Interferometric gravitational wave astronomy research in Australia

Physics Enrolments 2000 - 2005
Snapshot: George Dracoulis
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Cover image: Interferometric Gravitational Wave Astronomy Research in Australia

Editor
Corinna Horrigan

Reviews Editor
A/Prof CSL Keay
Physics, University of Newcastle
Callaghan NSW 2308
Tel: 02 4921 5451 Fax: 02 4921 6907
colin.keay@newcastle.edu.au

Editorial Board
Dr MA Box
Prof Ian Johnston
A/Prof CSL Keay
Prof RJ MacDonald
A/Prof RJ Stening

Associate Editor - Education
Dr Colin Taylor
Physics Director, RTASO
Box 7251, Canberra MC, ACT 2610
Tel: 02 6125 9780
Colin.Taylor@rtas.org.au

Associate Editors
Prof. Jeffrey Harris
Head, Plasma Research Laboratory
RSPhysSe, ANU, Canberra ACT 0200
Tel: 02 6125 5422 Fax: 02 6125 8316
jhh1126@rsphysse.anu.edu.au

Dr. Tony Collings
CSIRO Telecommunications and Industrial Physics
PO Box 218, Lindfield NSW 2070
tonyd@tip.csiro.au

Dr Howard Wiseman
Physics Group, School of Science
Griffith University
Nathan QLD 4111
Tel: 07 3787 7271

Dr Marc Duldig
Australian Antarctic Division,
Channel Highway Kingston, TAS 7050
Tel: 03 6322 3333 Fax: 03 6322 3476
marc.duldig@aad.gov.au

Dr Lloyd Hollenberg
Physics, University of Melbourne
Parkville VIC 3052
Tel: 03 9344 4210 Fax: 03 9347 4783
lth@swit.ph.unimelb.edu.au

Dr Chris Lund
Physics & Energy Studies
Murdock University, Murdoch WA 6150
Tel: 08 9360 2102 Fax: 08 9360 6183
clund@ffzy.murdoch.edu.au

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

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

Design
Sophie Campbell
Tel: 0402 101 090

Printing
Cliff Lewis Cronulla Printing
91-93 Parramatta Road
Caringbah NSW 2229
Tel: 02 9525 6988
Fax: 02 9524 8712
scott@clp.com.au

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

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In this special Year of Physics, it is perhaps a good time to reflect on the origins of the AIP. The present AIP Executive has decided to commission a project to write the history of the AIP.

Since the last issue of Australian Physics, the AIP has been involved with an unprecedented stream of activities for the Einstein International Year of Physics (EIYoP). Some of these have involved AIP members in a variety of roles. Others have been conducted with financial contributions from the AIP. All of these activities have put the AIP in the public eye. A report on these activities appears elsewhere in this issue. Here are just a few of the highlights in which I have been directly involved.

A full page article on William Sutherland (see also Australian Physics June issue) and other EIYoP matters appeared in The Age newspaper in Melbourne on July 31. I contributed material to this article during an interview with the journalist Paul Heinrichs. Bruce McKellar has also alerted me to interest in Sutherland’s work from outside Australia, including a reference to Sutherland’s work in a letter from Albert Einstein to his good friend Michele Besso in 1902!

The “Einstein’s Ideas Explained” lecture program has been running very well. Most recently, lectures were given in Brisbane, Canberra, Adelaide, Hobart, Sydney and Melbourne, Launceston, Devonport, Amidale and Wollongong. In Melbourne the lectures, given by myself, Ray Volkas, Bruce McKellar and Elisabeta Barbiero, attracted huge crowds with around 500 people turning up on the five consecutive Friday nights in July. Numbers were at the 100-200 level in the other capitals. Earlier lectures in Perth and Brisbane also attracted large crowds. At least half of the audience for the Sydney lectures indicated that the newspaper advertisement had attracted them to the lectures, but it would be nice to know how we could attract more people from most-populous-city Sydney to future events.

The Eratosthenes project, with major funding from the AIP and RMIT, was run during Science Week with a national launch by Science Minister Brendan Nelson, assisted by AIP Vice President Cathy Foley, in Sydney. Alex Merchant and the rest of the RMIT team are to be congratulated for running a program that involved more than 100 schools around Australia, including one from Christmas Island!

The AIP has been running these activities thanks to substantial assistance from a grant from the Department of Education, Science and Training (DEST) which we greatly appreciate. The AIP Executive is presently looking at proposals for an on-going relationship with DEST beyond 2005 for a program of outreach activities. In the recent American Physical Society (APS) news back-page there was an article about outreach and the associated funding problems because there is no “natural home” for outreach in our present funding systems. Government grants specifically for EIYoP activities, expressed per head of population, were about 3.3 cents/head in Germany, 0.4 cents in Australia and 0.26 cents in the USA. It is worth noting that in 2000, for the Planck anniversary, the Germans set up large tents in city squares staffed by graduate students offering hands-on physics demos for 16 hours per day. An up-turn in the physics enrolments in Germany by a factor of two was attributed to this activity! John O’Connor’s Science and Engineering Challenge had a similar effect in Australia. It would be great to find a way of doing this every year.

I hope that (at least) a raised awareness of Physics will be a lasting legacy of the AIP’s EIYoP activities. A substantial legacy is definitely going to be the proposal AIP has received from the Defence Science and Technology Organisation (DSTO) to initiate a major national scholarship scheme to commemorate the EIYoP. Two $15k scholarships will be made available to students undertaking an Honours year. I was present when the scholarships were announced by Senator Robert Hill (Minister for Defence and Leader of the Government in the Senate) at the launch of the Amazing World of Science Festival in Canberra on August 17. These scholarships will be one of the largest and most prestigious scholarship schemes on offer in Australia. The AIP will administer the scheme and devise suitable selection criteria.

Another important scheme run by the AIP is course accreditation in Australian Universities. This accredits Physics courses for which graduates can be admitted to the AIP as graduate members. I have been pleased to participate as a member of the accreditation committee and have had the opportunity to visit many Physics Departments around Australia. As reported elsewhere in this issue, the AIP was invited to conduct accreditation at the University of Kuwait which is the first time we have extended the scheme beyond the boundaries of Australia.

In this special year of Physics, it is perhaps a good time to reflect on the origins of the AIP. The present AIP Executive has decided to commission a project to write the history of the AIP. Dr Anna Binnie has agreed to be a consultant on this project. We anticipate that past members of the AIP Executive will be contacted so that their contributions can be recorded. If you want to participate in any way you can contact Anna directly on her AIP email: a.binnie@aip.org.au

In conclusion I would like to extend a special thanks to all those who have volunteered their time and energy to the many special events in which the AIP has participated so far this year.

Prof. David Jamieson
Editorial

A question of enrolments

For many years this journal has published the results of the enrolment survey carried out by some dedicated AIP members. The latest is included in this issue. The results are always interesting and often invite speculation on trends and causes. But the numbers tend to be small in statistical terms and this can limit the conclusions that can be drawn and the prognostications that can be made. It was with interest, then, that I perused the recently released report by the American Institute of Physics regarding enrollments and degrees in the United States.

The two reports aren’t directly comparable as the methodology differs between the two surveys and, of course, the US tertiary system is somewhat different. That said, there are definite similarities in trends over the past few years; both show a drop from a peak in the early nineties followed by a recovery over the last few years. As the US trends are based on much larger numbers, such a similarity strengthens case for the apparent trends in our own enrolments.

However, the numbers – and the extra resources the American Institute has – allow them to look at aspects that we cannot. For instance, information collected includes not only gender, but also ethnicity and citizenship. I’m not convinced that this is a good idea, but the figures do make interesting reading. It appear that, for the first time, foreign nationals now make up over half of new physics PhDs in the US; Hispanic and African-Americans are still under-represented; and women make up an rapidly increasing number of Astronomy graduates at all levels.

While these figures are interesting, I don’t feel that we need to include them in our own surveys. Not only is it a lot of extra data to collect but, with the small numbers involved, there could even be privacy issues. As far as participation in tertiary education in general is concerned, I expect that the Australian Bureau of Statistics has information relating to ethnicity.

I’ve had no room, or time, to do more than gloss over some of the aspects of this report that grabbed my attention. The full report can be downloaded from www.aip.org/statistics/trends/reports/ed.pdf

In this issue: As mentioned above, this issue contains the triennial report on physics enrolments in Australian and New Zealand universities. It’s a much more optimistic report than the last one and we can only hope that the trend continues. There is another in the series of interviews with eminent Australian physicists by Ragbir Bhatai. This time the subject is Prof. George Dracoulis.

And we can’t let the many activities forming part of the Einstein Year pass unnoticed, so there is a summary and photos of people having fun with physics.

Corrina Horrigan

Deadline for next issue: 21st October 2005

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.
Interferometric Gravitational Wave Astronomy Research in Australia

Gravity at Gingin

Over the past 4 years an isolated piece of pristine bushland near Gingin, about one hour’s drive from Perth, has been developed into a unique science precinct. It was first conceived as an ideal site for a future Southern Hemisphere gravitational wave detector, AIGO, the Australian International Gravitational Observatory. Since then it has developed into a precinct that not only supports gravitational wave research and may one day become the southern hemisphere gravity wave detector needed to turn the world array of detectors into a true omni-directional gravitational wave telescope, but is also a public education centre called the Gravity Discovery Centre (GDC).

The GDC consists of a set of galleries and exhibits that support public education and schools education programs, particularly in the areas of physics, astronomy and biodiversity (www.gdc.asn.au for more information). The concept for the GDC emerged when the WA ex-Deputy Premier Hendy Cowan suggested to his staff that there had to be more benefit to WA than just a ‘mob of boffins beavering away in the bush’. Cowan suggested in creating AIGO we should also look to school education and provide a facility that would contribute to Australia, WA and to the Gingin region in a much broader way. Professor David Blair was recently awarded the ANZAAS Medal for services in the advancement of science and the Eureka Prize for Promotion of the Understanding of Science for his efforts towards the creation of the GDC. More information on the Eureka Prize award can be found at www.amonline.net.au/eureka/promotion_science/2005_winner.htm.

The development of AIGO occurs under the auspices of the Australian Consortium for Interferometric Gravitational Astronomy (ACIGA), consisting of physicists at the University of WA, the Australian National University, the University of Adelaide, Monash University, the University of Melbourne and the CSIRO Optical Technology Centre. ACIGA brings together the expertise required to create a centre for the development of advanced techniques in gravitational wave detection.

