $250 are available for first, second and third prizes respectively. This year there were sixteen entries, all of high standard, in this competition.

Bob Lundie-Jenkins, CEO of AusTool began proceedings with a 40 minute talk in which he gave a brief overview of what AusTool is, and outlined the kinds of short run, highly automated, high technology areas in which manufacturing in Australia is viable, as opposed to the low technology areas of commodity product manufacturing that is done at much lower cost in China and elsewhere. He pointed up the following problems:

- There is a lack of strategic planning and direction from both State & Federal Governments for skills training of University & TAFE graduates.
- There is poor understanding of manufacturing amongst High School Teachers and students; there is a poor image of manufacturing in High Schools and in the community in general.
- HECS costs for students studying for degrees in Engineering & Science are high, contributing to the nation's skills shortages in these areas.
- The NSW Department of State & Regional Development should be more pro-active in encouraging R & D in manufacturing industries.

Graeme Melville (NSW Branch Secretary) is at left foreground and Tony Wallis (Bishop Technology) in dark suit in middle foreground.

Following Bob's introductory lecture there were twelve 20 minute talks dispersed throughout the day, an Industry Forum and tours of CSIRO & NMI Laboratories. Six of the 20 minute talks were delivered by representatives of companies that maintain manufacturing facilities in Australia.

1. Warren King outlined the development by Cap-XX of super capacitors for use in domestic products. At present Cap-XX fabricates about100,000 super-capacitors per month at its manufacturing facility in Sydney and has recently opened a manufacturing facility in Malaysia to meet expected increase in demand for super-capacitors.

2. Phil Timbrell from Preformed Line Products described the electrical power distribution components made by his company in their manufacturing facility at Glendenning and an equivalent manufacturing facility in Bangkok. A good advantage of such an arrangement is that when a problem arises with respect to component manufacture in Bangkok tests can be run on an equivalent product line at Glendenning to identify the cause of the problem in Bangkok (and vice-versa).

3. Adrian Rispler described the history of Hawker de Havilland and the aircraft components currently manufactured at Bankstown NSW and Fisherman's Bend in Victoria for Boeing. Hawker de Havilland has a number of research projects underway in collaboration with the Universities of Sydney, Melbourne, Wollongong, NSW and Monash University and the company is

financially viable because it forms part of the Boeing global network and exports 95% of its manufactured products.

4. Jim Patrick, Chief Scientist at Cochlear, outlined the development of the cochlear implant that has been manufactured in Australia from 1982 up to the present. The current design incorporates a detachable magnet to allow people with implants to undergo Nuclear Magnetic Resonance Imaging scans.

5. Tony Wallis from Bishop Technology spoke mainly about the automotive steering system developed by Arthur Bishop and the manufacturing theory and procedures devised by the Bishop group of companies that facilitated manufacture of the steering system. Bishop Technology has entered into joint manufacturing ventures with several automotive manufacturing companies around the world and maintains more than 400 worldwide patents to cover intellectual property developed in Australia.

6. Greg Lang from ResMed described the products manufactured by his company to correct sleep disorders such as sleep apnoea. ResMed has sales offices in many countries around the World but has established a large single campus manufacturing facility at Bella Vista NSW where all of its products are manufactured and from where most of its products are exported. ResMed firmly believes that the best way to retain intellectual property connected with a product is to retain 100% of the manufacturing of the product within ResMed.

The other six speakers were drawn equally from Government Institutions and University Departments as described below.

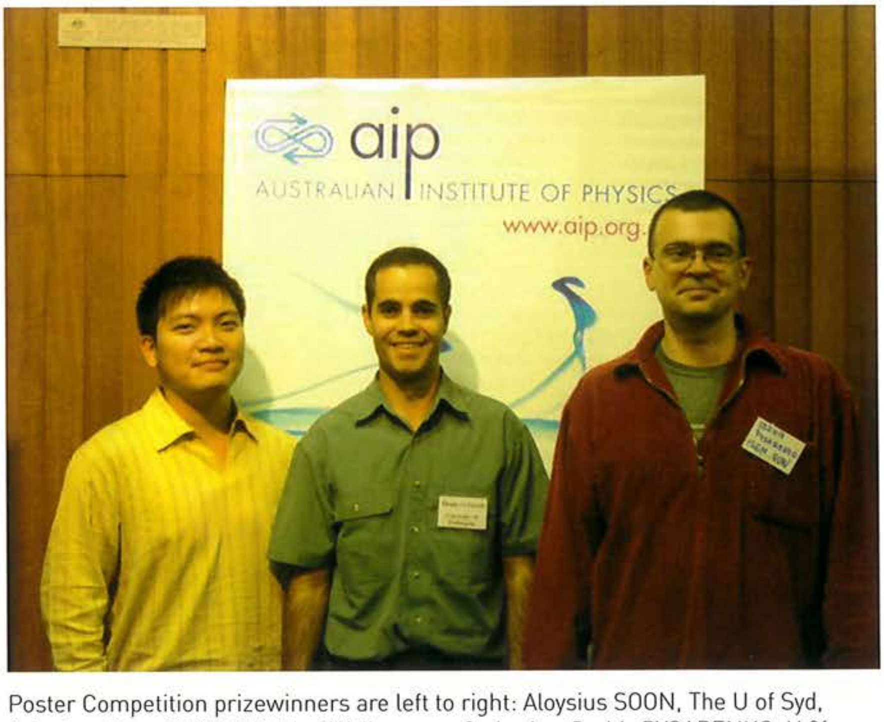
1. Cathy Foley, Vice President of the AIP, presented an overview of the diverse range of skills and current research interests of the CSIRO Division of Industrial Physics. The Division is committed to providing assistance to Australian Manufacturing Industry and Cathy described several projects involving collaboration with private companies such as the development of coatings for products made by Fisher & Paykel.

2. Mike Cortie from the Department of Applied Physics at UTS argued that Australia should work to improve its strengths and seek to value add to commodities that we currently export. He then discussed current research at UTS involving application of nano-particle doped coatings to silica glass for various applications including selective absorption of visible light that is converted into heat with corresponding reduction in reflected visible light.

3. Paul Dastoor described research within the Department of Physics at the University of Newcastle into protective coatings for metals and the development of a portable infusion device called the "***Mobi-drip***" that has been developed to deliver small accurately measured volumes of solution to patients. This multi-disciplinary project has resulted in the formation of a company called Keystone Product Developments to develop and manufacture the Mobi-drip.

4. Michael Lerch, Chairman of the NSW Branch of the AIP, provided an overview of two research areas at the University of Wollongong - Superconductivity & electrical materials and Medical radiation physics - that have significant interaction with private industry. Several radiation dosimeters have been and are being developed for medical and mineralogical uses.

5. Bob Harrison, acting head of the Division of Materials & Engineering Science at ANSTO, described the kinds of commercial projects that have been carried out using HIFAR and will be possible using OPAL, the new research reactor, when it is in full operation late this year. He then discussed various researches underway within Materials & Engineering Science including



Poster Competition prizewinners are left to right: Aloysius SOON, The U of Syd, 1st prize, Dean CUTAJAR ,U of Wollongong, 2nd prize, Serhiy PYSARENKO, U Of Wollongong, 3rd prize

Table 1: Summary of students and their postgraduate poster titles for Physics Industry Day, 2006

STUDENT	UNIVERSITY	POSTER TITLE
Martin AMS	Macquarie	Realistic photonic circuitry for future optical networks
Hemant BHATTA	Macquarie	Analysis of fluorescence microscopy images to characterise pure & mixed yeast populations.
Dean CUTAJAR	Wollongong	Development of a new monitoring system for prostate cancer treatment.
Ben DUCK	Newcastle	Photonic band response in polymeric photovoltaic devices
Marco FRONZI	Sydney	Stability & Chemistry of cerium oxide surfaces: first-principles investigations.
Shane HENGST	NSW	Optimisation of diesel engine power source for operation at high altitude at low temperature.
Ben JOHNSTON	Macquarie	Laser micromachining for photonics, optics & industrial applications.
Nemanja JOVANOVIC	Macquarie	Development of high power visible fibre lasers.
Tom McGREGOR	Macquarie	Colour: A new dimension in high speed imaging.
Graeme MELVILLE	Western Sydney	Production of ^{225}Ac for cancer therapy by photon induced transmutation of ^{226}Ra.
Joel O'DWYER	Wollongong	On-line mineralogical analysis using energy dispersive X-ray diffraction spectrometry.
Serhiy PYSARENKO	Wollongong	Multilayered deposition and its role in the enhancement of $YBa_2Cu_3O_7$ film performance.
Olga SHCHERBAKOVA	Wollongong	Advanced processing of MgB_2 superconducting wires with drastically enhanced current- carrying performance.
Aloysius SOON	Sydney	Catalysis at the sub-nano scale: characterising the copper-based catalyst for the water-gas shift reaction.
Benjamin TREMAIN	Newcastle	Molecular spacers in powder coatings.
Fang XIE	Macquarie	Homogeneous Au-core Ag-shell nanoparticles on glass substrates & their application for fluorescence enhancement.

collaborative work for private industry involving testing.

6. John Miles delivered the final talk of the day on behalf of the new National Measurement Institute (NMI), which, as a separate entity, is only two years old. John described the various standards of measurement of physical, chemical and biological quantities that NMI maintains and the kinds of research undertaken by NMI to maintain those standards. Currently NMI is developing standard measurement procedures for determining sizes of nanoparticles using Scanning Electron Microscopy, Atomic Force Microscopy and Dynamic Light Scattering and is setting up a nanoparticle measurement laboratory to facilitate this.

During the lunch break there were tours of several CSIRO and NMI Laboratories and then following lunch there was a thirty minute industry forum in which David Price from the Department of Industry, Tourism & Resources described

Physics Industry Day

two AusIndustry funding schemes, Grant Nicholson from IP Australia explained what can and what can't be patented, Tony Wallis provided historical background to outline the difficulties experienced by Bishop Technology to maintain patent protection and John Miles argued that only a small fraction of Australian Industry pays proper attention to measurement skills and Standards.

Postgraduate Student Poster Competition

There were sixteen excellent entries for the postgraduate student poster competition this year making this competition the largest and best that been held at a Physics Industry Day. A summary of the participating students is given in Table 1.

Judging of the student posters was done in the evening by Tony Murphy (CSIRO Industrial Physics), Bob Harrison (ANSTO, Materials & Engineering Science) and myself. This was a difficult task with marks being awarded for the physics content and the commercialisation possibilities of the project on a roughly equal basis. After some two hours of discussion with students and subsequent deliberation we decided to award first prize of $1,000 to Aloysius Soon from the University of Sydney, second prize of $500 to Dean Cutajar from the University of Wollongong and third prize of $250 to Serhiy Pyserenko also from the University of Wollongong.

Thanks to Cathy Foley, Scott Martin and Michael Lerch for assisting greatly with the planning and organisation of Physics Industry Day, to Tony Murphy & Bob Harrison for assisting with the poster judging and to all of the presenters who all gave excellent talks.

Images of Physics Industry Day can be viewed at *www.nsw.aip.org.au/*

Ken Doolan
Physics Industry Day Co-ordinator
NSW Branch of the AIP

Memoriam - Elizabeth Essex-Cohen

Dr Elizabeth Essex-Cohen, one of Australia's leading space physicists died from cancer on 21 March 2004.

Most commonly known professionally as Elizabeth Essex, she was one of the first women in Australia to complete a Doctor of Philosophy (PhD) in physics. She gained international recognition as a first class ionospheric physicist with her pioneering work using the global positioning satellite (GPS) system to study the ionosphere and plasmasphere.

Elizabeth studied physics at the University of New England in Armidale, NSW, in the early 1960s where she completed a PhD in ionospheric physics. She then lectured for three years at the University of the West Indies in Jamaica. On her return to Australia, she accepted a post-doctoral fellowship at James Cook University and soon after, in 1969, moved to a lecturer's position at La Trobe. Four years later she was promoted to senior lecturer. At La Trobe, Elizabeth was part of the Space Physics Group formed by La Trobe Foundation Professor of Physics, Keith Cole. The Group's research concentrated on the study of solar-terrestrial physics and particularly the influence of solar phenomena on the Earth's magnetosphere-ionosphere system.

In establishing her research career at La Trobe Elizabeth decided to concentrate on using satellite transmissions, initially from early US navigational satellites and later from the GPS constellation. Initially the Space Physics Group did not have a field site and Elizabeth first set up her antennas and receiving equipment at her home in Eltham, which was then on the outskirts of metropolitan Melbourne.

Her research attracted international interest and she was a long-standing member of the international Beacon Satellite community that developed techniques for ionospheric studies using satellite transmissions and methods for correcting GPS for ionospheric effects. She spent sabbaticals at the US Air Force Geophysics Laboratory in 1974 and again from 1978-1979 and from this developed many collaborations with NASA and other US agencies. She and her students have made major contributions to our understanding of ionospheric behaviour in the southern hemisphere and the generation and behaviour of ionospheric irregularities that cause scintillation of radio signals which in their severest form render GPS useless.

Elizabeth helped forge research links between La Trobe and the Australian Antarctic Division and several of her postgraduate students spent periods in Antarctica installing and operating equipment. In the 1990s she initiated La Trobe's partnership with the Co-operative Research Centre for Satellite Systems, the organisation that developed the Australian satellite FedSat launched in 2002. Elizabeth was project leader for FedSat's space-based GPS observations and experiments, with one of the main aims being to develop tomographic imaging of the plasmasphere from the FedSat orbit. This has been immensely successful and is an ongoing program with a major topic being the study of recently discovered plumes of ionisation that extend from the ionosphere up through the plasmasphere.

Elizabeth was quiet, gentle, yet very determined. She was widely respected as an academic and a person. She was a competent lecture and an important role model, particularly helping female students forge their careers in physics. She attended Grafton High School and on 23 July 2005 the school unveiled a plaque to commemorate her significant achievements.

Elizabeth is survived by her husband Harvey Cohen, a mathematician and children David, Alexander, Raymond and Zara.

Antimatter: a short history 5

Stuart Tovey
School of Physics, University of Melbourne, Victoria, Australia

Introduction

The existence of antimatter is experimentally well established. This article discusses its prediction, discovery and its use today.

Antimatter has often featured in works science fiction, starting as early as the 1940s. Often the pioneer in this genre, Isaac Asimov talks of "positronic brains" for robots. Probably the most well known work of fiction to utilise antimatter was the *Star Trek* television series and motion pictures.

However the facts about antimatter are far more interesting than fiction. There is an old adage that yesterday's discovery is today's signal, then tomorrow's background. Antimatter has not followed that route. It's now a very useful tool for seeking new particles and for diagnostic imaging, particularly in medical science.

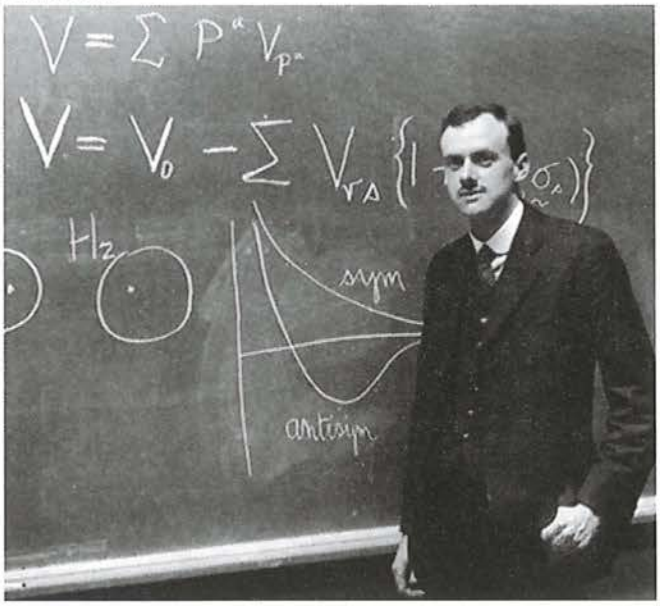
Finally, the puzzling lack of antimatter in the Universe today is discussed.

Dirac the man

In 1928 Paul Dirac published[1] his famous equation describing the electron. It is an elegant equation, which does not necessarily make it correct. In Dirac's view elegance was a necessary, but not sufficient, condition that an equation be correct. His equation remains the preferred description for the electron as well as for all other spin-half particles.

Dirac's equation is a relativistically invariant equation, and incorporates the spin of the electron in a natural way. It should be noted that the well-known Schrödinger equation is clearly non-relativistic[2], and does not include spin. Before discussing the equation and its implications in the next section, it is informative to discuss its author, a quite unique man.

Figure 1. Paul Dirac, the shy genius who predicted antimatter.



Richard Feynman[3] describes Dirac as his hero, and many consider him to be the only physicist working in the first half of the 20th century who should be compared to Einstein. While that may well be true of his achievements in physics, in every other sense they were total opposites.

Einstein was much celebrated, he was an extrovert and he became, and remains, a household name. To physicists he is remembered above all for his theories of relativity; to others he is most famed for the one equation ($E = mc^2$) that *everybody* knows. On the other hand very few non-physicists have heard of Dirac, and only a few physicists could write down his equation.

Dirac (Figure 1) was born in Bristol (UK) in 1902. His father was from the French speaking part of Switzerland, and French was often spoken in the Dirac household. However, Paul never expressed himself well in French and was reluctant to speak it. It's been suggested that that is why he remained shy and introverted for his whole life, but that seems implausible to me. He studied electrical engineering at the University of Bristol, and worked briefly as an engineer. He soon decided that his true calling lay in the mathematical sciences. He completed a degree in mathematics at Bristol, before moving to Cambridge where he remained for most of his life.

He hated publicity. To give an extreme example, in 1933 after his work had been experimentally vindicated, Dirac was offered a share of the Nobel Prize, together with Erwin Schrödinger. Amazingly he wanted to decline the prize, fearing the publicity that it would bring! It took Ernest Rutherford to convince him that refusing the prize would bring much more publicity.

Among his colleagues Dirac was known for his precise and taciturn nature. Two examples will suffice:

- While visiting the USSR he was invited to lecture on his philosophy of physics. He merely stood up, said nothing and wrote on the board: 'Physical laws should have mathematical beauty and simplicity.'
- In the USA he was asked what he liked most about America. The answer was simple: 'Potatoes'.

The Dirac Equation

The Dirac equation quickly passed many tests as an accurate description of the relativistic, spinning electron,

Antimatter: a short history

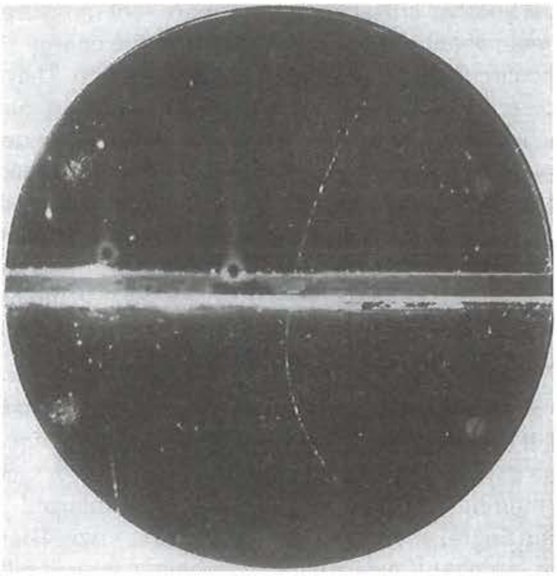


Figure 2. One of the first observations of a cosmic-ray positron

and that is still the case today. To give just one example, it predicted the correct relationship between the spin of an electron and its magnetic moment. An earlier theory, due to Pauli, gave the wrong ratio by a factor two.

In its most elegant, covariant form, the Dirac equation for a free electron may be written as:

$$i\gamma_\mu \delta_\mu \psi = m\psi$$

where the γ_μ (μ = 1,4) are 4x4 complex matrices, generalised versions of the Pauli spin matrices.

The wave function ψ is a 4-component spinor, but only two components of the spinor are needed to describe the electron.

The remaining two components correspond to states of negative energy. Or they can be interpreted as an antiparticle, with positive energy, travelling backwards in time. Dirac only knew of one positively charged fundamental particle, the proton, and for a short time he tried to argue that the proton was the anti-electron. However he was a great devotee of symmetry, and the mass ratio (nearly 2,000) between the proton and the electron made this hypothesis most unattractive to him.

Discoveries of the first antiparticles

The Antielectron.

The anti-electron, more usually called the positron, was discovered[4] by Carl Anderson at Caltech a few years later, in a cloud chamber exposed to cosmic radiation.

Many physicists were exposing cloud chambers to cosmic radiation at that time, but Anderson's experiment had an extra edge. His chamber had a diameter of 17 cm, quite large at that time, and was located in a very strong magnetic field. The field reached 2.4 *T*, about 10^5 times the Earth's field, and was powered by a 600 kW generator - very large for the time. In a magnetic field positive and negative tracks curve in opposite directions. He soon saw a number of tracks (15 in all) that could either be due to upward moving electrons or to downward travelling positive particles with roughly the same mass as an electron. At these momenta electrons and protons leave distinctly different tracks, and so the hypothesis that the downward tracks were caused by protons was easily excluded.

Anderson resolved the up-down ambiguity by putting a thin lead plate in the centre of the chamber, which clearly indicated his tracks were caused by downward travelling positive particles that lost energy in the plate. In his most often published photograph (Figure 2), a downward travelling positron enters the plate with energy of 60 MeV and exits with 20 MeV. It is inconceivable that an upward travelling electron could gain 40 MeV in a lead plate.

Although Anderson's paper is titled *Observation of a Positive Electron* it took time to identify this discovery with Dirac's predicted particle. Theorists in Cambridge (UK) and experimenters in California (USA) were largely ignorant of each other's work.

It should be noted that there is no evidence for the existence of positrons in the *primary* cosmic rays. Anderson's positrons were *secondary* particles created by an electromagnetic cascade in the atmosphere.

Blackett and Occhialini in Cambridge using a cloud chamber first observed the "pair conversion" of a photon, soon after Anderson's discovery. In every way this is a more dramatic phenomenon as it shows the creation of matter-antimatter pairs. The reaction

$$\gamma Z \rightarrow e^+ e^- Z^*$$

can only occur in matter. In order to conserve four-momentum a target particle (Z) and a recoil particle (Z^*) are needed.

A more recent bubble chamber photograph (Figure 3) shows two photons converting. The photons enter from above. One photon (top) converts on an electron target and an energetic recoil electron is seen ($Z = Z^* = e^-$); such events are called "tridents". The other photon (bottom) converts in the field of a nucleus and the recoil nucleus is too short to produce a visible track. The applied magnetic field causes oppositely charged particles to spiral in different ways. Tracks have been artificially coloured green (negative) and red (positive).

Soon after this Anderson discovered the muon, or heavy electron, although at that time he associated this newly discovered particle with the π-meson, the putative carrier of the nuclear force that had been recently proposed by Yukawa. It took over ten years to resolve that issue.

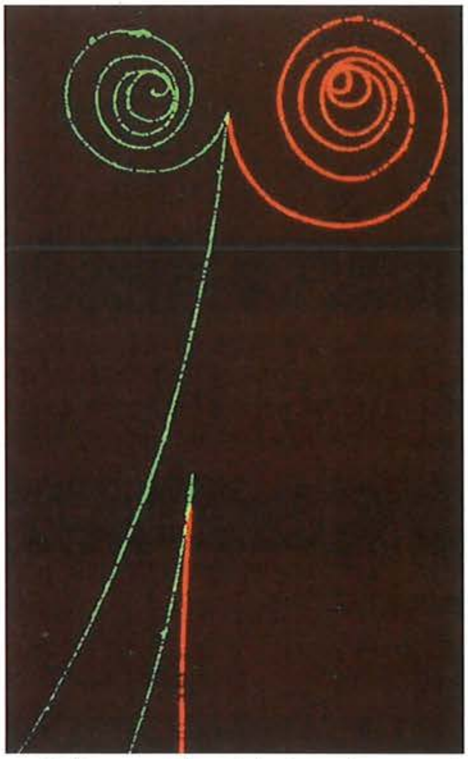


Figure 3. Two examples of photon pair conversion. See the text for details.

The Antiproton.

Because of its larger mass, the discovery of the negatively charged antiproton had to wait until higher energy accelerators could be built. The Bevatron[5] at Berkeley, California (Figure 4), started working in 1954, with a design kinetic energy of 6.2 GeV, and with the prime goal of finding the antiproton. Three experiments were constructed to search for the antiproton. That discovery[6] took 18 months to achieve as the favoured reaction ($pp \rightarrow pp\, p\bar{p}$) occurred rarely, roughly once in every million interactions. The "winning" experiment utilised what were, for those days, sophisticated data analysis tools. It measured the time that the putative antiprotons took to travel the *12 m* between two detectors. Antiprotons, being heavy, travelled relatively slowly, taking 51 ns. The background particles, mostly π^--mesons, took just 40 ns. Measuring times to that precision was far from routine in those days, but it is clear (see figure 10 of their paper) that they did achieve that precision. After considering the shape of the pulses they could measure times to 1 ns, which they quaintly called a "milli-microsecond".

However in their negatively charged secondary beam π^--mesons outnumbered antiprotons by a factor of about 10^5 and two π^- traversing the apparatus at nearly the same time could fake the timing of an antiproton; today this problem is called "pile up". In order to cross check, the experiment also measured particle speeds using a Cerenkov counter. As yet another crosscheck, the experiment measured the yield of antiprotons as a function of the energy of the circulating proton beam in the Bevatron. They discovered a significant amount of antiproton production at an incident kinetic energy below 5 GeV, well below the nominal threshold energy of 5.6 GeV. This "discrepancy" is informative. The internal Bevatron target was made of Copper and, for target protons within a Cu nucleus, the threshold drops to 4.3 GeV if the target proton has a kinetic energy of just 20 MeV directed towards the beam particle. This illustrates the power of colliders in which moving particles strike a moving target particle.