Gravitational Wave Detectors Worldwide

The quest to detect gravitational waves has been gradually hotting up for the last 30 years. What began as one-man research by an eccentric physicist, the late Joseph Weber, has grown into a field that commands funding on the billion dollar scale, and which at last looks certain of detecting gravitational waves in the foreseeable future. The terrestrial detectors of planned ‘Advanced Sensitivity’ are expected to detect hundreds of signals per year, while the planned space based detector LISA, a 5 million km laser interferometer, is expected to be swamped by gravitational wave noise - the confused clutter of signals from the prolific sources in the 100 microHertz band. At their present sensitivity the terrestrial detectors (LIGO in the USA, VIRGO and GEO in Europe) have a small chance of detecting known signals. The advanced techniques will give them a 10-fold improvement in sensitivity, increasing the event rate 10³-fold. As well as detecting prolific known sources at a rate probably between one per hour and one per day, they will also allow the birth processes of black holes to be studied for the first time and they may reveal undiscovered electromagnetic-dark sources. Hundreds of physicists around the world are working towards this exciting goal, including the members of ACIGA.

The High Optical Power Test Facility

The current role of AIGO site is to support the development of the High Optical Power Test Facility (HOPTF), which will develop advanced techniques to allow laser power of the order of 1 MW to be utilised in advanced interferometers. This power is to be built up by resonance from an injected laser power of ~100W. The need for such high power arises because the sensitivity at high frequencies is set by photon statistics or shot noise. But such high power levels introduce a whole new suite of problems: Optical wavefront distortion, often referred to as ‘thermal lensing’, due to residual absorption of the laser beam by the mirrors, can degrade the power buildup and lead to contaminated light leaking out the ‘dark port’ of the interferometer. The radiation pressure creates optical springs that can cause the optical cavities to become unstable. The development of the HOPTF is being done in collaboration with the LIGO Scientific Collaboration.
Cover

Long optical cavities in large diameter, clean, high-vacuum systems, high quality massive sapphire optics, superb vibration isolation, powerful single frequency Nd:YAG lasers, advanced optical alignment and wavefront detection techniques and exceptional clean room facilities are required to undertake this research. This research infrastructure is being installed at AIGO.

The 80 metre south arm of the AIGO research interferometer is being used for the initial HOPTF experiments. Sapphire mirrors and suspension systems supplied by LIGO have been installed in this arm (see front page image, top right corner) and initial lock of the optical cavity to a 10W Nd:YAG laser (shown in front page image, left hand side, along with David Hosken of Adelaide University) has been achieved.

An off-axis Hartmann wavefront sensor will soon be installed, allowing the effect of absorption by the mirror substrates to be investigated. Subsequent experiments will investigate the effect of absorption by the mirror coatings, the effect of wavefront distortion on the coupled optical cavities proposed to be used by advanced interferometer, and methods for controlling optical spring induced parametric instabilities. These experiments will require the installation of a single-frequency, diffraction-limited 50W Nd:YAG laser.

The east arm of the AIGO research interferometer is being instrumented with advanced vibration isolators (see front page image, bottom right hand corner) for a schematic of the isolators) destined for use on a future large scale AIGO interferometer. Ribbon suspensions will be used to obtain the highest possible Q-factor in the optics. These suspension systems will be incorporated in the optical spring and parametric instability experiments, where a low acoustic loss is a critical parameter for observation and control of optical spring instabilities.

For more information on gravity wave research in Australia, see www.anu.edu.au/Physics/ACIGA/, which has links to all ACIGA members.

Letters

To the Editor,

In the July/August issue of Australian Physics my review of Robyn Arranbho's book Einstein's Heroes is criticised by Michael Box for pointing out serious technical errors in the book, namely the incorrect claim in the book that no fringe shifts were seen in the Michelson-Morley experiment of 1887. This is such a fundamental ongoing misconception in physics that the actual results of the Michelson-Morley experiment need to be known to all physicists; namely that they did detect fringe shifts on rotation of the interferometer, and that their analysis of their fringe shift data gave a speed up to 8 km/s using Newtonian theory for the calibration. They rejected this solely because it was less than the known orbital speed of 30 km/s of the earth about the sun. But an interferometer requires a relativistic treatment to determine its calibration, and a revised relativistic analysis of the above fringe shift data now gives a speed greater than 300 km/s.

This result has been confirmed by 6 other experiments, two of which were non-relativistic coaxial-cable RF travel-time experiments. It is very important that physicists be better informed of the history of physics. Truthful reporting of experiments is essential for good physics.

Yours sincerely,

Reginald T. Cahill
A/Prof. Reginald T. Cahill
Faculty of Science and Engineering
Flinders University

2008 Physics Congress
Call for expressions of interest

The 2006 AIP Congress ("RiverPhys") will be held in Brisbane, from December 3-8, at the Brisbane Convention and Exhibition Centre. Further information about arrangements such as the call for papers and registration will be distributed later. This will also be placed on the AIP web site.

A call is now made for expressions of interest in running the 2008 Congress. Those who wish to be considered should be prepared to present a case to the Council meeting in early 2006. No detailed plans are expected for submissions, but there should be a broad outline of the proposal, including some information about the following:

- organizing committee
- location and venue
- budget
- time lines

Expressions of interest should be sent to the Hon. Secretary by December 15. Details of the Council meeting will be circulated by that time.

Ian Bailey
Honorary Secretary
Samplings

People
Geoffrey Ivan Opat
Geoffrey Ivan Opat, Professor of Experimental Physics at the University of Melbourne, died suddenly at home on March 7, 2002, at the age of 66. He was one of Australia’s most versatile and highly respected physicists, scholars and teachers and his death came as a profound shock to the staff of the University of Melbourne and to the physics community in Australia.

His enthusiasm for teaching physics at all levels, from kindergarten to post graduate, and his enormously creative ideas in many different areas have been the hallmarks of a remarkable career in research and in service to the physics profession and to education in Victoria, in Australia and internationally.

A memoir can be found online at www.science.org.au/academy/memoirs/opat.htm

Prizes reward high-energy physics
The European Physical Society (EPS) has recognized four individuals and a collaboration for their work on charge-parity (CP) violation, gamma-ray astronomy, cosmology and outreach activities. Heinrich Wahl, formerly of CERN, and the NA31 collaboration share the 2005 High Energy and Particle Physics Prize for their work on CP violation at CERN. Mathieu de Naurais of IN2P3 in France receives the Young Physicist Prize, Matas Zaldarriaga of Harvard University wins the Gribou Medal, and Dave Barney of CERN and Peter Kalmyus of Queen Mary, University of London, share the Outreach Prize.

PhysicsWeb

Dirac Medal goes to condensed matter physicists
The Abdus Salam International Centre for Theoretical Physics has awarded this year’s Dirac Medal to Sam Edwards of Cambridge University and Patrick Lee of the Massachusetts Institute of Technology (MIT). Edwards wins the prize for “his fundamental contributions to polymer physics, spin glass theory and the physics of granular matter”, while Lee is recognized for “his pioneering contributions to our understanding of disordered and strongly interacting many-body systems”.

PhysicsWeb

JShort Notes
A dimmer future for space telescope
The James Webb Space Telescope was designed to examine IR wavelengths, but would also be able to probe down to 0.6 microns. However, the telescope is already well over budget and a panel of scientists recommended reducing its ability to see shorter wavelengths. The limitation would result from polishing the telescopes mirrors only once. This would save $150 million and 6 months labour.

New Scientist

Cassini finds an active, watery world at Saturn’s Enceladus
Saturn’s tiny icy moon Enceladus, which used to be cold and dead, instead displays evidence for active ice volcanism.

NASA’s Cassini spacecraft has found a huge cloud of water vapor over the moon’s south pole, and warm fractures where evaporating ice probably supplies the vapor cloud. Cassini has also confirmed Enceladus is the major source of Saturn’s largest ring, the E-ring.

The fact that the atmosphere persists on this low-gravity world, instead of instantly escaping into space, suggests the moon is geologically active enough to replenish the water vapor at a slow, continuous rate.

Cassini’s cosmic dust analyser detected a large increase in the number of particles near Enceladus. This observation confirms Enceladus is a source of Saturn’s E-ring. Scientists think micrometeoroids blast the particles off, forming a steady, icy, dust cloud around Enceladus. Other particles escape, forming the bulk of the E ring.

NASA/Cassini

Making ice at room temperature
Researchers in Korea have shown that liquid water can freeze into ice at room temperature under certain conditions. Heon Kang and co-workers at Seoul National University confined water in a nano-sized gap and showed that it froze when an electric field was applied (Phys. Rev. Lett. 95 085701). The result could have implications for the formation of ice in a wide variety of natural environments.

PhysicsWeb

Geoneutrinos
Neutrinos are difficult to detect because they are electrically neutral and only interact weakly with matter. This means that they can pass through thousands of kilometres of matter without being absorbed.

Now, a new era in neutrino physics has opened up with the detection of electron antineutrinos coming from radioactive decays inside the Earth. The Kamioka liquid scintillator antineutrino detector (KamLAND) in Japan has registered the presence of candidate events of the right energy.

The neutrinos presumably come from the decays of U-238 or Th-232. They are sensed when they enter the experimental apparatus, where they cause a 100-ton bath of fluid to sparkle. Scientists believe the Earth is kept warm, and tectonic plates in motion, by a reservoir of energy deriving from two principal sources: residual energy from the Earth’s formation and additional energy from subsequent radioactive decays. The rudimentary inventory of geoneutrinos observed so far is consistent with the theory [Akai et al., Nature, 20 May 2005].

If the accuracy of the measurements can be improved it may be possible to use “geoneutrinos” to probe the Earth’s interior. The KamLAND results have already been used to place an upper limit on the heat generated by uranium and thorium inside the Earth.

PhysicsWeb/Physics News/KamLAND

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Scientists Discover Tenth Planet

A planet larger than Pluto has been discovered in the outer regions of the solar system.

The planet was discovered using the Samuel Oschin Telescope at Palomar Observatory near San Diego, Calif. The discovery was announced by planetary scientist Dr. Mike Brown of the California Institute of Technology in Pasadena, Calif., whose research is partly funded by NASA.

While it is a typical member of the Kuiper belt, its sheer size means that it can only be classified as a planet, Brown said. Currently about 97 times further from the sun than the Earth, the planet is the farthest known object in the solar system, and the third brightest of the Kuiper belt objects.

Brown, Trujillo and Rabinowitz first photographed the new planet with the 48-inch Samuel Oschin Telescope on October 31, 2003. However, the object was so far away that its motion was not detected until they reanalysed the data in January of this year.

Scientists can infer the size of a solar system object by its brightness, just as one can infer the size of a faraway light bulb if one knows its wattage.

"Even if it reflected 100 percent of the light reaching it, it would still be as big as Pluto," says Brown.

Gemini Observatory has obtained a preliminary spectrum of the "10th planet." These observations were obtained on January 25, 2005 by Chad Trujillo, a Gemini staff member who is also on the discovery team for the planet.

To better characterize the surface of the object the team obtained spectra with the near-infrared spectograph (NIRI) on the much larger 8 m Gemini North telescope on Mauna Kea, Hawaii. The NIRI spectra shows strong signatures of methane ice, remarkably similar to the spectrum of Pluto, which is also dominated by methane ice in near-infrared observations.