The story of the discovery of the antiproton has a sad end. It was made by a team of 4 physicists, large for those days, unbelievably small for today. However, only two members of the team (Owen Chamberlain and Emilio Segrè) shared the deserved Nobel Prize. The third team member (Clyde Wiegand) remained forever bitter at his exclusion. The fourth Thomas Ypsilantis was a graduate student, and there is a long history of ignoring their contributions when awarding honours.

More Antiparticles.

Following these two historically significant discoveries, many more antiparticles were found. In the next decade the antineutron and the antideuteron were added to the list.

We now know that many hundreds of mesons exist. Quarks are spin-half particles that obey the Dirac equation[7]. Mesons are quark-antiquark pairs, and their existence is a clear indication for antiquarks. The simplest meson, the π-meson, proposed by Yukawa in 1935 as the carrier of the force between nucleons is now understood as a quark-antiquark ($q\bar{q}$) pair, built from the up *(u)* and down *(d)* quarks and their antiparticles ($\bar{u}, \bar{d}$).

Figure 4. The Bevatron at Berkeley with the leaders of its construction, Ed McMillan and Edward Lofgren.

Antimatter: a short history5

The heaviest mesons studied in detail are B-mesons, in which a light quark *(u,d)* combines with a heavy antiquark ($\bar{b}$). There will be more about B-mesons later in this article.

The properties of Antiparticles

The positron is a point-like elementary particle, like its sibling the electron. The antiproton is a composite particle, consisting of three antiquarks ($\bar{p} = 3\bar{q} = \bar{u}\bar{u}\bar{d}$) and the dynamics of its annihilation with a proton ($p = 3q = uud$) were of greater interest.

Within a decade of its discovery, beams of antiprotons were routinely available at what were then the highest energy accelerators, the Proton Synchrotron (PS) at CERN and its equivalent (the AGS) at the Brookhaven National Laboratory (BNL) near New York. Both machines accelerated protons to about 28 GeV, and these protons produced a few antiprotons when they struck a target. Magnetic fields can be used to select particles of a definite charge (in this case negative) and momentum. Then electrostatic fields can be used to select particle speeds, thus separating antiprotons from other negatively charged particles (mostly π^-). The yield was about $10\bar{p}$ every machine pulse, typically about every 3 s. Not a high yield but well matched to the bubble chambers, which were the main detectors used in the 1960s. A University of Melbourne team was very active in this field[8]. A sample of over $10^6\bar{p}d$ interactions was recorded at BNL and subsequently analysed in Australia, the first venture of this country into accelerator based HEP.

Figure 5 shows a $p\bar{p}$ annihilation into eight π–mesons. The bubble chamber tracks have been artificially coloured. An antiproton (white) enters from the top and annihilates into four π^--mesons (green) and four π^+- mesons (red).

The mass production of antiparticles

We can now produce billions of antiparticles and study e^+e^- and $p\bar{p}$ annihilations. Such machines are called *matter-antimatter colliders*. The main purpose of these machines is not to study antimatter, but to use it as a tool to make new discoveries. Normally the incoming particles have equal energies, and opposite momenta, and the centre of mass (cms) energy is just twice the energy of each incident particle. Recently asymmetric matter-antimatter colliders have been built for specific purposes.

This cms energy limits the masses of particles the collider can produce, the higher the better if the aim is new discoveries. The other key parameter is the luminosity of the machine, a measure of the beam intensity, which determines how many events are produced.

The instantaneous luminosity (L) is defined via:

$$\frac{dN_i}{dt} = L \times \sigma_i$$

where dN_i/dt is the production rate of a certain final state and σ_i is the cross section to make that final state. Traditionally L is given in the units $cm^{-2}s^{-1}$ and so σ_i should be given in cm^2 rather than the more familiar *barns* ($1b = 10^{-24}cm^2$).

Over a period of time a useful measure is the integrated luminosity, which determines the total number of events of a given type produced:

$$N_i = \int L dt \times \sigma_i$$

Paradoxically integrated luminosities are given in units such as nb^{-1}, in which case cross sections must be expressed in *nb* (even physicists are not always logical!)

Electron-positron colliders

Given that positrons are easy to make compared to antiprotons, e^+e^- colliders, beginning in the 1960s, have a longer history than $p\bar{p}$ colliders. Only a few recent

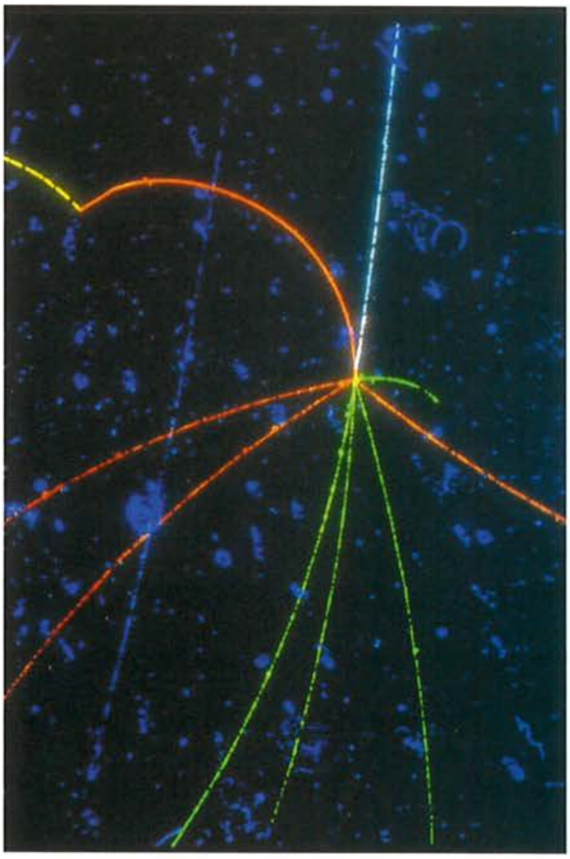


Figure 5. An antiproton-proton annihilation, which creates 8 π-mesons. See the text for details.

Antimatter: a short history5

frontier e^+e^- machines are discussed here: one operated until recently at the energy frontier and two are currently operating at the luminosity frontier.

The "Large Electron-Positron" collider (LEP) at CERN was a symmetric collider and operated at the energy frontier. In its final year (2000) the cms energy was just over 200 GeV. LEP achieved a peak luminosity of more than 10^{32} $cm^{-2}s^{-1}$ and an average integrated luminosity of better than 1 pb^{-1}/day. LEP was an outstanding success and created over $2x10^7$ Z^0 particles, where Z^0 is the neutral particle that transmits the weak force.

Post-LEP saw the construction of asymmetric e^+e^- colliders at the luminosity frontier. Two were constructed, one (KEK-B) in Japan and one (PEP-II) in the USA. An Australian team, from the Universities of Melbourne and Sydney, are a major part of the Belle experiment at KEK-B and so that machine will be discussed here.

KEK-B delivers luminosities of over 1.4 x 10^{34} $cm^{-2}s^{-1}$, a world record, slightly better than PEP-II and more than two orders of magnitude better than LEP. KEK-B collides 8 GeV with 3.5 GeV. Figure 6 shows the inside of the KEK-B tunnel with the e^- and e^+ rings clearly visible. The KEK-B tunnel has a circumference of about 3 km and the beams collide at one point, where the Belle detector is located.

The KEK-B cms energy is exactly tuned to a resonance that favours the reaction:

$$e^+e^- \rightarrow \Upsilon(4s) \rightarrow B\,\overline{B}$$

in order to copiously produce pairs of B and anti-B mesons. B-meson decay does not respect CP-symmetry, of which more below. The asymmetric energies give the $B\overline{B}$ pair a Lorentz boost along the beam axis. B-mesons have a lifetime, in their rest frame, of less than 10^{-12} s. The Lorentz boost causes them to travel a measurable distance in the detector (over 100 μm).

Proton-antiproton colliders

It was not until the 1980s that accelerator scientists understood how to produce and accelerate significant numbers of antiprotons. A key to this process is the problem of "cooling" the antiprotons so that they occupy a small volume in phase space — small enough to match the limited phase space acceptance of accelerators.

The SuperProton Synchrotron (SPS) at CERN, which until then had accelerated protons to 450 GeV and collided them with a stationary target, was converted to a $p\bar{p}$ collider, the so-called $Sp\bar{p}S$. Counter rotating beams of protons and antiprotons could be accelerated

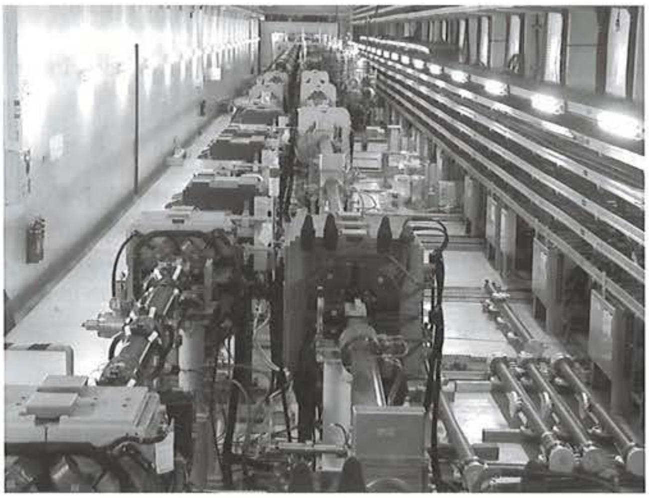


Figure 6. Inside the tunnel at the KEK-B e^+e^- collider in Japan.

in the same vacuum pipe, and made to collide at several points. Two experiments were built at those points: UA1 and UA2. (UA stands for "Underground Area".)

Operating the $Sp\bar{p}S$ was an amazing challenge. It took 24 hours to accumulate enough antiprotons (typically about 10^{12}) in a small region of phase space in order to provide a rotating beam in the main accelerator. Then the protons and antiprotons had to be simultaneously accelerated. The counter-rotating beams were then allowed to collide for up to a day, while the next "stack" of antiprotons was being made.

Both experiments were a great success. They found the $W^\pm$ and Z^0particles - the carriers of the weak force. The $W^\pm$often decays to a $q\bar{q}$ pair. Reversing the flow of time means that $W^\pm$ can be produced in $q\bar{q}$ collisions and these are best achieved in $p\bar{p}$ collisions.

UA2 was the first experiment at CERN in which an Australian group participated as a full collaborating institute, albeit only after the UA2 upgrade in 1986. It is therefore natural to include a photograph (Figure 7) of UA2. At the time it was a very large detector.

The major $p\bar{p}$ collider operating today is the *Tevatron*[9] at Fermilab near Chicago, which operates at a cms energy of 2 TeV.

Neutral antimatter atoms

In 1997, in an ingenious experiment at CERN, a small group succeeded in making a positron and an antiproton bind together to form neutral anti-hydrogen ($\overline{H} = \bar{p}e^+$). A total of about 10 events were found[10]. Amazingly this observation made instant news around the world. Typical headlines were:

- "Scientists create the fuel of science fiction" (*The Times* of London)
- "The gate of the Shadow Kingdom (*Der Spiegel*, Germany)

Antimatter: a short history

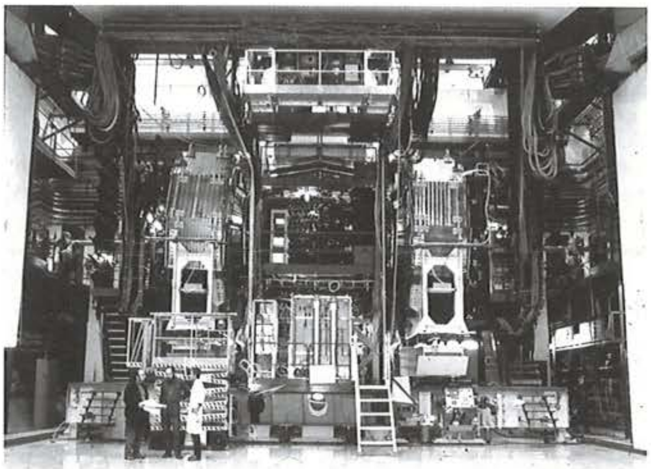


Figure 7. The UA2 detector at CERN, one of two experiments working at the $p\bar{p}$ collider in the 1980s.

Just why is unclear. Physicists had been creating and studying billions of antiparticles for many decades. And neutral anti-hydrogen is hard to confine, whereas charged positrons and antiprotons can be confined using electromagnetic fields.

This is not to belittle the experiment concerned. A positron-antiproton collision occurs as an unbound state. The skill was in carrying away enough energy and momentum to create a bound state ($\bar{H} = \bar{p}e^+$) and a recoil system. The reaction studied was:

$$e^+ \, \bar{p} Z \rightarrow \bar{H} \, Z'$$

where Z is a nucleus, which carries away four-momentum as Z'.

It was a very significant achievement, but not deserving the press coverage that it received.

Matter-antiparticle asymmetry

We live in a matter-dominated world and yet the Big Bang created equal amounts of each. A full discussion is way beyond the scope of this article. These brief notes are based on a recently published and very accessible text[11].

Let $N_B, N_{\bar{B}}, N_\gamma$ be the number densities of baryons (mostly protons), antibaryons and photons in the universe. Early in the universe when the temperature (kT) was large compared to nucleon masses ($m_p c^2$) then the reactions:

$$p + \bar{p} \leftrightarrow \gamma + \gamma$$

would cause $p\bar{p}$ pairs and radiation to be in thermal equilibrium. When the temperature of the universe dropped to about $kT = 20$ MeV these numbers should have been "frozen out". Most predictions give ratios of about:

$$\frac{N_B}{N_\gamma} = \frac{N_{\bar{B}}}{N_\gamma} \approx 10^{-18}$$

Recent measurements give

$$\frac{N_B}{N_\gamma} = (4 \pm 2) \times 10^{-10} \text{ and } \frac{N_{\bar{B}}}{N_B} \leq 10^{-4},$$

where the last figure on the $\bar{B}/B$ ratio is conservative. Obviously there are *large* discrepancies between theory and observation. How might they arise?

As long ago as 1966 Sakharov[12] showed that three conditions are required in order that a baryon asymmetry could arise from an initially baryon-antibaryon symmetric universe. These are:

- The existence of baryon-number violating interactions. These are predicted by some Grand Unified Theories, but have yet to be seen experimentally, for example in proton decay searches.
- A period of non-equilibrium in the early universe. This can occur in inflationary models.
- A violation of both CP and C symmetries, where C (Charge Conjugation) converts particles into antiparticles and P is the parity operation, closely related to mirror reflection. This is discussed in the next section.

The hypothesis is that a small excess of matter over antimatter formed in the very early universe, perhaps 1 part in 10^{-9}.

$$N_B \big/ N_{\bar{B}} \approx 1 + 10^{-9}$$

The antibaryons all annihilated with baryons producing radiation (γ), leaving a very small residual $\bar{B}/B$ ratio. The photons produced in these annihilations contribute to the dominator in N_B/N_γ.

It should be emphasised that this hypothesis is just that. It is the best explanation of the ratios given above, but it is by no means established. However the existence of a $\bar{B}/B$ asymmetry, both in our galaxy and in the universe in general is well established.

CP violation

It has long been known that the weak interactions strongly violate both C and P invariance. The combined CP symmetry is almost but not quite respected in the decays of neutral *K*-mesons, but is significantly broken in the decays of neutral *B*-mesons.

By far the best observations of CP violation[13] have been recorded over the last 5 years at the asymmetric e^+e^- colliders, termed "B factories", mentioned above.

Antimatter: a short history

Although these results are very exciting, the level of CP-violation observed is not sufficient to explain the observed $B\bar{B}$ asymmetry. Far larger CP-violating effects must have occurred in the early universe.

Antimatter as an energy source for weapons or rocket fuel

The idea of using antimatter as a rocket fuel was made popular by the *StarTrek* series. How plausible is that?

The energy released when a $p\bar{p}$ pair annihilates is immense. The rest mass of both particles is released; that is 940 MeV per particle. That is to be compared with 7 MeV per proton produced in the pp fusion reaction in stars or in H-bombs. Antimatter annihilation is over two orders of magnitude more efficient than fusion.

The problem is that it takes a lot of energy to create an antiproton, far more than the 940 MeV released when it annihilates. As discussed above the $p\bar{p}$ collider at CERN was a copious source of antimatter, and it ran for about a decade. If all the antiprotons produced at CERN in that time were collected and made to annihilate on protons, they would power a 100 W light bulb for about a minute! And the ratio of energy produced to energy expended was about 10^{-10}. Obviously antimatter as a source of energy is hopeless for everyday use.

One might argue that the builders of weapons and spaceships have almost unlimited funds. The problem that they face is the storage of antimatter until its energy is needed. If solutions to this problem have been found, they are certainly not published.

Antimatter as a tool

The most widely used application of antimatter today is in Positron Emission Tomography (PET), in particular in medical imaging.

In PET a patient is injected with a substance that includes an isotope that decays via positron emission. In tissue a positron from a typical β^+-decay travels a few millimetres before coming to rest and annihilating an electron. The result is two photons, each with energy equal to the electron's rest mass (511 keV) travelling "back to back". The detection of these photons, and many similar pairs, allows the site at which the isotope has been concentrated to be located. Many excellent reviews exist. PET is also widely used in medical research, in particular into the functioning of the brain.

Summary

In roughly eighty years antimatter has changed from a being a bold prediction by an unsung genius, Paul Dirac, to being a useful tool, both to particle physics and to medical science. That's quite an odyssey, even compared to that of *Star Trek*!

Further reading

A Google search for books with antimatter in the title produces many results. The best of the bunch is *Antimatter*[14] by Gordon Fraser, erstwhile editor of the CERN Courier.

In *The Physics of Star Trek*[15] Lawrence Krauss, himself a respected theorist in HEP, shows how many loopholes exist in this work, which he nevertheless regards as an important work of fiction and a stimulus to scientific imagination. Stephen Hawking wrote the forward.

References

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2. The space coordinates enter as second derivatives, while time enters as a first derivative.

3. R. Feynman in *Elementary Particles and the Laws of Physics*, Cambridge University Press (1987).

4. C. Anderson, *Phys. Rev.* **43** (1933) 491 - 494.

5. At that time, at least in the USA, the unit BeV was used, where1 BeV = 10^9 eV. Today the unit GeV is universally used for this quantity.

6. O. Chamberlain et al, *Phys.Rev.* **100** (1955) 947 -950.

7. Quarks do not obey the Dirac equation for a *free* particle given above. The evidence is that quarks only exist as bound states.

8. R. D. Burrows et al, " $\bar{p}\,d$ Topological cross- sections in the momentum range 50–920 MeV/c". *Aust J Phys* **23** (1970) 819–821.

9. 1 TeV = 10^{11} eV .

10. G. Baur *et al,*. *Phys.Lett.* **B368** (1996) 251-258.

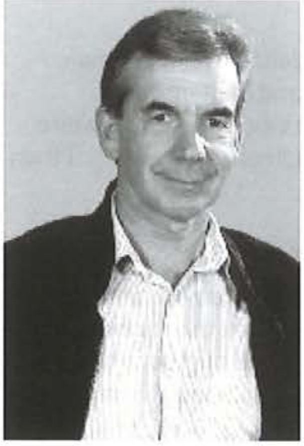
11. D. H. Perkins, *Particle Astrophysics*, Oxford University Press (2003)

12. A. Sakharov, *JETP Letters* **5** (1967) 24.

13. See for example K. Abe et al, "Observation of large CP violation in the neutral B-meson system", *Phys. Rev. Lett* **87** (2001) 091802. This paper has received over 350 citations.

14. G. Fraser, *Antimatter*, Cambridge University Press (2000).

15. L. Krauss, *Beyond Star Trek: From Alien Invasions to the End of Time*, HarperCollins (1995).



Stuart Tovey obtained his B.A. from the University of Cambridge and his Ph.D. from the University of Bristol in the U.K. He joined the University of Melbourne in 1975 and is currently a Principal Fellow in the Experimental Particle Physics group there. His ongoing interest for over 30 years has been experimental High Energy Physics. In that period he has worked on four experiments involving the study of antimatter.

Conferences

2006

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

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

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

2007

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

February 15 -17
6th Biennial Australian and New Zealand Society of Biomechanics Australasian Biomechanics Conference – ABC6
Auckland, NZ.
www.cce.auckland.ac.nz/conferences/index.cfm?P=9173

April 15 - 19
5th World Conference of Science Journalists
Sydney, Australia
www.scienceinmelbourne2007.org/

July 2 - 6 ,
18th International Conference on General Relativity and Gravitation & 7th Edoardo Amaldi Conference
Melbourne, 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/

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

2008

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

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

Press Room Government media releases relating to science

Science, Technology and Maths Teaching Innovations

On 8th November the Minister for Education, Science and Training, the Hon Julie Bishop MP, announced a new third round of the $33.7 million Australian School Innovation in Science, Technology and Mathematics (ASISTM) Project which will help invigorate science, technology and mathematics classes in Australian schools.

"These innovative projects achieve an unprecedented level of collaboration between Australian schools and universities, industry, science organisations and the broader community," Minister Bishop said. "The Australian Government has invested more than $6.5 million in 98 new ASISTM projects nationwide, bringing total funding to $23 million.

"This key initiative is part of the Government's commitment to develop innovative and effective science, technology and mathematics teaching in schools and to maximise Australia's scientific and technological potential.

"Funding grants of between $20,000 and $80,000 will go to 586 different schools and around 324 partner organisations. These projects follow on from the 202 diverse and innovative projects announced in the previous two rounds of the ASISTM Project."

A list of successful Round Three projects and further information about ASISTM is available at: *www.asistm.edu.au/*

Australians to Prosper from $365 Million in Research Projects

The Minister for Education, Science and Training, the Hon Julie Bishop MP, announced $365,069,342 in Australian Research Council grants on 11th October 2006.

The 1,154 grants were awarded in the latest Australian Research Council funding round for its two major schemes—*Discovery Projects* and *Linkage Projects*—and three smaller schemes, *Discovery Indigenous Researchers Development; Linkage Infrastructure, Equipment and Facilities;* and *Linkage International.*

"The projects funded today affect the whole community. Issues that are important in the lives of all Australians such as our health and wellbeing, the environment, and national security are all represented in the successful research projects".

Among the many successful projects are research programs that will:

- study the role that participation in organised extracurricular activities may play in the healthy development of Australia's youth (Murdoch University)
- develop micro-robots that will be powered to 'swim' through the vascular and digestive systems of the human body to perform medical tasks via remote control and, in many cases, avoid invasive major surgery (Monash University)
- investigate previously unmapped venom systems for divergent, bioactive proteins with practical implications for the treatment of envenomations (from sources such as snakes, spiders, mosquitos and jellyfish), which is a recognised problem in Australia, as well as drug discovery and other commercial applications (The University of Melbourne)
- develop service delivery systems in the criminal justice system to better meet the needs of victims and witnesses (Monash University and Victoria Police).

Minister Bishop praised the 380 organisations partnering ARC-funded researchers in the *Linkage Scheme*, which have pledged a total of $105,481,215 in cash and in-kind to the successful projects, representing $1.77 for each dollar provided by the Government.

"When an independent organisation invests in an ARC-supported research program, it can be confident that it is committing its hard-earned dollars not only to a worthwhile project, but to a project undertaken by some of Australia's best researchers," Minister Bishop said.

In this round, average funding for *Discovery Projects* increased by 12 per cent on the previous funding round to $334,267 per project, while average *Linkage Projects* funding increased by 9 per cent on the previous funding round to $285,745 per project. The successful projects were selected from a record number of 4,834 applications and will begin in 2007.

For more information, visit *www.arc.gov.au.*

Cooperative Research Centres boost economy by $2.7 billion

On 18th October, the Minister for Education, Science and Training, the Hon Julie Bishop MP, released a report that shows the work of Cooperative Research Centres (CRCs) boosts the Australian economy by an estimated $2.7 billion.

The *Economic Impact Study of the CRC Programme* measured net economic benefits for the economy for the period 1991 to 2010. The report only considered benefits that could be quantified by industry and occurred as a direct result of the CRC Programme's research, training and commercialisation activities.

Minister Bishop said that the CRC Programme has played a key role in supporting the success of Australian industry in global markets.

"The report shows the net benefits of the CRC Programme are at least twice the level calculated previously. The return to Gross Domestic Product (GDP) for each dollar invested in the CRC Programme is $2.16 a return of more that 2:1."

"The 2006 study shows that as a result of the research, training and commercialisation activities of the CRCs, Australian GDP has been increased by nearly $2.7 billion."

The Economic Impact Study of the CRC Programme report is available from *www.crc.gov.au/*

$93.8 million in Capital Funding for Universities

On 6th September, Minister for Education, Science and Training, the Hon Julie Bishop MP, invited eligible higher education providers to apply for $93.8 million in funding from the Capital Development Pool (CDP) Programme.

The Government has restructured the CDP programme so universities can apply for funding for projects spanning 2008-09. Funding will also be available for projects in 2007. In total, the amount available for allocation in this round will be about double that of the last round. All successful projects will be announced later this year.

All eligible higher education providers have been sent invitations to apply for CDP programme funding.

Australian students to get international qualifications "passport"

Australian university students will in the future receive a qualifications "passport" to improve international recognition of their qualifications and open the door for long term educational and employment exchange, the Minister for Education, Science and Training, the Hon Julie Bishop MP announced on 7th September.

"The Australian Government will invest $400,000 for the development of a template for an *Australian Diploma Supplement* by a consortium of universities," Minister Bishop said."The ultimate aim for an *Australian Diploma Supplement* is to assist students and employers, both at home and abroad."

The *Australian Diploma Supplement* will be a translation tool, outlining a student's achievements, the learning outcomes of their particular course of study, provide information about the university awarding the qualification and, potentially, promoting the Australian system of higher education worldwide.

Development of the *Supplement* is in response to feedback to the Minister's discussion paper, *The Bologna Process and Australia: Next Steps.* It also follows on from the Brisbane Communiqué as a result of the Asia-Pacific Education Ministers Meeting, hosted by Minister Bishop in April this year.