At your fingertips

Yoshio Hayasaki of Tokushima University and colleagues have discovered that data can be written into a human fingernail by irradiating it with femtosecond laser pulses. Capacities are said to be up to 5 megabits and the stored data lasts for 6 months — the length of time it takes a fingernail to be completely replaced (Optics Express 13 4560).

The team's approach is simple: use a femtosecond (10-15 seconds) laser system to write the data into the nail and a fluorescence microscope to read it out. Initial experiments were carried out on a small piece of human fingernail measuring 2 x 2 x 0.4 cubic millimetres. The writing system comprises a Ti:Sapphire oscillator and Ti:Sapphire amplifier. Pulses of less than 100 femtoseconds at 800 nanometres are then passed through a microscope and focused to three set depths (40, 60 and 80 microns) using an objective lens.

Each "bit" of information has a diameter of 3.1 microns and is written by a single femtosecond pulse. A motorised stage moves the nail to create a bit spacing of 5 microns across the nail and a depth of 20 microns between recording layers.

An optical microscope containing a filtered xenon arc lamp excites the fluorescence and reads out the data stored at the various depths. The same fluorescence signal is seen 172 days after recording.

Initial experiments have concentrated on small pieces of nail but the team is working on a system that can write data to a fingernail that is still attached to a finger.

PhysicsWeb

Inner spin

The inner core of the Earth is a dense ball of solid iron and nickel with a radius of about 1280 km that is surrounded by the outer core — a 2210 km thick layer of liquid metal. The next layer, the mantle, is made of molten rock and has a thickness of about 2850 km, while the topmost layer, the crust, is less than 100 km thick. It is thought that the Earth's magnetic field is produced by the rotation of the outer core and mantle.

Just like electromagnetic waves, the seismic waves produced by earthquakes refract at boundaries between two different media. Therefore by detecting seismic waves that have been created on the other side of the globe, it is possible to extract information about the earth's interior.

Zhang, Song and co-workers compared the seismic waves from "Earthquake doublets" — pairs of quakes which occurred at the same location but at different times. They studied 18 doublets in which the waves were created by quakes in the South Sandwich Islands in the South Atlantic Ocean and detected at 58 seismic stations in and near Alaska. The largest gap between the two quakes in any doublet was 35 years. Each quake results in a characteristic signal known as a "waveform".

They found that when the waves did not pass through the inner core, both waveforms in the doublet were the same. However, if the waves had passed through the inner core and were more than four years apart, the waveforms were different. This means that something must have changed along the path followed by the waves during this period (Science 309 1357).

PhysicsWeb
Physics Enrolments in Australian and New Zealand Universities 2000 to 2005

John de Laeter, Philip Jennings and Graeme Putt

Introduction
This is the thirteenth of a series of triennial surveys of physics enrolments in Australian and New Zealand Universities. This project began in 1974 with surveys by Watson-Munro¹ and de Laeter² for physics enrolments at Australian Universities and Colleges of Advanced Education respectively in the period 1963 to 1973. The original aim of the surveys was to collect data for planning purposes and to study the effects of Government policy on the physics profession.
In 1975, de Laeter and Watson-Munro³ produced the first of their combined surveys for all Australian tertiary educational institutions covering the period 1965-1975. They repeated the exercise in 1979.⁴ Following the retirement of Professor Watson-Munro in 1979, Philip Jennings and John de Laeter combined to continue the surveys at triennial intervals through the eighties.⁵ In 1993 the survey was expanded to include New Zealand universities and Graeme Putt joined the team.⁶ We now have a consistent set of data covering the period 1968 to 2005 for Australian universities and from 1991 to 2005 for New Zealand universities.
Originally, the surveys focused on the numbers of third and fourth year physics students. These were easier to identify than graduates in physics, as some students study double majors which are difficult to keep track of, while others graduate at mid-year. Although it is easier today to collect the data on physics graduates because it is required by the Federal Government, we have continued to count third and fourth years physics enrolments for historical consistency. They also represent a more realistic estimate of the class sizes in physics rather than the output of physics departments.
Beginning with the 1982 survey, we began to collect the total number of postgraduate students in physics. Here again we chose to count the total number of postgraduate students to gain an indication of the size of the postgraduate effort. In earlier surveys we also estimated the number of pass, honours and higher degree graduates each year. In 1991 we also began to address gender issues because of the perceived low level of participation by females in physics. Initially there was some difficulty in obtaining this information, but we now have sufficient data to draw conclusions and, as time goes by, we are able to study trends in participation rates of males and females.

Methods
In the 2002 survey, in addition to collecting data about third year students, from left to right: Emeritus Professor J.R. de Laeter is at Curtin University, Professor P.J. Jennings is at Murdoch University and Dr G.D. Putt is at the University of Auckland.

Good News at Last
The Physics communities in Australian and New Zealand Universities have endured a difficult period over the past decade or so in terms of a marked diminution in funding, leading to a serious decline in the number of academic and technical staff, a marked deterioration in the infrastructure of undergraduate teaching laboratories and increased teaching loads. This has affected the research output of many Departments. Although a reduction in funding for universities has affected disciplines other than physics, it has been particularly serious for physics and other laboratory-based courses as teaching costs are high, student numbers at the senior level are sometimes low and there are difficulties in attracting full fee-paying international students. This has been compounded by the loss of service teaching, such as engineering physics units, because these disciplines are also facing funding constraints. Thus the term "Enabling Sciences" has become a misnomer in many universities. These problems have caused some universities to close down or amalgamate some Physics Departments on the grounds that they are high-cost, low-enrolment Departments - despite their obvious importance to the profile of the university, especially in research.

Due to the severe budget cuts and declining enrolments in Physics in many tertiary educational institutions, the 1996, 1999 and 2002 surveys were undertaken in the midst of considerable upheaval and unprecedented anxiety about the future of physics in Australia and New Zealand. In our last report, we noted that there was some indication that the number of third year students was increasing, and that some stability was returning after the "rationalisation" policies of the past years. This prognosis has proved to be accurate as demonstrated by the statistical information presented in this paper. A comparison of the total number of third year students in the 2000 to 2002 period with the 2003 to 2005 period, for example, reveals an increase of over 42% in this most recent survey. Increased enrolments have also occurred at the fourth year and postgraduate levels. This renaissance in physics enrolments has been brought about in part by a diversification of "pure" physics into "applied" physics courses such as Astronomy/Space Physics, Computational Physics, Medical Physics, Nanotechnology and Photonics, but also in the realisation that basic physics underpins many of the developments in these applied fields. This report is therefore good news for the Australian physics community. However, except at the fourth year level, these encouraging trends have not been reflected in New Zealand.
fourth year (Honours and Diploma) and postgraduate (MSc and PhD) enrolments, we asked a set of questions about recent changes in course content and structure, and to the administration of the physics courses in the various Universities. We also sought information about changes planned for the near future, changes in the student population and significant problems facing the departments. We have continued this practice in the present survey.

The data was obtained from the Heads of the various physics departments in Australian and New Zealand universities. We have tried to ensure that the data is consistent and accurate by circulating the tables to Heads for checking. However, there are certain to be minor errors due to the difficulty of uniquely identifying physics majors. If Physics-related courses have been accredited by the AIP, or have 50% or more Physics content, their enrolments have been included in the statistical data in Table 1. We encourage readers to notify us if they detect any errors in the data.

Analysis of Enrolment Data
The third year, fourth year and postgraduate enrolments for the period 2000 to 2005 are presented in Tables 1, 2 and 3 respectively. Figures 1, 2 and 3 show the trends in total enrolments at third year, fourth year and postgraduate level over the 38 year period since data collection began in 1968. The following observations are made on this data:

Third Year Enrolments
Australia: Twenty eight universities are now offering some sort of Physics degree compared with 30 a decade ago. Third year enrolments have increased after falling from 704 in 1993 to 488 in 2001. The results for 2002 showed an increase in enrolments and this trend has continued from 2003 to 2005. The average number of students per year over the period 2000 to 2002 was 528, as compared to 761 students per year from 2003 to 2005. The 870 students enrolled in 2005 exceeds the previous record of 704 in 1993 by a massive 166. This increase is partly due to the introduction of new physics-related degrees such as Astronomy/Space Physics, Computational Physics, Medical Physics, Nanotechnology and Photonics that are taught alongside the existing physics degrees and utilize their third year units. The proportion of female students in third year physics has slightly decreased from 23% of the cohort in the 2000 to 2002 triennium to 21% in the 2003 to 2005 triennium. The only university to register zero student enrolments in 2005 was Western Sydney, but the enrolments in Victoria University have declined rapidly since the decision was taken to phase out the physics course in 2001. This was a surprising decision in that the average number of enrolments from 2000 to 2003 was 23 per year. On the other hand Swinburne University of Technology has re-introduced a physics course which has 18 enrolments in 2005.
New Zealand: Six universities offer a degree in physics, the same as a decade ago. Enrolments continued at a relatively steady average level of 131 students per year. The percentage of females increased only marginally above the previous triennium from 15%, to 17% for the 2003 to 2005 triennium.

Fourth Year Enrolments
Australia: Fourth year enrolments in physics have increased again after falling substantially from 264 in 1996 to 132 in 2001. The average number of enrolments over the period 2003 to 2005 of 187 per year represents an increase of 26% over the previous triennium of 148 per year. The gender balance in fourth year courses has remained stable and similar to that in the third year courses over the past decade, but it decreased from 24% in 2000 to 2002, to 22% in the present triennium. The Universities of Central Queensland, Western Sydney, Swinburne and South Australia reported zero enrolments in 2005.
New Zealand: There has been a noticeable increase in enrolments in fourth year over the last triennium. This most likely reflects the increasing interest in four-year programs of extended undergraduate study like BTech and BScs in Applied Science rather than postgraduate studies. Interestingly the increase is a stepped one, increasing from a flat 66 students per year (2000 to 2002) by almost 20% to a relatively flat 79 students per year (2003 to 2005). It is a trend that will probably hold up as physics departments attempt to provide attractive four-year program alternatives to Engineering Schools, who actively recruit able Physics/Mathematics secondary pupils directly from school into their own degrees. The gender balance has remained relatively stable over the past decade.

Postgraduate Enrolments
Australia: Postgraduate enrolments in physics fell from a high of 1023 in 1993 to 739 in 2002. In contrast, the postgraduate numbers steadily increased during the present triennium by 9% with respect to the previous triennium. The proportion of female postgraduate students in Australia is about 23% over the past six years. The Northern Territory University (now Charles Darwin University) has had no postgraduate enrolments in physics in the present triennium.
New Zealand: There has been a drop in enrolments over the last triennium from the relatively higher and stable numbers of the first six years of the past decade. Numbers have now levelled out in line with the 17% plunge that occurred in 2002. Some of this decline can be attributed to government funding for PhD students, progressively reducing from a 6 year to 4 year maximum. Whatever the reason, it is a worrying statistic to departments given the heavy demand for such students to assist with departmental teaching needs (laboratories and tutorials), as
well as prosecute research. The gender balance has risen slowly for females over the past decade and in the present triennium it is 22.9%.