Further information on the Diploma Supplement is available at *http://aei.dest.gov.au/aei/governmentactivities/diplomasupplement* Further information on the Brisbane Communiqué is available at */www.dest.gov.au/sectors/international_education/communique_doc.htm*

Inaugural materials conference provides meeting ground for materials sector professionals to cross interdisciplinary boundaries

Materials scientists, nanotechnologists, physicists, chemists, different types of engineers and industry practitioners will be gathering in **Sydney in 4-6 July 2007** to take part in Australia's newest and largest interdisciplinary scientific and technical meeting for the communication of the latest advances in materials science, engineering and technology.

Materials Australia and the Australian Ceramics Society, the two sponsoring organizations of this initiative are committed to fostering the strong communication links that are essential across an increasingly interdisciplinary Materials community. The shared vision of both bodies is for the biennial **MATERIALS & AUSTCERAM Conference** to become Australia's premier domestic, interdisciplinary materials event.

Besides providing the opportunity for showcasing many different areas of materials innovations, practical application and cutting edge research, the event will also provide a meeting place for researchers, academics and industry practitioners, and will create networking, ideas sharing and interaction between people from different yet complementary sectors of the broad materials community.

Recognising the emergence of interdisciplinary approaches to innovation both for fundamental R&D and for commercial breakthroughs, the International MATERIALS and AUSTCERAM Conference is bringing to Australia the first interdisciplinary conference and is encouraging stand alone materials related Institutes and Societies to take an active role in coordinating streams and sessions in their fields of expertise at this event.

The Conference will include national and international plenary lecturers, a range of scientific and technical symposia with invited speakers, oral presentations and poster sessions, with time allocated for discussion with authors at the posters and prizes for top posters. Postgraduate students are particularly encouraged to participate. Prof. Simon Ringer (The University of Sydney) and Dr. Dan Perera (ANSTO) are serving as Conference Co-Chairman and Dr. Julie Cairney (The University of Sydney) and Dr. Lou Vance (ANSTO) are Co-Chairing the Technical Program Committee. Helen Woodall and her expert staff at Materials Australia are serving as the Conference Secretariat. A number of symposium streams have already been earmarked, including Biomaterials, Materials for Energy and The Environment, Electronic, Photonic and Magnetic Materials, Advanced Ceramics and Computational Materials Science. On behalf of the conference organisers, you are your team are warmly invited to investigate the meeting details including the Technical Focus; Calls for Papers, Instructions to Authors; Timelines, Dates as well as other information are available on *www.materialsaustralia.com.au/ma2007*.

Dreamtime astronomy

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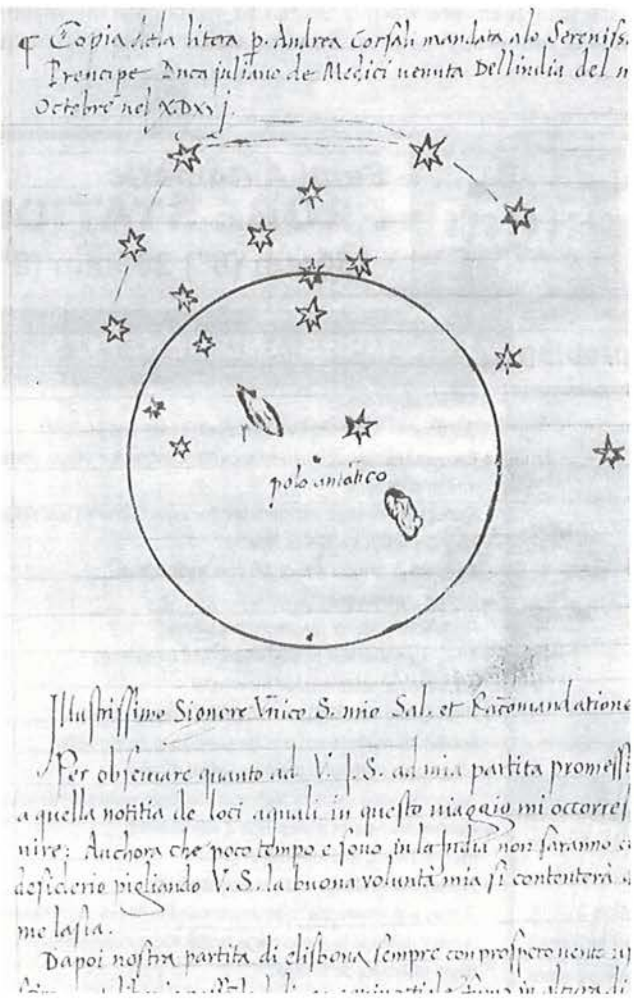
UWS Observatory, School of Engineering,
University of Western Sydney, NSW 1797, Australia

The Aboriginal people of Australia have lived continuously for well over 40,000 years on the Australian continent and their descendents still enjoy the wonderful spectacle of the Milky Way Galaxy which passes directly over-head. In that long period of time they built an astronomical knowledge system that they were able to absorb into their social, cultural and religious life. The system they constructed is different from that of modern day physicists and astronomers. It is not based on the hypothetico-deductive system that modern day physicists and astronomers use and validate by observation and experiment. It's a knowledge system based on other knowledge traditions – traditions that do not require or are not amenable to falsification of its tenets because it is socio-cultural astronomy.



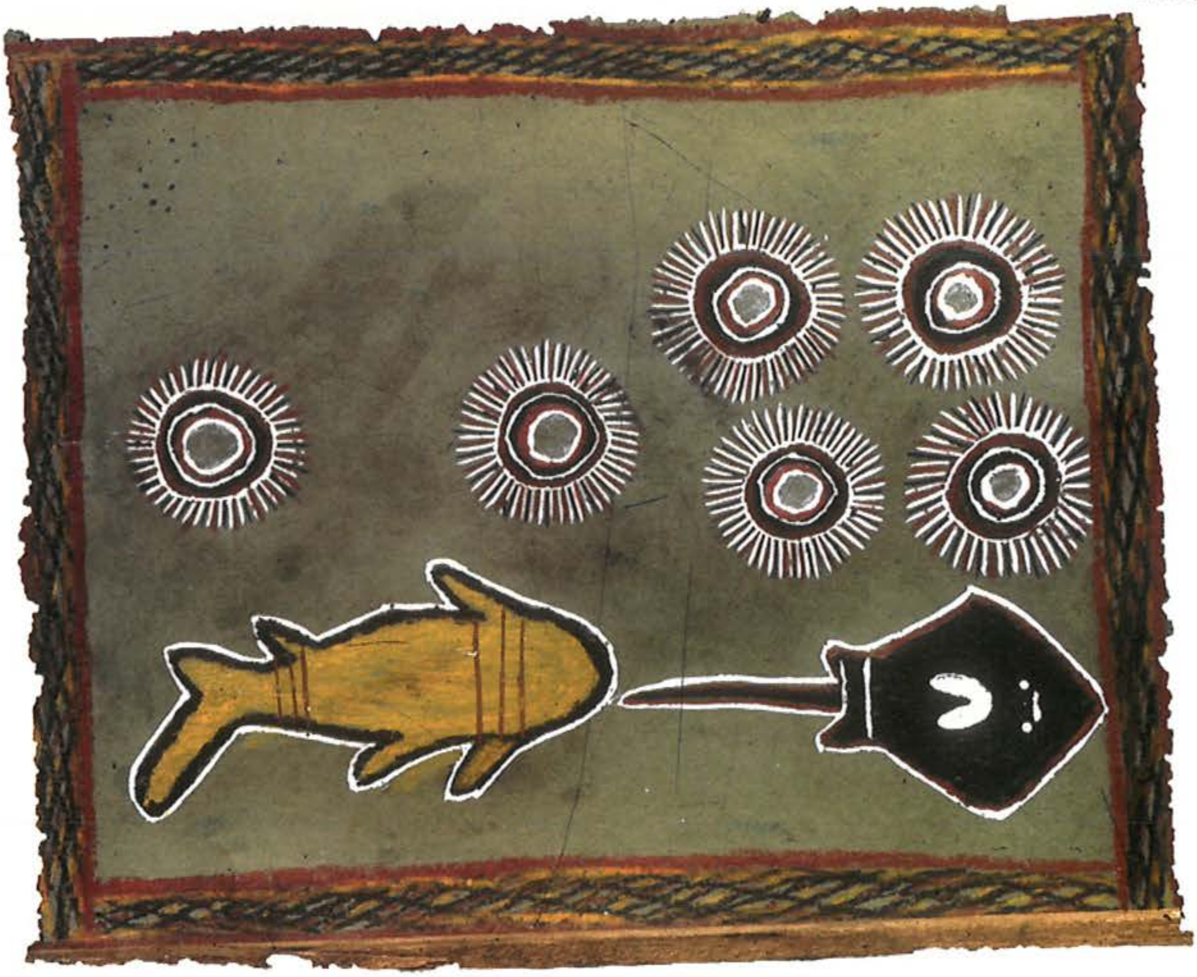
Drawing of the Southern Cross by Andrea Corsali. Mitchell Library, State Library of New South Wales.

Southern Cross

In all probability, the Aboriginal people were some of the first human beings to name the celestial objects in the sky. According to Daisy Bates, a Commonwealth Aboriginal Protector who lived with them for over forty years of her life in the late 19th and early 20th centuries, "Many of the star groups which we call constellations were divided and named by the Aborigines thousands of centuries before ancient Egyptians or early Greek astronomers observed and named them"[1]. Thus, the most conspicuous and well known constellation in the southern hemisphere, the Southern Cross was known as the "Eaglehawk's foot" while "the Pointers of the Cross being the Eaglehawk's Club and long before Canopus was named by some early Egyptian astronomer it was known to the central Australian Aborigines as joorr-joorr".

The well-known and late Aboriginal poet, Oodgeroo Noonuccal (Kath Walker), expresses the same sentiment when she talks about the origin of the Southern Cross. When she was growing up on Stradbroke Island off the coast of Queensland she was told stories of how the Southern Cross came into being. According to her, Biami, the Good Spirit in the sky, was extremely busy keeping an eye on the Aboriginal people but found he could not watch them all the time. He decided that he needed the assistance of someone to help him in his guardianship of his people. He chose a man named Mirrabooka who was not only loved by everyone but also looked after the welfare of his tribe. So, "Biame gave him a spirit form and placed him in the sky among the stars, and promised him eternal life. Biami gave Mirrabooka lights for his hands and feet and stretched him across the sky, so that he could watch forever over the tribes he loved. And the tribes could look up to him from the Earth and see the stars which were Mirrabooka's eyes gazing down on them"[2]. However, she says when the "white invaders came across the seas and stole the tribal lands, they did not know that this group of stars across the southern sky was Mirrabooka, and they renamed them. They named Mirrabooka the Southern Cross. In fact, Europeans first observed the Southern Cross only in the 16th century. Andrea Corsali, a Florentine traveler who sailed with a Portugeuse expedition to Goa in India in 1515, described a distinctive constellation of stars as a cross. It was variously named on star maps as 'cross', 'crosiers', 'crucero' or 'crux'[3].

The Southern Cross is known by many different Aboriginal names across the continent of Australia.



An Aboriginal drawing of the Southern Cross in which a sting ray (the Southern Cross) is chased by a shark (the Pointers). Image courtesy of the State Library of South Australia.

Like the American Indians, the Australian Aborigines are made up of many nations or language groups. So, it is not surprising that the constellations and celestial objects have different names and different interpretations placed on them amongst the various tribes spread across the length and breadth of Australia. Thus, to the fishing communities around Arnhem Land in Northern Australia the Southern Cross and the Pointers are represented as a sting ray (Southern Cross) being chased by a shark (the Pointers)[4]. The association with fish arises from their daily fishing activities and culinary tastes. In the desert regions of central Australia the Southern Cross represents the footprints of an eagle while the pointers (Alpha Centauri and Beta Centauri) are his throwing stick while the Coal Sack is his nest[5]. The present tense is used in describing the celestial objects and their interpretations because amongst the Aboriginal people (unlike the ancient peoples of other lands) the stories are still part of their present day living culture.

Aboriginal universe

Long before European explorers made contact with the Aborigines, the Aborigines of northern Australia had contacts with the Indonesian, Malay and Macassan fishermen who came in search of trade, of trepang (beche-de-mer) and tortoise-shell. However, when Europeans made first contact they labeled the Aborigines either as savages or noble savages according to the fancy of the person or persons who were recording their impressions in their notebooks or diaries or paintings. Later in the 19th and early 20th centuries ethnologists, anthropologists and scholars found that the Aborigines in fact had a complex socio-cultural religious system that was used to conduct their daily lives and the life cycle of birth, growth and death. Within this system astronomy had a role to play that was not only utilitarian but also associated with their cosmological view of the universe, their mythology and the morals and customs of their society. According to Dawson, "Of such importance is a knowledge of the stars to the Aborigines in their night journeys and of their positions denoting particular seasons of the year, that astronomy is considered one of the principal branches of education"[6]. Mountford in his classic study of the Aborigines of the central

desert of Australia echoes the same sentiment. He found, "the Aborigines of the desert are aware of every star in their firmament, down to the fourth magnitude, and most, if not all, of these stars would have myths associated with them"[5].

Modern day physicists and astronomers would probably have difficulty in empathizing with the Aboriginal conception and origin of the universe. Their universe is not the universe of the big bang, inanimate matter, dark energy, dark matter or the accelerating universe. Their universe is a living universe. In Aboriginal astronomy the origin of the universe goes back to a time called the Dreaming. It is a remarkable concept which Spencer and Gillen immortalized as the 'dreamtime' or 'alcheringa of the Arunta or Aranda tribe of central Australia[7]. According to Stanner, "A central meaning of the Dreaming is that of a sacred, heroic time long ago when man and nature came to be as they are; but neither 'time' nor 'history' as we understand them is involved in this meaning"[8]. The Dreaming is not only an ancient era of creation but continues even today in the spiritual lives of the Aboriginal people. All life, human, animal, bird or fish is part of an ever-transforming system that can be traced back to the Spirit Ancestors who go about the Earth in an eternal time called the Dreaming. As these spirit people roamed the Earth they made the mountains, rivers, the sky with its celestial objects and all the other features we see in the natural environment around us. The Aborigines are in fact co-creators of the universe they live in. The observer and the observed are the same entity.

Keen observers

The Aborigines were curious about the natural world. They were not only keen observers of the night sky but took much delight in classifying the physical characteristics of the stars above them. For example, the Aborigines of central Australia divided the sky into two groups, viz: the winter sky consisting of Scorpius, Argo, Centaurus and the adjacent stars belonged to the nananduraka group while the summer sky consisting of Orion, the Pleiades and Eridanus belonged to the tanamildjan group[5]. The Aranda of central Australia made a distinction between red, white, blue and yellow stars. The star Antares is classified as tataka indora, a very red star while the stars of the V-shaped Hyades cluster, which are taken to be two groups of girls, are divided into a red group (tataka) and a white group (tjilkera). The tataka stars are said to be the daughters of the red star Aldebaran[9].

By watching the movement of the stars the Aborigines of central Australia had discerned for themselves that certain stars neither rise nor set, i.e. they are circumpolar. Thus, they knew that the Iritjinga (Eagle) constellation, which was made up of some of the stars of the Southern Cross (Gamma and Delta Crucis) and the Pointers (Gamma and Delta Centauri), was circumpolar.

It is interesting to note that in Aboriginal astronomy it is not necessarily the case that only the brightest most conspicuous stars are grouped together when forming a constellation. This is illustrated in the case of the Aboriginal constellation Iritjinga (Eagle). In this group the stars of the Southern Cross, Alpha Crucis (with magnitude 0.75) and Beta Crucis (with magnitude 1.25), are connected by their marriage classes with the Pointer Alpha Centauri (with magnitude -0.04), whereas the stars Gamma and Delta Crucis (with magnitudes 1.56 and 2.78 respectively) are grouped with the less luminous stars Gamma and Delta Centauri (with magnitudes 2.18 and 2.56 respectively), in disregard of their close proximity to the brilliant stars Alpha and Beta Crucis[9]. [Note that the smaller the magnitude the brighter the star]. This different perspective arises as a result of grouping the stars in Aboriginal astronomy according to family and social relationships in Aboriginal society.

Commandments in the sky

The Aboriginal people use the celestial objects in the sky as a moral book to inform their people of how to conduct themselves. The rules they enact on land are transposed into the sky for all to read. For example, the star Aldebaran referred to above also serves to illustrate a story about what happens to people who are adulterers. According to the Aborigines of the Clarence River region in New South Wales Karambal (Aldebaran) stole the wife of another man and hid her in a tree. The husband set fire to the tree and the flames carried Karambal into the sky where he is easily seen and pointed out as the red star that is still burning[10].

Seasons and seasonal supply of food

Just like the ancient Egyptians and other ancient peoples the Aborigines associate the appearance of the stars at certain times of the year with the seasons and seasonal food cycles. When the Aborigines in Arnhem Land see Arcturus in the sky they know that it is time to harvest the spike rush or rakia which is used to make fish traps and baskets to carry food[4].

However, to the Boorong tribe who inhabit the Mallee country in the neighbourhood of Lake Tyrril in Victoria, Arcturus represents the spirit of Marpeankurrk who showed them where to find the pupa of the wood ant while Vega which represents the spirit of the Mallee hen showed them where to find her eggs[11].

On Groote Eylandt and Yirrkala in northern Australia the appearance of Scorpius represents different things to the tribes in these locations. On Groote Eylandt

the appearance of Scorpius informs the Aborigines that the wet season has come to an end and that the south-easterlies will begin to blow. According to the Aborigines at Yirrkala the appearance of Scorpius heralds the arrival of Malay fishermen who come to collect trepang[4].

The appearance in the dawn sky in late autumn of the stars that form the cluster called the Pleiades informs the Pitjantjatjara tribe in the Western Desert region that the annual dingo breeding season has begun. It provides a signal to the Aborigines to raid the liars and have a feast of the young pups[12].

Pleiades

The Pleiades also have another interpretation among the Aboriginal people. As in the stories about them in the many cultures around the world the Pleiades are considered to be a group of girls or young women by a number of the tribes of Aborigines in Australia. In Greek mythology the Pleiades are the daughters of Atlas who are running away from Orion and in order to escape from him they fly into the sky. In the central Australian Aboriginal stories of the Pleiades, the cluster of stars also represents young women who are fleeing from the unwelcome attention of Orion[5]. There is also a violent and unpleasant side to their stories. But not all stories are about violence and harassment by males. For example, in Melville and Bathurst islands in northern Australia the Pleiades are seen as a group of kangaroos that are eternally chased by pack of dingoes that are represented by the stars of Orion[5].

Unlike the stories about the Pleiades in other cultures, in Aboriginal society and culture the stories regarding the Pleiades have some restrictions. Some of the stories are common knowledge, while others are only known to men and still others are only known to women or told only to those who need to know. In the case of the stories only known to women they fall under the umbrella of "secret women's business". The stories about the Pleiades and other stories of the night sky have been handed down orally for thousands of years from one generation to another in Aboriginal society. This oral tradition and secret women's business about the Pleiades clashed with Australia's legal system in the 1990s in the well-known case of the construction of the Hindmarsh Island Bridge near Adelaide in South Australia[13]. The affair embroiled the Minister for Aboriginal Affairs, prompted a Royal Commission, scholarly reputations were questioned, careers were destroyed and the Aboriginal women were labeled as liars because it was said that they had fabricated their secret women's business stories to stop the bridge from being built. According to Dreamtime astronomy, before the Pleiades (the seven sisters) left the Earth and flew into the sky they went into the mountains and made springs of water to feed the rivers. Hindmarsh Island sits at the mouth of the Murray River where the fresh waters mingle with the salt waters before finally draining into the sea. The Aboriginal women claimed that the waters around Hindmarsh Island were secret women's business and that the bridge should not be built there, as it would constitute desecration of a sacred place. Building the bridge would impede the free movement of the Pleiades from the water to the sky and vice-versa. The waters had to do with creation and procreation in their culture. They lost their battle and the bridge was built. However, a subsequent Royal Commission found in favor of the Aboriginal secret women's business but it was too late. Nevertheless, it was seen as a moral victory for the Aboriginal women and their Pleiades. The women burnt the earlier report of the Royal Commission and marched through the streets holding up banners with a seven sisters design and bearing the words 'Elders tell no lies'.

Stars of the Tagai

The conflict between the oral history tradition of the Torres Strait Islander people and Australia's legal system in the much celebrated case of Mabo vs the State of Queensland and the Commonwealth of Australia in the High Court of Australia, had many ramifications for Australian society. The stars of the Tagai had a particular role to play in the outcome of this case. The stars of the Tagai were first studied and recorded by scholars of the Cambridge anthropological expedition to the islands in 1898. Tagai is a sea hero in the culture of the islander people. The stars of the Tagai are represented by a large constellation that consists of Scorpius, Lupus, Centaurus, Crux, Corvus, with part of Hydra and one star of Ara. According to the Meriam people in the eastern Torres Strait, Tagai is a man who is composed of Centaurus and Lupus standing in a canoe with a fishing spear (Crux) in his left hand and a fruit (Eugenia) in his other hand (Corvus). His canoe is made up of the body and tail of Scorpius. The story of the Tagai is about Tagai and his crew, who are made up of six Usiam (Pleiades) and six Seg (Orion) stars. His crew ate the food and drink that had been prepared for the journey. Tagai tied Usiam and Seg and threw them into the sea as punishment. Their images are reflected in the sky as the Pleiades and Orion constellations[14].

The stars foretold the seasons and gave the islanders a seasonal calendar which allowed them to regulate their cycle of fishing, agricultural, social, ritual and cultural activities. They also provided them with a cultural identity and laws to regulate their lives and codes of conduct. For example, when the Pleiades (Usiam) appeared in the sky it informed them that it was a sign of fair weather and time for sailing. It was also the turtle-mating season and a time to prepare the land

for planting before the rains came. The stars thus were evidence of the fact that the islanders had been tilling their lands for generations.

In their evidence to the High Court the Torres Islander people of Mer (Murray Island) spoke of following Malo's law - an ancestral spirit who gave them the law about their land, its ownership, its succession and trespass[15]. It was their land and they had for generations past and present occupied and used the land according to Malo's law. To them the law was akin to the law of the stars of the Tagai, which was integrated into their culture and society. The stars they said followed their own path across the sky and everything has a place and a path to follow. They had to follow the footprints of their ancestors. Their law had been passed down from one generation to another in their oral tradition. However, within the Australian legal system of common law, testimony may be classified as hearsay and it is therefore inadmissible as evidence. To the credit of the Australian legal system the majority of the judges accepted the oral tradition and Malo's law was placed on par with British common law. Thus, on 3 June 1992, the Full Bench of the High Court recognized Meriam rights to the Murray Islands. In handing down their judgment the judges noted "the Meriam people are entitled as against the whole world to possession, occupation, use and enjoyment of the lands of the Murray islands"[16]. Judge Brennan condemned the way common law "made the indigenous inhabitants intruders in their own homes and mendicants for a place to live". The case of the Meriam people ended the fiction of terra nullius (no man's land) that was first propagated by Captain Cook and continued by successive Australian governments and historians of Australian history. The case also showed how the stars played a role in the social and cultural traditions of the islander people.

Acknowledgements

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News

Concern for a secure career path for scientists

Grave concern for the future health and competitiveness of the nation's scientific research has been voiced by Australian Academy of Science President Professor Kurt Lambeck in the wake of the announcement of the latest Australian Research Council Discovery Project grants.

Despite the fact that an overwhelming number were deemed suitable, only 20 per cent of the 4,033 applications eligible for the $365 million in grants on offer have been approved.

Professor Lambeck said: "Only 49 applications were deemed ineligible, leaving 3,137 potentially solid, viable research proposals out in the cold. The situation for Australian research becomes even worse when you consider that the success rate has dropped by 4.1 per cent compared to last year's ARC grants.

"The Academy is not advocating smaller allocations to more projects. This is a wonderful scheme that the Academy fully supports. But we do need recognition by Government at federal and state levels as well as business and industry that pure and applied scientific research across all disciplines brings benefits to all Australians — and a consequent boost in funding from the Federal Government for the ARC grants."

He also pointed out that the proportion of Queen Elizabeth II Fellowship research awards within the Discovery grants were seriously under-represented. He said: "This is a major concern for mid-career scientific researchers, who have to engage in ferocious competition for this, one of the few sources of major funding available to them.

" A number of our best people are increasingly being lured overseas. If the funding situation does not improve, what's now a fast-flowing trickle will become a flood."

AAS media release

The perfect slow wave

Sydney University physicists have invented a device that creates perfect slow light waves. Their discovery, reported on 23rd October in Nature Physics, brings light-based computing and communications a step closer.

Their device slows light by about 20 % without losing information. Until now, when light was slowed down information was lost. But the self-reinforcing soliton waves made by the device ensure that the shape of the wave is maintained.

This matters because communications depend on buffering - holding and releasing batches of information. In this experiment the team buffered just a few bits. If they can get to 100 bits then the team from CUDOS (Centre for Ultrahigh Bandwidth Devices for Optical Systems), a consortium of five universities will have a winner.

These slow waves could help unleash a much faster internet, and replace the millions of energy hungry routers that power the web. "We are planning to work with Australian companies to bring the technology to market," says Professors Ben Eggleton, CUDOS Director. The team comprised PhD student Joe Mok, CUDOS Senior Research Fellow Dr Ian Littler, Professor Martijn de Sterke and Professor Ben Eggleton. They are all based in the School of Physics.

Sydney University media release

CSIRO astronomer wins Malcolm McIntosh Prize

On 16th October, CSIRO astronomer Dr Naomi McClure-Griffiths has been awarded the 2006 Malcolm McIntosh Prize for Physical Scientist of the Year for research that has re-shaped our knowledge of our own Galaxy. The Prize – a silver medallion and a tax-free grant of A$50,000 – is awarded for outstanding achievement by a scientist aged 35 or less - was presented by the Minister for Education, Science and Training, the Hon. Julie Bishop, at the Prime Minister's Science Prizes award ceremony at Parliament House, Canberra.

Dr McClure-Griffiths, 31, is a Senior Post-Doctoral Fellow at CSIRO's Australia Telescope National Facility. She uses radio telescopes, such as CSIRO's Parkes radio telescope and the Australia Telescope Compact Array, to map the distribution of hydrogen gas in our Galaxy.