Analysis of the Questionnaire Data

In addition to the enrolment data we collected responses to five questions. A content analysis was carried out on these responses and the results are summarised below:

1. Describe any major changes to your educational offerings in Physics over the past five years (eg new directions, new awards, termination of courses, etc)

   **Australia:** Over the past five years, twenty new, physics-related courses have been introduced. These include Astronomy/Space Physics [4], Computational Physics [2], Medical Physics [2], Nanotechnology [6] and Photonics [6]. In the same period of time, two courses in Medical Physics have been discontinued and three courses in basic physics have suffered the same fate.

   Most universities have undertaken major reviews and subsequent restructuring of their physics courses over the past five years. Four universities have introduced joint degrees with physics and engineering. Only five Universities reported no substantial changes to their offerings over the past triennium.

   **New Zealand:** While most universities have adopted a conservative approach to initiatives because of staff depletion and decreasing postgraduate student numbers, some new offerings have emerged with Biomedical Physics or Electronics slants. Canterbury has introduced PGDipSc, MSc and PhD programs in Medical Physics (the PGDipSc/MSc in response to demands from the medical physics profession) to which they have this year added a BSc (Hons) degree in Medical Physics. Interestingly, their near neighbour, Otago, has decided to withdraw the MSc in Medical Physics they had introduced some five years ago because of limited, subsequent uptake. A national restructuring program driven by Government to enable greater transportability of undergraduate course credits between universities has generally usurped interest in fresh offerings. This normalisation of all three-year degrees to a common 360-point tally has resulted in universities like Auckland needing to repackage existing 21 (equal credit value) courses to 24 (15 point) courses.

   Academic administrators there have temporarily embargoed new courses and programs until things have settled following implementation in 2006.

2. Are there any major changes planned in your educational offerings in the next three years?

   **Australia:** Nineteen universities indicated that no major changes were planned.

   Ten universities have planned major new initiatives for the next three years, including Astronomy/Space Physics [1], Medical Physics [2], Nanotechnology [2], Photonics [1], and Physical Science [1].

   **New Zealand:** Massey, Canterbury and Otago have BSc degrees with Electronics majors that are sponsored by Physics (rather than Electrical Engineering) in the pipeline. Auckland has a bold plan for a BTech program in Medical Technology to attract students otherwise enrolled in pre-medical programs. This is a four-year program that will result in students being effective majors in both Physics and Physiology. Waikato, although cautious about overstretching its depleted academic establishment in Physics, also intend to revamp current course offerings with a biophysics focus. Wellington has no immediate plans, anticipating that the on-site establishment of the MacDiarmid Institute for Advanced Materials and Nanotechnology will attract a growing number of able students into the BSc Physics program.

3. Have you observed any substantial changes in the Physics student population at your University over the past five years? (eg change in gender balance, change in quantity or quality of students, changing age profile, etc)

   **Australia:** Nine universities report an increase in enrolments over this triennium, but five report a decrease. Most universities report a decline in the quality in students entering a physics course, with respect to their preparation in mathematics and physics, but there is some evidence to suggest that allied courses such as Nanotechnology have attracted a better quality of student intake. One university has introduced a bridging course to alleviate the problem of poor student preparation for tertiary level physics. Part of the increase in student numbers is undoubtedly due to the introduction of allied physics courses, including combined degree programs.

   **New Zealand:** The Physics student population has remained stable throughout the past triennium. The ethnicity make-up has also steadied within each university even though it differs from university to university from north to south in the country. Otago, which has experienced some growth in numbers, reports increased numbers of females taking Physics. However, Waikato has experienced declines with fewer females beyond first year.

4. Have there been any significant changes to the administration of your Physics degree over the past five years? (eg mergers, closure, etc.)

   **Australia:** Eighteen universities said that there had been no significant changes in the administration of their physics degree over the past three years, but all the other universities have experienced substantial changes. The most common were mergers with a related discipline and consequent loss of Departmental autonomy. The most common mergers were with engineering, mathematics and chemistry. Three universities have phased out their physics programs,
but two universities have elevated their Departments of Physics to School status.

New Zealand: There have been no significant changes to the administration of the degree courses. This is primarily because of the major national restructuring changes that are to be implemented in 2006. It will probably remain so until the restructuring changes of 2006 have settled down.

5. What do you consider are the most significant problems facing your Department at this time? (eg declining enrolments, lack of junior staff, etc)

Australia: Four universities said that there were no significant problems facing their Department. The remaining universities listed a wide variety of issues of concern. These are listed below in descending order of frequency of response.
- Funding cuts/funding crisis
- Loss of staff
- Workload explosion for staff
- Loss of service teaching
- Administration-generated workload
- Lack of administration/university support
- Skewed age profile of staff/succession crisis

New Zealand: Diminishing numbers of postgraduate students is a worry for several departments. For some time, the recruitment of interested international postgraduate students to New Zealand has been thwarted by funding short-sightedness in Government policy. Accordingly, a recent Government announcement to subsidise tuition fees for international students (currently around $22,000 for students not sourced as nationals from Australia, France or Germany) and reduce them to the same level as fees for domestic students (about $4,000), is very welcome, even though vague in implementation details at this stage. Another problem specified is the aggressive recruitment of the ablest physics and mathematics school students by the Engineering and Health Science Faculties, especially the former. This threatens the potential pool of local postgraduate students and some departments are looking at ways of addressing this. Finally, staff losses and increases in workload are highlighted as a major concern for smaller Departments.

Conclusions

The past six years has been a time of major changes in Physics education in Australia and New Zealand. Many departments have undergone changes of structure and many have been merged with other departments. At the end of this survey period the third, fourth and postgraduate enrolments in Australian Universities have increased significantly. In contrast, the corresponding enrolments in New Zealand Universities have remained almost static over this period, except for the fourth year enrolments, which have increased. Presumably these numbers will flow on to the postgraduate level in future years.

Some physics departments have introduced new allied courses in applied areas such as Astronomy/Space Physics, Computational Physics, Medical Physics, Nanotechnology and Photonics in a successful attempt to make their courses more attractive. Others are planning to make similar changes in the near future. There is some evidence that these changes have also been successful in attracting more high-quality students into physics. Many physics departments are facing funding crises and workload explosions as a result of the departure of staff who are not being replaced. Many Heads of Department expressed concerns about continuity and succession planning as older staff retire and are not replaced. Most departments now have highly skewed age profiles with most staff over 50 years in age and in senior positions. A loss of service teaching to Engineering and other disciplines is of major concern to many universities.

Overall, it appears that the funding and enrolments crises that appeared in the mid-nineties may have almost run their course, and that physics departments have successfully restructured in many cases to cope with the new funding arrangements. Considerable staff losses have occurred and further losses seem inevitable, but the enrolments picture is encouraging and there are early signs of a recovery. Over the next five years most physics departments will have to cope with an increasing workload and declining staff and financial resources, but the future does look much more promising than it did three years ago.

Acknowledgements

The authors are indebted to our colleagues in the various Universities of Australia and New Zealand who have supplied us with the data and checked the tables for us.

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**Table 3**

Physics Enrolments in Australian & New Zealand Universities 2000 - 2005

Numbers of Postgraduate Physics Students

**Australian Physics** Volume 42 Number 4 September/October 2005
Science Commercialisation
Pathways to Success

▷ Want to get your research commercialised?
▷ Want to find new technology?
▷ Want to find the new breakthrough product?

Come along and make a presentation at a series of interactive events bringing academia and industry together.

- Sydney 29th September  
- Brisbane 3rd October  
- Adelaide 18th October  
- Perth 20th October  
- Canberra 3rd November  
- Melbourne 16th November

An opportunity for research community to present their research and for industry to present their interests so that connections can occur during the events.

Keynote speakers will include Ted Tussing, Manager of New Ventures at Stanford University (Sydney and Brisbane) and the Australian Institute of Commercialisation.
Einstein International Year of Physics

Einstein year in August – events, guests everywhere
100 years on, how are we celebrating?

National Science Week 2005 overflowed with physics events, guests and interviews around the country.

A special edition Science Week Einstein Year bulletin was sent out highlighting some of the events.

Just a few of these were:
• Ken Skeldon performed his Arcs and Sparks show and rebutted moon sceptics
• Noel Sharkey, the inspiration for Robot Wars, spoke on artificial intelligence
• Scientists in lab coats were spotted on masse on buses, ferries and trains as part of the Einstein Rally at The Domain in Sydney
• At the University of Adelaide, Baroness Susan Greenfield discussed Australian Nobel Prize winning father and son, William and Brian Rippon

Physics in film
Periodic Reproduction personifies the process of fusion; The Chaos Theory, a film involving a disgruntled housewife; a strange news team; and an explanation of chaos theory; and Saving the Dinosaurs were some of the films entered into the student physics category for Scinema.

Scinema is a national science film festival run by CSIRO and the National Museum of Australia. Over 40 films were included, and this year, the student category had a physics theme in honour of Einstein Year. A recipient of an AIP seed grant, the film festival showcased ten finalists - two primary school entries, six secondary and four tertiary.

Scinema films have been shown across the country.

what did you do?
If you have run an Einstein Year event this year, we’d love to hear about it.

Send us a short paragraph and any photos or images as we’ll be profiling events on the Einstein Year website.

Contact us on einstein@aip.org.au or www.einstein2005.org.au
Students teach students energy
Science teacher Jane Hall-Dadson received a seed grant for 'Exploring Energy at Exeter', a 14 day science fair with a focus on energy in Tasmania.
This was a fair with a difference - 150 students from years 9 and 10 presented science shows to local primary students. 250 primary students witnessed demonstrations of plasma balls, hydrogen fuel and static electricity.
The school has created an energy fair manual to assist others interested in running a fair.

Measuring the earth is one immense task...
Schools across the country paired up during Science Week to measure the circumference of the earth. This was a national experiment conducted for the Einstein Year and coordinated by RMIT Applied Physics.
Students recreated an ancient experiment first performed by Greek astronomer and poet, Eratosthenes, in Egypt more than 2,200 years ago.
A total of 103 schools across Australia first determined their local noon and then measured the elevation of the sun on the same day as their partner school which was on the same longitude but different latitude. Students then shared their data to calculate the diameter of the earth, with some overcoming the additional challenge of cloudy skies.
Students both submit their results and analyse the reliability or uncertainty of the estimate. The pair of schools with the closest estimate and strongest analysis will win $1000.
The results will be published on 26 September at www.rmit.edu.au/scienceweek.
A national press release was sent out and a number of schools contacted their local media. Brendan Nelson, Minister for Education, Science and Training launched National Science Week by assisting students at St Ives in NSW with their experiment.
Contact: Alex Merchant (03) 9925 3388, alex.merchant@rmit.edu.au

In search of explorers
The second Einstein Year poster has been printed. It depicts an astronaut floating in space above the earth on the first untethered space walk.
The idea 'in search of explorers' invites students and others with an interest into the world of physics which allows us to explore the world around us and the world beyond us.
The posters have been distributed to science teachers across Australia through the journals for each of state's Science Teacher Association.
A limited number have also been sent to the AIP state branches.
If you would like posters for your Einstein Year event, please contact the communication team at einstein@aip.org.au

Australia's forgotten Einstein
Melbourne honours William Sutherland, Australia's forgotten Einstein, during a physics forum hosted by ABC Science's Bernie Hobbs at the Melbourne Town Hall.
More than 1,500 secondary students learnt about Einstein's big ideas, watched demonstrations and heard from physics graduates on jobs and careers.
And Sutherland's ghost made a special appearance.