She has led an international team of astronomers in a project to map the hydrogen gas in the half of the Galaxy that is visible from the Southern Hemisphere. Her research has led to new insights about the Galaxy – from the behaviour of the gas between the stars to the large-scale spiral structure of the whole Galaxy.

In 2003 she discovered a new spiral arm at the outer edge of the Milky Way – a discovery that is forcing astronomers to redraw the map of the Milky Way.

The Malcolm McIntosh Prize commemorates Dr Malcolm McIntosh, who was CSIRO's Chief Executive from 1996 until his death in February 2000.

CSIRO media release

Scientists copy the brilliance of a leaf

A University research team has created synthetic copies of the light-harvesting molecules found in plants - a development that could change the face of solar power.

"We've created one of the key systems plants use in photosynthesis. A leaf is a cheap and efficient solar cell. The best leaves can harvest up to 40 per cent of the light falling on them," said Deanna D'Alessandro, a post-doctoral fellow in the molecular electronics group, led by Professor Max Crossley in the School of Chemistry.

Dr D'Alessandro, a laboratory researcher and team member on the project,has just been announced as the winner of Fresh Science 2006, a national competition promoting the work of early-career scientists.Her prize involves a study tour of the UK sponsored by the British Council Australia and the opportunity to present her work at the Royal Institution in London.

The Sydney researchers have constructed synthetic porphyrins made from carbon, hydrogen and nitrogen atoms. More than 100 porphyrins can be assembled around a tree-like core - a dendrimer - to mimic the wheel-shaped arrangement in natural photosynthetic systems.

Because there are a large number of porphyrins in each molecule, a significant amount of light can be captured and converted to electrical energy. "Since they are so efficient at storing energy, we think they could also be used as batteries - replacing the metal-based batteries that our high technology devices depend on today," said Dr D'Alessandro.

The research will also offer a considerable improvement on current artificial solar cells. Silica-based solar panels, such as those on roofs, are expensive to manufacture and are only

around 15 per cent efficient - that is, only 15 per cent of the light that falls on them is converted to energy.

The Sydney team - Professor Crossley, Dr D'Alessandro, Tony Khoury, Adam Hambly, Dr Joe Sly and Mark Absalom - is in the early stages of building practical solar energy devices using the synthetic molecules. Over the next five years, they will work with collaborators at Osaka University in Japan to use the technology on commercial-scale solar panels.

Sydney University media release

CSIRO boasts Ig Nobel Laureates

The 2006 Ig Nobel Prize in mathematics was awarded to Dr Piers Barnes and Ms Nic Svenson of CSIRO for figuring out how many photographs to take of a group of people to be confident of getting at least one where no-one's blinking.

CSIRO's laureates accepted their prize (described by the international science journal *Nature* as "no cash, but much cachet") at the traditionally unorthodox ceremony at Harvard University in Boston last night.

"We are proud to have made a gross simplification of complex physiological and psychological factors backed up with no empirical data," physicist Dr Barnes said. "Like many other theories, if enough assumptions are made, we are confident that our expression holds," he said.

For the record: for groups of less than 20, you divide the number of people by three if there's good light or a decent flash, and two if the light's bad.

The Sixteenth First Annual [sic] Ig Nobel prizes honour research that first makes people laugh, and then makes them think. "CSIRO has an ongoing responsibility to help inspire and educate about science," said writer and sometime photographer Ms Svenson. "It's like Isaac Asimov said: 'The most exciting phrase to hear in science is not 'Eureka!' but 'That's funny...'," she said.

CSIRO media release

New clue to world's tiniest particles

Particle physicists around the world will be designing their next generation of billion-dollar experiments following new findings from a University of Adelaide-led research team. The University of Adelaide's Associate Professor Derek Leinweber, leading a team of international theoretical physicists, has established a new approach to precision calculations on the properties of subatomic particles.

The proton, one of the three main components of an atom, is known to consist of point-like particles called quarks, bound together by gluons. There are six different types of quarks and the most mysterious of these is the strange quark, which "boils up" inside the proton and then "simmers back out of existence".

The new finding, published recently in the *Physical Review Letters*, is a precise calculation of the strange quark's distribution within the proton. The calculation predicts that the short-lived strange quarks display an unanticipated level of symmetry in their journey.

"Technically the strange quark contribution to the proton's charge distribution has proven elusive," said Dr Leinweber, who is Deputy Director of the University's Special Research Centre for the Subatomic Structure of Matter. "At the University of Adelaide, working with physicists at the University of Edinburgh and the Thomas Jefferson National Acceleratori Facility in the US, we've been able to calculate the strange contribution with unprecedented accuracy by applying a unique combination of cutting-edge numerical and analytical approaches.

"There is a huge industry in particle physics with groups of researchers around the world making new measurements that could reveal physics beyond the standard model of the universe. Our result presents a huge challenge to experimental physicists in planning the next generation of experiments. Billions of dollars are going to be spent, based on this result."

Adelaide University media release

Professor David Solomon wins 2006 Victoria Prize

Eminent scientist and inventor of the plastic bank note, Professor David Solomon, Honorary Professorial Fellow in the Department of Chemical & Biomolecular Engineering at the University of Melbourne, has been awarded the prestigious 2006 Victoria Prize. The Lieutenant-Governor of Victoria, The Hon Justice Marilyn Warren, presented the Prize to Professor Solomon at a function at Government House.

The annual $50,000 Victoria Prize is awarded by the Victorian Government to a leading scientist or engineer whose discovery or innovation is advancing knowledge and has the clear potential to be commercialised.

Melbourne University media release

Big Bang Theory saved

Astrophysicists examining the movement of gases in stars have reconciled an apparent discrepancy in the Big Bang theory of the universe's evolution. Professor John Lattanzio from Monash's School of Mathematical Sciences and Director of the Centre for Stellar and Planetary Astrophysics said the confusion surrounding the Big Bang revolved around the amount of the gas Helium 3 in the universe. "The Big Bang theory predicts a certain amount of Helium 3 in the universe," Professor Lattanzio said. "The trouble is, low mass stars also make Helium 3 as a side product of burning the hydrogen in their cores.

"It's been thought that when the star becomes a giant it mixes the helium 3 to its surface and, near the end of its life, spews the helium 3 into space just before it becomes a planetary nebula.

"But there are inconsistencies with the amount of Helium 3 predicted to be in the universe and the amount that's actually there; there's much less than expected."

Professor Lattanzio, in collaboration with Dr Peter Eggleton and Dr David Dearborn from the Lawrence Livermore National Laboratories in the US , ran 3D computer models of a red giant's life on some of the world's fastest computers to investigate whether there was some sort of gaseous mixing occurring in stars that destroyed Helium 3.

Their findings have been published in the international journal *Science*.

Near the end of a star's life there is a 'core flash' and it was at around this time that the computer models revealed a small instability in the movement of the gases in the star. "When we looked at this in 3D we found this hydrodynamic instability caused mixing and destroyed the helium 3 so that none was released into space," Professor Lattanzio said.

Monash University media release

Prompt Critical

A Matter of Balance. Scaremongering is the word to best describe the latest anti-nuclear-power tirade from Dr Helen Caldicott, a pediatrician opposed to all things nuclear. Titled *Nuclear Power is Not the Answer to Global Warming or Anything Else* her book presents every scrap of negative information she can find and skillfully weaves them into a highly emotional presentation intended to sway a general reader against nuclear electricity. Bolstered by 27 pages of Notes, mostly from newspapers, emails and phone messages, with very few peer-reviewed papers, her case lacks balance. Renewables, good. Nuclear, bad. Totally black and white.

The book itself would not merit a lead review in this or any other seriously scientific publication but for the worrying fact that it has been published by the University of Melbourne Press, a publishing house from whom higher standards might be expected. But that's not the only shameful aspect. I happen to know that a senior physical science academic from that respected University attempted to persuade their Press to publish a balanced educational treatment of energy issues that favoured nuclear power for base-load electricity generation with renewables filling those supporting roles for which they are suited. The person in charge of publishing rebuffed the approach. Their subsequent publication of Caldicott's polemic starkly reveals the extreme bias existing against nuclear power for Australia.

When a pro-nuclear viewpoint is offered to the media the cry is for "balance" and the offering is frequently swamped by anti-nuclear material. Unfortunately it doesn't seem to work the other way. More's the pity, because I like reliable electric power.

Colin Keay
Reviews Editor

Reviews

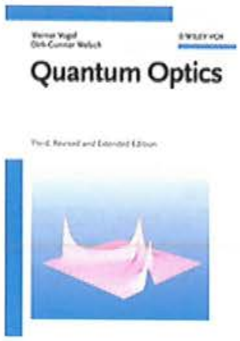
CCD Astrophotography
Adam M Stuart
Springer, New York NY 2006
xii + 193 pp., EUR 32.05 (paperback)
ISBN 0-387-26241-5.

Adam Stuart's book is a practical, enthusiastic, hands-on tale of the numerous challenges he faced and overcome during the construction of a home observatory under the light-polluted skies of southern Florida. He begins with the issues involved in sifting those rare, night-time photons that arrive from cosmic sources from the multitudes originating in nearby Miami. Here we run into the first of many non-sequiturs, some of which are surprising from a medical man: "Fully two thirds of Americans and Europeans can no longer discern our own Milky Way with the unaided eye..." (page 2), or from an astronomer: "If you ... look skyward ... in the United Kingdom or America ... the stars are anything but obvious in all directions" (page 3). There follows some discussion of interference filters "... which have special coatings that reject sodium, incandescent and mercury vapour, ..." (page 5).

We then move to the selection of telescopes, followed by a meandering discussion of the other items needed for a home observatory. On page 20 we come to the CCD itself, where we find that a CCD is "... a matrix of light-sensitive regions called pixels (1 pixel = 1/1000-mm, or about 4 ten-thousandths of an inch).", after which my interest in the book waned, especially as the facing page had an unrelated concrete-laying diagram!

There follows much more in a chatty, first-person style, before we reach computers, software and CCD cameras and eventually A Night Under the Stars, where the author describes his observing procedure and how he (digitally) processes his astrophotos. The book concludes with a short but interesting chapter on minor planet astrometry, where amateurs can make very useful contributions to mainstream astronomy. The final section is a technical glossary, where we are told "Agressiveness: Term used when making guiding adjustments."

David Malin
Anglo-Australian Observatory
RMIT University



Quantum Optics
(3rd Revised and Extended edn.)
W Vogel and D-G Welsch
Wiley-VCH, Weinheim 2006
xii + 508 pp., EUR 129 (hardcover)
ISBN 3-527-40507-0

In a timely follow up to the award of the 2005 Nobel Prize in Physics to the pioneer of quantum optics, Roy Glauber, Wiley-VCH have released the latest version of this well-known text on theoretical quantum optics which was last produced in 2001. It provides a thorough introduction to the field at graduate level, and complements the companion text in the Wiley-VCH series: A Guide to Experiments in Quantum Optics by Bachor and Ralph (2004). The latest edition makes contact with some more recent developments in the field which include interactions with the vacuum (spontaneous emission, Van der Waals and Casimir forces), measurement criteria for entanglement of bosons, and decoherence in the motion of trapped atoms. The authors have had to be selective because of the burgeoning nature of the field, and in particular have not extended their work to include topics related to laser physics and laser spectroscopy (two of whose proponents, Ted Hansch and Jan Hall, incidentally shared the Nobel Prize with Glauber). However, while the authors have delved into the motion of trapped atoms, they have neglected the promising overlap of quantum optics with atom optics where statistical effects in quantum degenerate Bose and Fermi gases are now at the forefront of modern science. Nevertheless this text is a well laid out and well referenced theoretical primer to basic "optical" quantum effects, and is a clear introduction to any aspiring practitioner in the field.

Ken Baldwin,
R S Phys S E
Australian National University

Reviews

Lectures on Quantum Mechanics

Berthold-Georg Englert
World Scientific Publishing, Singapore 2006
597 pp total, US$ 68.00 (paperbacks, 3 vol. set)
ISBN 981-256-790-9 (set)

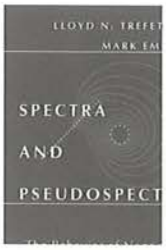
This series provides a thorough formalism of Quantum Mechanics, but does so without restraint. Volume 1 (Basic Matters) assumes no prior knowledge of the subject (according to the Preface at least). Interestingly, the author starts with the Stern Gerlach experiment to expose the reader to classical versus quantum concepts and introduces Heisenberg's matrix and Dirac's bra-ket notation at the outset (Schrodinger follows later). The strong influence of Schwinger and Feynmann's approaches are clearly evident in the treatment.

Volume 2 (Simple Systems) reviews quantum dynamics before presenting standard examples such as the harmonic oscillator and hydrogen-like atoms. Once these are covered, approximation methods including Rayleigh-Schrodinger and Brillouin-Wigner Perturbation theories, as well as WKB are discussed.

Volume 3 (Perturbed Evolution) introduces complimentarity, Schwinger's Quantum Action Principle, Fermi's Golden Rule etc and time-dependent perturbation theory of two-level atoms before applications to scattering theory, angular momenta and many electron atoms. Theoretical treatment is well-balanced with description throughout, and the field of Quantum Mechanics (up to but not including relativistic and field theories) is extensively covered.