The panel of young physicists on the stage as the student audience asks them questions about their work and tries to match faces to careers. The student who made the best guess is awarded an AIP-sponsored iPod shuffle.
Einstein International Year of Physics

Melbourne Physics Forum

Among the Physics Outreach Program highlights this year was the School of Physics inaugural Melbourne Physics Forum for the Einstein International Year of Physics, which drew well over 1500 senior secondary school students from 40 schools across the state to the Town Hall in July.

The show was designed in anticipation of changes to the VCE physics curriculum, which for the first time this year seeks to incorporate Einstein's work. Demand exceeded all expectations — the number of students attending represented about 15 per cent of Victorias Year 11 VCE physics cohort.

The evening was compered by Ms Bernie Hobbs [of the ABC's The New Inventors], Einstein actor Ben McKenzie Evans] was on hand to explain his famous achievements of 1905: E=mc\(^2\); the Einstein-Sutherland Diffusion Equation relating to Brownian motion; the photoelectric effect; and the Special Theory of Relativity.

Professor Rachel Webster, Dr David Hoyle, Dr Roger Rassool and Professor David Jamieson gave short lectures and postgraduates Clare Henderson, Russ Anderson and Alastair Meehan warmed up the crowd with innovative and entertaining hands-on demonstrations. Mr Anderson delighted the audience by discharging a fire-extinguisher while wearing roller-skates, ably demonstrating Newton's third law of motion — that for every reaction there is an equal and opposite reaction.

The show concluded with a panel of physics alumni answering students' questions about their jobs, exposing the students to the diverse career paths available to physicists.

The program was conceived and realised by School of Physics staff Dr Shane Huntington, Professor David Jamieson, Dr Roger Rassool, and Ms Helen Conley, and event directors Dr James McCaw and Ms Joanne Kulveevski.
Drawing on 130 years of experience, the Leybold Group is a world leader in vacuum technology. Javac in conjunction with Leybold are able to offer a complete range of vacuum equipment and systems. Personnel trained in Leybold’s factories enable Javac to offer High Quality professional service to support Leybold equipment in Australia.
Prompt Critical

According to Einstein

This being Einstein year, and with nothing new to review, I thought it timely to browse through Einstein’s thoughts on his various acquaintances from the deity down. Alice Calaprice, in her wonderful collection of Einstein quotes, remarks that he often explained his religion as an attitude of cosmic awe and wonder and a devout humility before the harmony of nature, rather than a personal god. Einstein wrote in a letter “I see only with deep regret that God punishes so many of his children for their numerous stupidities, for which he himself can be held responsible; in my opinion, only his nonexistence could excite him.” On the afterlife he wrote “...the concept of a soul without a body seems to me to be empty and without meaning.”

Einstein had equally succinct views of fellow mortals he had known. On the Curie he was rather ambivalent. Just a few months after apologising for “my crude manners” in their company, he wrote “Madame Curie is very intelligent but as cold as a herring...” “...and she has a daughter who is even worse – like a grenadier. This daughter is also very gifted.”

In his essays Einstein wrote “What is so marvelously attractive about Bohr as a scientific thinker is his rare blend of boldness and caution; seldom has anyone possessed such an intuitive grasp of hidden things combined with such a strong critical sense.” And on another great name Einstein remarked “This Pauli is a well-oiled head.” Of Max Planck Einstein wrote “He is one of the finest people I have ever known... but he really did not understand physics.” On the other hand Einstein once said of Heisenberg “He is a great physicist, but not a very pleasant man.”

Colin Keay
Reviews Editor

Reviews

General Relativity

General Relativity with Applications to Astrophysics
Norbert Straumann
Springer-Verlag, Berlin 2004
xii + 674 pp., EUR 69.95 (hardcover)
ISBN 3-540-21924-2

Geoffrey Bicknell
Research School of Astronomy & Astrophysics
Australian National University

General Relativity has assumed an ever-increasing importance to professional astrophysicists ever since the development of cosmological models in the 1920s and the explosion of new mathematical results on black holes in the early 1960s. However, general relativity is a mathematically complex subject and in this book Norbert Straumann presents a pedagogically precise and highly informative account of both the physical and advanced mathematical concepts that a professional working in this field requires. The essential differential geometry background is placed in an extensive part III at the end of the book, which includes a welcome exposition of the calculus of differential forms. Readers familiar with this background can immediately launch into the physical basis of general relativity (Part I) and physical applications (Part II). Astrophysical applications include gravitational waves, black holes, neutron stars and white dwarfs and the treatment is both physically rigorous and comprehensive. This book is an important acquisition for anyone working in this area. However, the mathematical aspects are frequently presented in a formal, purely mathematical, style, without a lot of physical motivation. Therefore, using this book as an undergraduate or graduate text requires the lecturer to do a fair bit of work to make the mathematics comprehensible.

Einstein’s Other Theory, The Planck-Bose-Einstein Theory of Heat Capacity
Donald W. Rogers

The title of this book says it all. It is not about Einstein’s theory of relativity, rather it is about Einstein’s other great theory, that of the Bose-Einstein condensate. This book written by Professor of Chemistry Donald Rogers traces the history of radiation and heat capacity theory from the early nineteenth century until present day. Pitched at a second year physics/chemistry student level the book is well written and well laid out. What I liked particularly about this book was the logical way it progressed. Starting with rudimentary concepts, each chapter builds on previous results, making the book easy to follow.

Interestingly it is written from the point of view of a chemist rather than a physicist, and this is clearly noticeable in the text. The derivations are well done, with all the maths explicitly laid out (including all those tricks that can take hours to figure out yourself). The chapter on quantum statistics is particularly well done, with the derivation of the Bose-Einstein, Fermi-Dirac and Boltzmann distributions being the highlight.

In summary I would recommend this book to anyone interested in the underlying physics of heat capacity or indeed the early history of quantum statistics. It is perhaps too specific to be useful as the sole textbook for an undergraduate physics course, but it would make a good reference book.

A. G. Truscott
RS Phys SE
Australian National University

xii + 175 pp., US$49.50 (hardcover)
ISBN 0-691-11826-4
This book follows on from Visual Quantum Mechanics (VQM) (published in 2000). It is a standard textbook for theoretical quantum mechanics, but with extensive computer visualizations. VQM dealt with quantum mechanics in one and two space dimensions. ADVQM, which is essentially independent of VQM, does three-dimensional systems, the hydrogen atom, spin, and relativistic quantum mechanics. Most interesting is the inclusion of a basic course in quantum information theory, including quantum teleportation, the EPR paradox, and quantum computers.

I eagerly opened this book expecting, as the title alluded, a volume encompassing a wide number of techniques, arranged in logical 'themes' such as scanning probe microscopies. Unfortunately, I was disappointed to find instead a collection of specific applications, namely microrelaxation, particle image velocimetry, electrokinetic flow, thermal imaging of microelectronic devices, mechanical characterisation of carbon nanotubes and quartz crystal microbalances for microdevice

Einstein's Miraculous year
J. Stachel (ed.)
Princeton University
Press, Princeton
NJ 1998
xv + 198 pp.,
US$39.95
(hardcover)
ISBN 0-691-05938-1

In case you've missed it, this is the centenary year of Einstein's Annus Mirabilis and here are the five key papers in new English translations, together with useful commentary by renowned Einstein expert John Stachel. The first two papers are on atomic theory - one estimating the size of molecules (his Ph D thesis), the other, rather better known, on the Brownian motion. Then come his two papers on relativity theory. The first of these lays the basic principles, the most revolutionary of
GO FURTHER
than you ever imagined

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GRADUATE CERTIFICATE OF MEDICAL PHYSICS

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Our programs have been designed to meet the global demand for graduate scientists with the knowledge, understanding and expertise to work within the highly scientific and technical environment of Medical Physics.

The Institute of Medical Physics at the University of Sydney offers students a wide variety of subjects in radiation physics, radiation dosimetry, anatomy and physiology, instrumentation, radiotherapy physics, medical imaging physics, image processing, radiation biology and health physics and research methodology.

Higher research degrees of Doctor of Philosophy (PhD) and Master of Science (MSc) are also available.

POSTGRADUATE OPEN NIGHT

We invite you to find out more at our Postgraduate Open Night which will include a range of seminars about our coursework programs and a research exhibition.

Wednesday 12 October 2005
5:30pm - 8:30pm
Medical Physics Seminar from 7:30pm - 8:15pm
The Eastern Avenue Complex
The University of Sydney

Refreshments will be served. There is no charge to attend this event; however, seminar places are limited. Register to attend on-line at:


For more information call (02) 9351 3021.

POSTGRADUATE PROGRAMS SCIENCE

The University of Sydney
GO FURTHER go beyond
George Dracoulis is an internationally recognised leader in nuclear spectroscopy, which is central to the discipline of nuclear physics. His research work in this area has placed Australia in the top league of the international nuclear scene and has set benchmarks, in particular for time-correlated gamma ray and electron spectroscopy. His work showed the importance of systematic interpretation. The results led to a new understanding of the nuclear system. He is a Fellow of the Australian Academy of Science, the Australian Institute of Physics and the American Physical Society. His citation for the Fellowship of the American Physical Society noted that the Fellowship was awarded to him for his contributions to the understanding of nuclear structure in the mass 190 transitional and translead nuclei from comprehensive nuclear spectroscopy.

Australia is a nation of migrants and since the 18th century several waves of migrants have descended in this land of the dreaming peoples. The first European colonists and settlers arrived on the shore of Sydney Harbour in 1788 and amongst them was an astronomer who set up an Observatory at Dawes Point. This Observatory began the tradition of astronomy and the physical sciences in Australia.

In the 20th century other waves of migrants arrived from war torn Europe and Asia to find solace and to start a new life. It was in one of these waves that the Greeks arrived in Melbourne and founded one of the largest Greek communities in the world outside Greece. Dracoulis' ancestors came from Ithaca, which is famous for being the kingdom of King Odysseus, a hero of the Trojan War, who was immortalised in Homer's epic The Odyssey. By nature Ithacans have always been a seafaring people and, like their famous ancestor, they loved to travel.

Australia was a favourite destination for Ithacans. In fact, two of the first Ithacans to migrate to Australia were George Morfesis (in 1840) and Andreas Lekatsas (in 1845) from the village of Eoighi. The latter took part in the Eureka Stockade. Thus the Ithacan community in Australia has a rich history that goes back to the 1840s. In common with many young men from the islands Dracoulis' father had been a merchant seaman who first went to the US before coming out to Australia. The more distant part of his father's family were associated with the Dracoulis shipping firm which had offices in London.

Growing up

Dracoulis was born into one of these Ithacan families in the years of the Second World War. His parents had come out from Greece before the Second World War but they had met in Australia and got married. Over the years his father owned a fruit shop and when he didn't have a fruit shop he 'usually worked as a waiter in some of the big restaurants and some of the hotels in Melbourne', Dracoulis told me. He came from a close knit family that helped in running the fruit shop but was also part of the larger Greek community which was very much involved in the Greek Orthodox rituals of "christenings, marriages, deaths, etc". Although the church was central to the Greek culture he was born into, however, Dracoulis said that "as a person I don't believe in God".

The early European and Asian settlers suffered prejudice in a society made up mostly of British and Irish settlers. But as a young boy he was not aware of this prejudice. However, he recalls an incident that took place in his primary school days that has always perplexed him. "I was a small young child and I was stood up in front of the class by an elderly man who seemed to be a very angry teacher who said something like, 'Oh well, you're Greek are you? Why don't you say something in Greek then' and stood me up in front of the whole class and I was sort of petrified".

He was much more fortunate in his secondary school years to have attended a government school (Glenroy High School) which had students from various countries and cultures. "There was no point in picking on a Greek when there was an Italian next door or a German up the road or a Dutch person here or an Englishman or whatever". Glenroy High School consisted mainly of 'migrant kids'. It was a new school in Broadmeadows, a new housing commission area 15 kilometres north of Melbourne. "A lot of the people who were living..."
there had moved there from what was a migrant hostel called Camp Pelt which was originally a Victorian Military Camp”, he said.

He did well in school and was encouraged by the young teachers in his school. "I was moved a few times into, for example, the higher maths class”. He was influenced by the young, energetic and socially orientated teachers at Glenroy High School. "I was influenced and encouraged by the young teachers at Glenroy High School and they were young. I mean, they were probably only 22 or 23 years old at the time. Certainly the physics teacher talked a lot about physics as a discipline and the personalities in physics, if you like, and I quite liked his style. I was impressed by that and that probably had an influence on me".

A pen portrait about him in the school magazine noted - Ambition: physicist.

Studying at Melbourne University
At his school the teachers only mentioned Melbourne University and not Monash as the university to go to. So he enrolled at Melbourne University and "did the traditional science, pure and applied maths, chemistry and physics. It was a fantastic environment in those years but not from an academic point of view. It was stimulating intellectually and I didn’t mix terribly much with science students. I found most of my friends in other areas, so I had a great time at university but I probably was lucky to get through”, he said.

He did not find the lecturers either outstanding or inspiring. "There were a lot of people who I would say were memorable in the sense that they were idiosyncratic, but we didn’t have inspiring lecturers. But again, the classes were very big as well. I can remember for physics, there was something like 160 kids in a class, and I don’t think that’s an environment where you really have inspirational lectures”. He was not adopted by any particular mentor by the time he got to his final year, he noted. However, according to Dracoulis, “I was offered a scholarship to go and do a Master’s degree - and I was actually rather surprised to be offered the scholarship because I didn’t think I’d done terribly well and I didn’t realise that I obviously had been noticed in some way”.

After completing his Master’s degree he undertook a PhD degree in the area of nuclear physics under the supervision of George Legge, then a senior lecturer in the department. For his PhD dissertation he said, he “measured excitation functions in inelastic proton scattering on nitrogen 15, which is a gas - with a very high resolution instrument. It was the first time it had been used, and we did an extensive set of measurements which had some very interesting structures in them which could be correlated with structures from other sorts of reactions and I think had a lot of structure information in them”. But the data he had gathered was published "with some hard waving discussion, but no real interpretation”. The reason mainly being that "we didn’t have either personally or around us the theoretical understanding of these sorts of reactions to be able to interpret the data properly".

Well before Dracoulis had finished his PhD thesis in 1970, the Australian National University had already been established in Canberra and under the leadership of Mark Oliphant and Ernest Titterton had set up an active nuclear physics department.

To Manchester University
After trying unsuccessfully to get a postdoctoral fellowship in the United States, he managed to get one in England. In a sense, this was good for his career although at the time he probably did not know where it was going to lead him in his future years. Legge had written to Manchester University to secure a postdoctoral fellowship for him. Manchester was famous because Rutherford had done some of his most significant work on atomic structure at that institution. So it was an important career move for Dracoulis.

As chance would have it, John Newton, who had been at Manchester, had become the new head of nuclear physics at the Australian National University. He was in the process of setting up a laboratory to exploit heavy ion reactions, a field that Dracoulis was going to be involved in at Manchester. "So that was a great place to go historically and it was also a terrific place to go to at the time. I didn’t know this at the time but they had a heavy ion accelerator, one of the only ones in the world”.

Manchester turned out to be an exciting place. "It was also a great place to go at the time because they appointed quite a few new staff, so there were four or five people, some postdoctoral people but a number of lecturers and senior lecturers at the same time. So there was quite a large group of new people all trying things and doing things. We made a lot of mistakes but there weren’t that many people who actually knew what they were doing, so it was a great environment to show a bit of independence”.

While there, Dracoulis began research into gamma ray spectroscopy and also got involved in the “sorts of problems I am doing now at the Australian National University. We did those sorts of measurements and they’re things in which we exploit beams of heavy nuclei on other heavy nuclei and, using fusion, make new nuclei and then you study the properties of these”. He did experiments with the six million volt tandem accelerators at Manchester, Harwell and Liverpool. The experience was extremely useful for his career development. “/
made a lot of contacts and I had all sorts of experiences, if you like, of different levels of organisation and experimentation.” He also acquired a great appreciation of “what physics was about”.

Scaling the heights of nuclear research

In 1973 Dracoulis returned to Australia as a Research Fellow at the Australian National University. Eighteen years later he had risen to the position of chair and Head of the Department of Nuclear Physics. As the head of the group at the Australian National University he has built an international reputation for the department. In fact, an overseas visiting scientist [Graeme Putt] remarked “he found the atmosphere [in the department] very exciting”. It reminded him of what he imagined it was like at Los Alamos during the atomic bomb project”.

According to Dracoulis, the Australian National University nuclear laboratory, “is, in terms of capabilities of the accelerators, comparable to a national lab in the US. We have probably a third of the staff or even fewer”. This has not stopped them from being very competitive in international terms.

Dracoulis’ area of research has been in nuclear spectroscopy and he has made significant contributions in his study of the shape co-existence in nuclei.11, 12, 13, 14, 15, 16, 17 Atomic nuclei make up 99.9% of matter in the universe. They are made up of neutrons and protons (collectively called nucleons) and they orbit around each other in a well-defined way. Pairs of nucleons orbit in opposite directions and if the total number of each type of nucleon is even, the nucleus as a whole has no net rotation in its lowest state of energy. The nucleus can be made to rotate by giving it energy from an accelerator and, as the spinning slows down, gamma rays are emitted. By studying the energies of these gamma rays, physicists such as Dracoulis can learn about the spinning nuclei. They find that not only are there changes in the motion of the nucleons inside the nucleus, but the overall shape of the nucleus also changes. Thus, when the nuclei are made to rotate rapidly they take on various shapes. The name ‘shape coexistence’, according to Dracoulis, “comes from the fact that nuclei exist in different shapes”. He was able to arrive at an understanding of the shape of the nucleus because he was “interpreting experimental results from a theoretical viewpoint - using models. I understand the models well enough to know where such things would occur again”, he said. He explained that, “Many of the shapes are spherical like a planet. Many of them, though, are deformed. In other words, they’re a bit more like a football shape in their ground state. Whether they’re deformed or spherical will depend partly on the particle orbits inside the nucleus. I’m already talking about something that’s contradictory here. I’m talking about this body that’s got a rugby shape and yet I’m talking about particles, whereas it’s actually the mean field created by the particles that makes the rugby shape. That’s one of the difficulties in concepts in nuclear physics. We tend to talk about microscopic properties on the one hand at the same time really as macroscopic properties”.

“But shape coexistence refers to the fact that in some nuclei these properties are rather delicately balanced, so the nucleus doesn’t know whether it wants to be spherical or deformed. It was a bit of a shock to find that nuclei near their ground state in fact will flip into a different shape and that these shapes actually can coexist almost independently. We did quite a bit of work, going back to the early eighties. We thought about where these things would be. They were known to be in one particular region of the periodic table, particularly in the mercury nuclei18. I looked at the systematics of these things and thought a bit about the structure and the orbits of the particles and predicted - really, guessed - that these things should really occur in the neutron-deficient platinum nuclei. If that interpretation is right, they should probably also occur in the very neutron-deficient osmium nuclei”. When I say ‘neutron-deficient’, I mean nuclei that don’t exist in nature. They’re ones that have proton and neutron combinations that have far fewer neutrons than you get in stable nuclei”.

This is one of the exciting things in the type of nuclear physics he does. He can, one might say, play the role of God in making things at the nuclear level. “We can make these artificial nuclei with protons and neutrons that don’t exist in fact in stable nuclei. We can take protons and neutrons and manipulate them, so we can create these environments in the lab. What we did was to work out reactions through which we could actually make these new nuclei that would be efficient. We identified the nuclei and we identified the nuclear structure. So that there’s two components to it. We’re making nuclei that nothing is known about and we have to prove, for example, that this is platinum 176, and then we found structures in them that we interpreted immediately as evidence for shape coexistence. That led, in fact, to an understanding of a whole series of nuclei around that region, some of which was controversial initially”. The work he did in this area was influential.

Dracoulis went on to investigate metastable multi-particle states in nuclei and coupling in multi-particle states. “A metastable state”, he said, “is something that lives longer than you think it should live under normal circumstances”. He continued rather excitedly, “A class of metastable states (or isomers) in a particular group of nuclei, and these are nuclei round the region of proton No 82, lead, and with more protons added, these states are often metastable because they’re a peculiar structure. The reason they don’t decay to the next state down is because you have
to rearrange many particles. For example, most nuclei in the ground state have all the particles paired, so every pair is two protons orbiting in opposite directions, coupled to spin zero. You have all these pairs of particles moving around the nucleus not seeing each other’.

“If you take a metastable state in one of the nuclei we were looking at, we believed it looked more like a group of protons and neutrons orbiting around the equator of the nucleus, all in the same direction, like a lot of moons around a planet. To rearrange those states, those protons, half of which are going in the wrong direction, to go back the other way, that would decay to the next state down. That’s something that’s very hard to do, so the state sits there for a long time essentially. That’s one interpretation of it. These states in these particular nuclei, they tend to be the lowest states you see. They’re very strongly populated and they dominate the nucleus, in terms of the most efficient way it likes to couple up its protons and neutrons”.