In summary, if you use bra-ket or matrix approaches and need a worthy textbook, then this set definitely warrants a look. It does, however, assume that the reader has strong mathematical skills and would only suit advanced courses.

Jamie Quinton
School of Chemistry, Physics and Earth Sciences
Flinders University



Spectra and Pseudospectra: The Behavior of Nonnormal Matrices and Operators

L N Trefethen and M Embree.
Princeton U Press, Princeton NJ 2005
xvii + 606 pp., US$65.00 (hardcover) ISBN 0-691-11946-5

This book starts with a quiz. The reader is presented with two, 2 by 2, upper triangular real matrices and plots of the corresponding norms of exp(A*t) versus t for each matrix A. The reader is then asked which curve corresponds to which matrix. Both matrices have negative eigenvalues, one has repeated eigenvalues. The temptation is to identify the lower curve with the matrix that has the smallest (most negative) eigenvalue. It is also tempting to identify the curve that shows initial growth as that corresponding to the matrix with the repeated eigenvalue. But this is incorrect, in both cases. It is subsequently revealed that one of the matrices shown is a nonnormal matrix and the transient behaviour can be understood by examining its epsilon-pseudospectrum.

The quiz captures the main theme of this book, that the spectrum (set of eigenvalues) of a nonnormal operator (nonnormal matrix) fails to capture transient behaviours, but these behaviours can be captured in an epsilon-pseudospectrum.

A related theme is that the resonances of a nonnormal operator may not be determined by the spectrum alone. The book explores a plethora of topics (sixty in all) around the main themes ranging from fluid instability and turbulence through to random matrices and Anderson localization. The importance of eigenvalues in physics is well known to all of us; less well known is what to do when eigenvalue methods fail.

This book is the essential reference for learning about the importance of pseudospectra and their use in qualitative and quantitative applications. It is very well written by leading experts in the field. All of the topics are clearly explained, and there are numerous references to the research literature. If you routinely use eigenvalue methods in your research then you should arm yourself with a copy of this book.

B I Henry
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The Physics of Phase Transitions (2nd Edn.)

Pierre Papon, Jacques Leblond and P H E Meijer
Springer, Berlin 2006
xvii + 409 pp., EUR 96.25 (hardcover)
ISBN 3-540-33389-4

Phase transitions are a class of phenomena which are both spectacular and ubiquitous, and of interest to physicists, chemists, materials scientists, biologists and engineers. They provide challenges to our fundamental understanding, as well as both opportunities and difficulties in real world applications. Most physicists will be familiar with the normal transitions between solid, liquid and gas phases of pure substances as well as those of magnetic order, superconductivity and superfluidity. But there are also structural transitions in materials, including both crystalline and glassy phases, and transitions in 'soft matter', such as liquid crystals, gels, colloids and polymers, and in biological systems.

To cover this vast area in a single volume is a difficult challenge, undertaken in the present book. It is the only book I know of which attempts such a wide coverage, and it manages to do so with a considerable degree of success. The original was published in French in 1999, with an English translation in 2002. This new edition is largely unchanged, but does include, albeit in only a few pages, a discussion of Bose-Einstein condensation in trapped atomic gases. The authors, who have backgrounds in applied physics and chemistry, take a thermodynamic and largely phenomenological approach in discussing the mechanisms and dynamics of the various kinds of transitions, and in attempting to give some unity to the subject. This is probably all that can be done, and the result is a book that should be in any institutional library.

Nevertheless many readers may feel, as I did, somewhat dissatisfied. There is not enough depth in any one area to provide 'meat', and to provide an entry to current research. At a fundamental level, there is little attention paid to some of the most seminal ideas post Landau, such as universality, scaling and renormalization, which are, after all, the primary unifying paradigms of phase transitions in such a vast variety of different systems.

J Oitmaa
School of Physics
University of New South Wales

Product News

Coherent Scientific

Small Instrumentation Modules from Stanford Research Systems

Stanford's SIM (Small Instrumentation Modules) product range is a robust, flexible platform in which up to eight high-performance instruments share the same compact mainframe and computer interface. The platform allows users to address numerous applications by selecting from a wide range of available modules.

The SIM mainframe includes RS232 and optional GPIB interfaces as well as a 10MHz master clock. The clock may be either free-running or phase-locked to an external reference. Multiple mainframes may be connected together if required.

The available modules incude:
- Analog PID controller
- AC resistance bridge
- Diode, Pt and RTD temperature monitors
- Precision current preamplifiers
- Voltage preamplifiers
- Isolated precision voltage source
- Summing and scaling amplifiers
- Quad digital voltmeter
- Rubidium frequency standard

All modules may be controlled from the front panel as well as from the computer interface.

The SIM platform is ideally suited to a wide range of applications in low-temperature physics as well as general applications involving precise analog measurement and control.

For more information please contact
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The TLB-7000 series StableWave™ tuneable external-cavity diode laser

The TLB-7000 series StableWave™ tuneable external-cavity diode laser (ECDL) from New Focus raises the bar for performance and stability in its class. As the name suggests, the StableWave™ series offer exceptional long-term wavelength stability, better then +/- 1pm over a 12 hr period. Couple this drift free operation with wide tuning ranges, up to 150 GHz, and low line widths <500 kHz and this laser is well suited for frequency modulated absorption spectroscopy, Rubidium and Caesium atomic clock pumping,

interferometry, atomic cooling and other test and measurement applications.

The TLB-7000 series boasts improved performance at application specific wavelengths, such as increased power for Cesium (D2) (~852 nm) and Rubidium (D2) (~780 nm) saturation spectroscopy, with over 50mW available, and a new model at 795nm for Rubidium (D1) (~795 nm) spectroscopy. The laser is easily integrated into experiments due to its small footprint. Exceptional low noise performance is achieved when locking it to atomic hyperfine transitions.

Long-term wavelength stability can be attributed to New Focus' monolithic construction (yielding low oscillator component counts), patented tuning mechanism, and low noise controller. Spurious amplitude modulation (AM) effects in frequency modulation (FM) saturated spectroscopy are also reduced by the proprietary antireflection coating on the output facet of the laser diode (LD), reducing LD born etalon effects.

Coherent Scientific will be demonstrating the TLB-7000 series ECDL at this year's AIP 2006 Congress being held from 3- 8 December in Brisbane, along with associated New Focus products. Come along and see why New Focus is Simply Better™ or contact us for further details.

For more information please contact
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www.coherent.com.au

WARSASH Scientific Pty Ltd

New Laser Diode Driver

Warsash Scientific is pleased to announce the release of Model 772, a pulsed laser diode driver from Analog Modules Inc.

The model delivers 70- to 140-A current pulses with <10-µs rise time into diode stacks of 15 to 24 V at an average power of up to 20 W with >70% efficiency.

Measuring 4.3 x 2.7 x 1.5 in. and weighing <10.5 oz, the polyphase unit provides power and trigger signals for the company's Pockels cell drivers. It can be cooled with natural convection and offers open- and short-circuit and thermal overload protection.

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

NewSpec

New 1931-C/2931-C Series Optical Power Meters

For applications requiring measurement of low-power light sources, Newport's model 1931-C Single channel meter and 2931-C dual channel meter have broken the barrier of temporal measurement performance with calibrated results. This new series of power meters have the ability to handle repetition-rates of up to 20 kHz at a sampling rate of 250 kHz.
Peak-to-peak and DC source measurements can be displayed in units of W, dBm, dB, and A. Simultaneous measurements of a variety of light sources operating at different power levels and wavelengths can be performed with the dual channel 2931-C Optical Power Meter.
Low-power measurements, of pW to tens of Watts can be accomplished with any one of Newport's 918D or 918L Series Silicon (Si), Germanium (Ge) or Indium Gallium Arsenide (InGaAs) Detectors, covering 190–1800 nm wavelength range. All 918D and 918L Series Detectors have a built-in temperature sensor for active compensation of temperature-induced measurement fluctuations.
True Root-Mean-Square (rms) measurements, providing the most accurate rms value regardless of the shape of the input waveform.

Other advanced features include a 250,000 data point storage buffer, analog and digital filtering, programmable sample rates, moving statistics, plotting, and multiple user-configuration storage.

Features
- 5.7" Graphical TFT LCD, ¼ VGA provides excellent legibility from any angle, in any light

Product News

condition or colored eyewear

- Data storage via internal memory or *USB Flash Drive*
- Color plotting, statistics and on-board data post-processing
- Analog and digital filtering
- USB and RS-232 computer interfaces
- Trigger in/out control with alarm levels
- Analog bar graph with 10X zoom
- Advanced Programming toolkit - .NET, LabVIEW, High-speed

For more information please contact Neil, Graeme or Dennis at:
sales@newspec.com.au
Tel: 08 8273 3040
Fax: 08 8273 3050
www.newspec.com.au
NewSpec Pty Ltd
83 King William Road
Unley, South Australia, 5061
ABN 82 882 831 899

New Cylindrical Lens Mounts

The CYM-2R can hold and position cylindrical optics as large as 2-in in height. What makes this mount unique is its ability to rotate a cylindrical optic about its center. This feature eliminates unwanted translation during rotation of the power axis. 100-TPI adjustment screws provide ±5° roll adjustment range with a sensitivity of 6 arc seconds. The CYM-2R is post-mountable, with a mounting hole that accepts 8-32 or M4 screws. With the use of adapters (sold separately), other sizes of cylindrical optics can also be held. Adaptors are available to mount 1/4-in., 1/2-in., 1-in and 19-mm high cylindrical optics. Each one of these adaptors places the centre of the cylindrical lens at the axis of rotation and has a location pin for quick installation.

Features

- Rotates lens about its center
- ±5° rotation range
- 6 arc-sec sensitivity
- Adaptors for many lens sizes

For more information please contact Neil, Graeme or Dennis at:
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ABN 82 882 831 899

New Mini-Spectrometer

The Oriel IS-Series of Mini-spectrometers offer significant advantages over traditional mini-spectrometers. Newport took Oriel's 30+ years of designing and manufacturing spectroscopic instruments, combined with customer feedback, and designed a family of instruments that truly addresses the needs of both the Researcher, and the Systems Integrator.

Models are available to cover various spectral ranges from 190 to 1000 nm, in both fiber-coupled and free-space configurations (NIR spectral ranges may be available upon special request). After exhaustive testing of numerous arrays, Newport selected a Si NMOS photodiode array for the IS Series. These arrays have a broad spectral response, superior sensitivity in the ultraviolet, and lower cross talk than most other arrays. Because these PDAs have inherently good UV performance, they do not require a UV enhancement coating, which is often used on CCDs, and is prone to degradation over time.

Features

- Si NMOS array for superior UV sensitivity
- Spectral ranges from 190 to 1000 nm
- High resolution models: 0.45 nm
- Low stray light
- USB 2.0 communication to PC
- Options for order sorting filters
- Fibre coupled and free space models

For more information please contact Neil, Graeme or Dennis at:
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Lastek P/L

Nanonics appoints Lastek as its distributor in Australia and New Zealand

Nanonics, a leading manufacturer of AFM Raman and SPM, Scanning Probe Microscopes, has appointed Lastek as their new distributor in Australia and New Zealand.

Nanonics pioneered commercial scanned probe microscopy systems with normal force probes associated with tuning fork feedback and now introduces the Integra Control System designed with all the unique capabilities tuning forks in mind, such a extreme stability and without any interference or lever excitation that are associated with beam bounce systems. It also eliminates feedback laser excitation, which is very important in applications such as electrical measurements of carrier concentration in semiconductors or in optical experiments such as simultaneous confocal imaging or near-field optical measurements. In all such experiments the tuning fork provided a zero background for monitoring the scanned probe microscopy parameters of interest.

The Tuning Fork Systems can use all of the probes available today for SPM, be they glass or silicon cantilevers, or the Akiyama probe, recently introduced by Nanonics.

With the unique features of the ultralow noise Integra Controller one has the ultimate in AFM feedback without mechanical or other alignment being required. Simply place the probe and you are ready for repeatable and ultimate resolution AFM scanning, even with samples such as highly oriented pyrolytic graphite, HOPG.

For further information please call Alex Stanco at Lastek on 1800 882215 or via email at alex.stanco@lastek.com.au

New OceanOptics MMS Raman Spectrometer

OceanOptics offers the next-generation Raman spectroscopy that combines the simplicity of dispersive instruments with the multiplex advantage of a transform spectrometer. The MMS Raman Spectrometer uses Centice's patent-pending Multimodal Multiplex Spectroscopy www.centice.com/technology/sensitivity_resolution.htm to provide high-performance Raman analysis for a fraction of the cost of research-grade systems.

The MMS Raman Spectrometer offers a unique combination of resolving power, spectral range and flexibility, making it an ideal system for the routine analysis of many types of liquids and solids. It is especially useful for measuring measure weak, scattering and diffuse sources with the highest possible sensitivity.

Key applications include material inspection, identification of unknown materials, and quantitative analysis of both intermediates and final products in the chemical and pharmaceutical industries. The system is also ideal for teaching and research applications in colleges and universities.

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