When asked what he was trying to solve, he replied, “What we were trying to do and what we were worried about was something that goes back to what I mentioned before about systematic studies and thinking a little bit harder about some of these nuclei, was that some of the properties of those states agree with the simple picture, but some of their most profound properties didn’t fit at all with the structures that were supposed to be there, the particular proton and neutron orbits that had been assigned. Now, we were in the process of both finding such states, identifying them, measuring their spins and parities. All of which involve rather comprehensive experimental work, and understanding all their properties at once, what their energy was, which orbits were involved, how long they lived for, why they did or didn’t decay, and the transition strength, how fast they actually decayed”.

According to Dracoulis, they found “the predominant mode of decay in those nuclei was octupole E3 multipolarity transitions”. The thing that had been hanging around for a long time in the field was that people had explained these states, but they’ve never explained the fact that the transitions in fact were cooperative ones. They carried the strength of not one single particle unit but 50 single particle units. Something like that you have to explain. The configurations previously assigned in fact patently didn’t explain it. I used to get quite angry about it because I stood up at conferences quite often and theoreticians were saying, ‘Look, we’ve explained every one of these states, a one to one correspondence’. I would have to stand up and say, ‘Yes, but if you look at the configurations you’ve assigned, those two states cannot be connected by a 50 single particle unit E3 transition, so they must be wrong’.

So his group did experiments on a whole series of nuclei, such as radon, radon 212, radon 211, radon 210, radon 209 and radon 208. So we measured the magnetic moments, octupole moments, all those things, and we tried to interpret the structures in terms of what was known to be coupling between particles and octupole vibrations. That was known for one-proton nuclei but it had never been translated to multi-particle states where you had, say, four protons and four neutrons. It turns out if those protons and neutrons are in special orbits; the same octupole coupling that occurs in a one-proton nucleus is in fact multiplied in a non-linear fashion in these special structures. It was done in fact by a Master of Science student [Stephen Polett] who made the little model and managed to explain it in a completely consistent fashion so that we could explain in fact all the properties in a natural fashion. The coupling was already known but its influence had never been appreciated in the multi-particle state, partly incorrectly because people often think that a multi-particle state will somehow be more complicated.

That’s the interesting thing about nuclei. These states are not really more complicated. You can see very simple structures. They might involve many particles but they often have simple, almost physical models that you can use to think of them”.

Dracoulis continued his investigations into nuclear structure and made further significant contributions to the field. He began a series of investigations into K isomers, and nuclear superfluidity. According to him, “High K isomers are another class, if you like, of metastable states. I said before, in one sort of nucleus we could have many particles orbiting around in the same direction. They like to stay together. If you take a deformed nucleus, one shaped like a rugby ball, then, if you’re in the right region of the periodic table, you can do the same thing. You can break pairs of particles but now you point them, the angular momentum at least, along the direction of the deformation axis. That projection along the deformation axis is a quantum number that’s conserved. It’s the quantum number K. The more particles you break, you can add up this K value and get a high K. That state finds it very hard to rearrange itself to most of the other nuclear states around that region because the other states around that region will have much lower K values. You can’t change the K value, the direction of the angular momentum, with the emission of a photon very easily. You can change it by one or two units but you can’t change it by 10 or 12. So that state, if you can make it, will sit there, its got nowhere to go”.

His group discovered many of those too and classified them. They measured their properties and also predicted regions where they will occur more profusely. According to
Dracoulis, "They're interesting for two reasons. One is just a formation mechanism and the other is the fact that when they do decay, they decay by a very special path and they'll try and pick out all the other high K states. So, if you like, you make yourself a single generator on top of the nucleus and when you wait for it to decay, you get a very special class of states being revealed and those states in the decay are usually ones you can't see by any other process. So they give you a very important experimental handle".

His work on super-fluidity was a bit more complicated, Dracoulis said. He continued, "Nuclei in their ground state are not rigid. The particles pair off and one consequence of that pairing is a phase transition to a super-fluid state. So the nucleus in its ground state, most spherical nuclei and deformed nuclei, are in fact effectively super-fluid. If you spin them around, there's a part inside which has no inertia. That was found back in the fifties and it was called super-fluidity in analogy with super-fluidity in other systems and it's very similar in construction to super-conductivity in metals, a similar sort of process, but it's not the same. The reason it's not the same is because you don't have an infinite object. You have an object in fact, where the particles involved in forming this super-fluidity, are only a few interacting particles near the nuclear surface.

"So the nucleus then is very sensitive. If you change the orbit of one particle, the expectation is that you might be able to see its direct effect on the super-fluidity. What we were trying to chase was through these high K isomers, the high K isomers are states where we know that we've got this particular proton, that particular neutron, in a particular orbit. So what we tried to do - and this is really the background thought to it - was to take that high K isomer and spin it around. In other words identify the rotational band based on it, then we would be seeing the collective motion of the high K isomer state, not the ground state but a state with particular particles blocked. That motion would be affected by the amount of super-fluidity left because of the blocking. Then we looked at another state. More particles, different orbitals. So we were trying to see directly, if you like, the effect of the individual particles on a collective phenomenon. It's still controversial, I must say".

Dracoulis has a substantial record of publications. On average, he publishes between six to eight papers a year, which is comparable to the publications record of other international elite scientists. So I asked him what was his strategy. According to him "one of the abilities I have is to do more than one thing at a time. We have a whole range of experimentation going on simultaneously and we're doing developments at the same time. So we never drop our tools on the ground and wait for the next thing to come along. And another thing he said was "We try and work out what will work, if you like, and we have quite a bit of knowledge within the laboratory within different groups of heavy ion reactions, of techniques and we've worked very hard over the years to build up almost a complete set of complementary instrumentation. So when we do something, when we study a nucleus or we look at trying to find a new nucleus then we have a lot of things we can look at it with and we try and do a complete job".

Dracoulis has come a long way from his early days at Glenroy High School to becoming one of the top nuclear scientists in the world. He has not only been a mentor to a number of PhDs who have found jobs in industry, the public service and academia but he has also been responsible for helping to give his department an international profile and making it competitive in the field of nuclear physics.

Acknowledgements
I wish to thank the National Library of Australia for sponsoring the National Oral History Project on Eminent Australian Physicists. I also wish to thank Mark Cranfield and the staff of the Oral History Section of the National Library of Australia for their cooperation and assistance in the project.

References
3. For a brief history of Ithacans see www.ithaca.org.au
10. Ernest Rutherford was awarded the Nobel Prize in Chemistry in 1908 for his researches into the disintegration of elements and the chemistry of radioactive substances.


A Brief note on the author
Dr. Ragbir Bhathal is an award winning author, astrophysicist and scholar in Australian studies in science. He was Foundation Chairman/Director of the SETI Australia Centre and is the Director of the OZ SETI Project, the only dedicated search for ETI in the optical region of the electromagnetic spectrum in the southern hemisphere (He's considered the father of SETI in Australia). He is a member of the multi-university and ATNF Hubble Multibeam Research Project. He was awarded the 1988 Royal Society of NSW Medal for research and services to science, the prestigious C. J. Dennis award for excellence in natural history writing and the prestigious State Library of NSW Nancy Keeving Fellowship. He is at present writing books on the Australia Telescope and Australian Scientists.
Aussie astronomers find "lost city" of stars

An Australian-led team of astronomers using the 8 m Gemini South telescope has revealed the faint outer parts of the galaxy NGC 300, showing that the galaxy is at least twice as big as previously thought. The finding implies that our own Galaxy too is probably much bigger than textbooks say. And ideas on how galaxies form will have to be rethought, to explain how NGC 300 could have stars so far out from its centre.

The research is published in the August 10 issue of Astrophysical Journal.

NGC 300 is a spiral galaxy 6.1 million light-years away. It looks rather like our own Galaxy, with most of its stars lying in a thin disk like a pancake.

Using the Gemini Multi-Object Spectrograph instrument on the Gemini South telescope in Chile, the observers were able to see stars in the disk up to 47,000 light-years from the galaxy's centre—double the previously known radius of the disk.

These were extremely sensitive measurements capturing light levels more than ten times fainter than any previous images of this galaxy.

The finding has profound implications for our own Galaxy. Most current estimates put its size at 100,000 light-years across, about the same as the new estimate for NGC 300. "However, our galaxy is much more massive and brighter than NGC 300. So on this basis, our Galaxy is also probably much larger than we previously thought—perhaps as much as 200,000 light-years across," said the paper's lead author, Professor Joss Bland-Hawthorn of the Anglo-Australian Observatory.

The observers found no evidence that the outer part of NGC 300 was falling abruptly in brightness, or truncating, as many galaxies do.

"We now realize that there are distinctly different types of galaxy disks," said team member Professor Ken Freeman of the Research School of Astronomy and Astrophysics at the Australian National University. "Probably most truncate—the density of stars in the disk drops off sharply. But NGC 300 just seems to go on forever. The density of stars in the disk falls off very smoothly and gradually."

The observers traced NGC 300's disk out to the point where the surface density of stars was equivalent to a one-thousandth of a Sun per square light-year.

The researchers have been granted more time on Gemini South to determine exactly what kind of stars they are seeing in the outskirts of NGC 300, and to make similar studies of other galaxies.

AA/AT/Gemini media release

New title honours significant academic achievement

Academics who have made an outstanding contribution to Curtin University of Technology are being recognised by a new award of John Curtin Distinguished Professor.

Amongst those honoured was Emeritus Professor John de Laeter (John Curtin Distinguished Emeritus Professor). He is recognised for his contributions to science research and teaching in Western Australia.

Curtin University media release

Just a spoon full of diesel...

The Hydrogen and Allied Renewable Technology research group, based at the University of Tasmania's School of Engineering, has discovered that running a compression engine with a combination of diesel and hydrogen increases power output, drastically cuts emissions and massively reduces diesel consumption.

The discovery, at the specially designed Hydrogen Laboratory the building of which was sponsored by Hydro Tasmania, has the potential to be used for both domestic and commercial purposes.

Associate Professor Vishy Karri, of the Intelligent Car Program at UTAS, said it adding just a just a "spoon full" of diesel and running the generator with hydrogen resulted in a 20 per cent increase in power output.

"The mixing of both hydrogen and diesel in the same combustion chamber is a revolutionary world-first. Other conversion kits on the market are designed to be 'all or nothing' - either 100 per cent diesel or 100 per cent hydrogen. There is nothing available for diesel engines that is specifically for diesel-hydrogen gas mixtures."

Dr Karri said one of the most exciting
aspects of the system is that it is retro-
fittable.

Hydro Tasmania has contributed $350,000 to the university's hydrogen program, through funding equipment for the laboratory and sponsoring a research fellow for three years.

University of Tasmania media release

Top universities to form strategic partnership

Presidents of eight leading universities from Asia, Australia, Europe and the United States have signed a Memorandum to create a powerful new global university partnership.

This new partnership will comprise The Australian National University (ANU), ETH Zurich, National University of Singapore, Peking University (PKU), University of California, Berkeley, University of Copenhagen, The University of Tokyo and Yale University. Discussions are continuing with the University of Oxford and one other leading university has been approached. The membership will be limited to ten for the first three years after which additional members may be added to widen geographic representation.

ANU media release

Bragg’s Adelaide residence

Bragg House on 207 East Terrace Adelaide was saved from sale in early 2004. It had become the home of the Public Schools Club and was saved by some extremely stalwart members of the Club. The AIP also lobbied the SA Heritage Minister to save this house from re-development.

This house was Heritage listed early 2005 due to efforts of the Public Schools Club Committee and with the assistance of Mrs. Lomax-Smith of the S. A. Government.

A piece of Bragg's heritage has been preserved. Clearly people do care!

AIP website

Defence awards two scholarships in physics

On August 17, Defence Minister Robert Hill announced that the Federal Government will award two scholarships for final year honours students studying physics in Australian universities.

The scholarships, worth $15,000 each, will be offered to students who have completed three years of undergraduate studies in physics by the Defence Science & Technology Organisation (DSTO) and have been identified as being suitable to undertake an honours year. Senator Hill said he was pleased to announce the Scholarship in Physics as Defence's contribution to the International Year of Physics.

Govt media release/AIP website

$6M ANU designed instrument bound for Hawaii

The $6 million Near-infrared Integral-Field Spectrograph (NIFS), completed by engineers at the Research School of Astronomy and Astrophysics, is the first major international telescope instrument completed at Mt Stromlo Observatory since the bushfires of January 2003. It’s on its way to its new home at the international Gemini Observatory in Hawaii.

It will be mounted on one of the world’s largest telescopes, the 8.1 metre Gemini North, used to study objects in deep space. NIFS will allow astronomers to observe space at a resolution on par with the Hubble Space Telescope.

The Gemini Observatory is an international partnership, including Australia, to build and operate two 8.1 metre telescopes in Hawaii and Chile. NIFS is the first instrument built in Australia for the Gemini Observatory.

The original NIFS was destroyed in the January 2003 bushfires and the Canberra-based aerospace company, Auspace Ltd, in collaboration with its Mt Stromlo designers and engineers, has rebuilt NIFS-2.

The NIFS Project Scientist, Dr Peter McGregor, said, "A major spinoff of NIFS is the guaranteed observing time for our Australian team using the instrument on Gemini."

ANU media release

Terabytes for Queensland

The Queensland Microtechnology Facility (QMF) being built at Griffith's Nathan campus in Brisbane will become a new home for Australian research into novel memory devices including silicon carbide memory chips.

Griffith Professor and QMF Director Professor Barry Harrison said silicon carbide chips have the potential to store terabytes of information – more than 1000 times the capacity of existing silicon chips.

The purpose-built facility – due to open in 2006 - will house Griffith's new semiconductor equipment which is used in the design and fabrication of silicon carbide chips. Professor Harrison said the research facility would be the only one of its kind in the world and feature multiple "clean spaces" for chip fabrication.

The QMF is a joint initiative between Griffith and the Queensland Government.

Griffith University media release

More than US$2 million for photovoltaics

Professor Martin Green and Dr Gavin Conibeer have won a Stanford University Global Climate and Energy Project (GCEP) grant estimated at US$2.37 million.

Professor Green, of the Centre of Excellence for Advanced Silicon Photovoltaics and Photonics, and Dr Conibeer, of the Centre for Photovoltaic Engineering, will lead a team of 10 researchers investigating nanostructured silicon-based tandem solar cells.

This project will explore the use of nanostructural engineering to control silicon’s bandgap in quantum-confined structures to develop tandem stacks based entirely on crystalline silicon and its compounds with oxygen, nitrogen and carbon.

UNSW media release

2005 Eureka Prizes

A record of over $230,000 was presented to the winners of 24 Australian Museum Eureka Prizes at the 16th annual Australian Museum Eureka Prizes dinner. The event was compared by Sally Loane, Richard Morecroft, Adam Spencer and Sandra Sully at Sydney’s Royal Hall of Industries on August 9, 2005.

The prizes are in four major categories: Research, Innovation and Leadership, Education and Science Communication.

Physicists gained prizes in two categories:

- In the Research category, Dr Peter Tuthill shared the $10,000 University of NSW Prize for Scientific Research for his infra-red images of life and death among the stars.

- In the Science Communication category, David Blair and John de Laeter won the $10,000 Australian Government Eureka Prize for Promoting the Understanding of Science for the Gravity Discovery Centre.

The full list of winners in all categories can be found at www.amonline.net.au/eureka which also has links to more information about the winners.
AIP News

S.A. Branch

The SA branch has continued with its public activities to promote the International Year of Physics. On Friday July 8th Colonel Pamela Melroy gave a public lecture entitled "Human Space Exploration - Space Station and Beyond". This lecture was very well attended with over 450 people packing the Union Hall in Adelaide. Colonel Melroy's visit was made in conjunction with the South Australian Space School (SASS), which was held from July 7th - 9th. On this occasion forty city and country, year 10 high school students from the state, independent and catholic sectors attended the school. In 2005 the Australian International Space School (AISS) will also be run in SA over the long weekend of 29th September to October 3rd. This school is open to all Australian Year 11 students, with the two most meritorious students being sent to the Space Camp in the USA. Further information, including registration details, can be found at the web site: www.spaceschool.com

Other branch-sponsored activities that are coming up include the annual AIP Super Science Quiz (Friday August 19th), which focuses on students between years 10-12, and the annual postgraduate student seminar night (Thursday 8th September). On this latter occasion one PhD student from each of the University of South Australia, Flinders University and the University of Adelaide give a short talk on their respective thesis projects. The 2004 Silver Bragg Medal, for the top 3rd year undergraduate at each SA University, is also presented at the postgraduate student seminar night. Finally, we note that on behalf of the branch, our Chair has been working with the SA Department of Premier and Cabinet to organise the "Science Outside the Square" initiative. This initiative, which seeks to raise an awareness of science amongst the general public, is being held on Sunday 7th August at the Investigator Science and Technology Centre. The theme of the afternoon is "Space and Exploration" with talks being presented by Dr Rob Morrison, Professor Roger Clay and Dr Olivia Samardzic.

Summary of Executive Meeting E257
Meeting held Tuesday July 12, 2005

Econophysics Colloquium: An econophysics colloquium is to be held 14-18 November this year. It was thought that this should receive AIP support. It was agreed that Branches would be asked to give publicity to the colloquium and asked to solicit applications for student grants to attend the colloquium.

Archiving: The AIP now has a considerable amount of material in store, and this needs to be either archived or discarded. An archiving policy has yet to be developed, especially with respect to electronic documents.

Nuclear Power: Reports have been produced looking into the feasibility and practicability of nuclear power in Australia. Reports are being collected to assess the arguments, and to consider the development of a policy on nuclear power by the AIP.

Conference Funding: The information on the web site about AIP funding for conferences is inadequate in its present form. The policy is being reviewed, and the web site will be updated when this is finalised.

Direct Debit: Initial quotes for the implementation of direct debit for the payment of AIP subscriptions were exorbitant. New quotes had been received and the costs were much more reasonable. It was decided that the AIP would implement direct debit, to be in place for the next round of subscriptions.

Accreditation: The accreditation reports for the University of Melbourne and Kuwait were approved.

A report on the accreditation of the Kuwait University degree program is being prepared for publication in Australian Physics.

Careers in Physics: It was agreed that there is insufficient information available for students and career guidance counsellors about careers available for physics graduates. Consideration will be given to raising this topic with FASTS, and a discussion document regarding the promotion of careers in physics is to be prepared.

Memorabilia: Work is gradually proceeding on the production of a memorabilia that would be available for sale, one possible outlet being for student prizes.

Australian Physics: The editing, production and cost of Australian Physics is being reviewed, and means of reducing costs or increasing income are to be investigated.

2008 Congress: Calls for expressions of interest in running the 2008 Congress would be made in the next issue of Australian Physics. Applications would be discussed at the next Council meeting.

Education Convener: Dr. Mark Butler has been appointed as the new AIP Education Convener. He replaces Dan O’Keeffe, who has given many years of valuable service in this position. Dan will continue to be involved in activities such as Switched on Science, and his contribution in this area is much appreciated.

Next meeting: Meeting E258 was scheduled for September 5.

Ian Bailey,
Hon secretary.
Students to benefit with more staff for Australia’s university students

Staff to student ratios at Australia’s universities have fallen as additional funding and places begin to flow into the sector as part of the Howard Government’s $11 billion higher education reform package.

Minister for Science, Education and Training, Dr Brendan Nelson, welcomed the announcement from the Australian Vice Chancellors Committee (AVCC) that the trend of increasing student to staff ratios in Australia’s universities has been reversed.

The AVCC has revealed that the average student to staff ratio in Australia’s universities has decreased from 19.7 students to each member of staff to 19.4 in 2004.

This follows recent figures released by the AVCC which showed a 45% drop in unmet demand for university places while the number of Australian students attending university continues to grow to 716,422 in 2004 - an increase of more than 130,000 since 1996.

As a consequence of the Government’s reforms, which provide for additional public investment and HECS revenues, universities have also employed more staff - with the AVCC pointing out that the fall in the student to staff ratio can be attributed to the growth in teaching staff numbers - 30,956 in 2003 to 31,689 in 2004.

Teacher’s legacy inspires a new generation

Dr Brendan Nelson, Minister for Science, Education and Training, presented the inaugural Len Basser Award for Leadership in Science to Chang Lian, a student at the 33rd Professor Harry Messel International Science School at the University of Sydney.

Lecturers at the International Science School and members of Young Scientists Australia voted Chang Lian, from the People’s Republic of China, as the most deserving student for the Award. The award recognises students with originality of thought and a willingness to assist others at the school. Both of these qualities were epitomised by the outstanding science teacher, the late Len Basser.

Len Basser was a chemistry teacher at Sydney Boys’ High School from 1931 to 1959 and was well known for his inquiring mind and passion for nurturing his students’ understanding of science.

He taught some of the most gifted scientists of our time, eight of whom are currently Fellows of the Royal Society. The President of the Royal Society, Lord Robert May of Oxford University, is amongst them.

The Australian Government is committed to fostering the next generation of scientists and last year made a $1 million contribution to the Messel Endowment Fund, which is designed to support the International Science School’s operating costs in perpetuity.

Responsible management of radioactive waste in Australia

The Australian Government has finalised a list of possible locations for the siting of a future Commonwealth Radioactive Waste Management Facility.

These are Defence Department properties at Mount Everard, Harts Range and Fishers Ridge in the Northern Territory.

The process for selecting suitable sites followed the Prime Minister’s announcement on 14 July 2004 that the Government would proceed with the establishment of a national low level radioactive waste repository at site 40a near Woomera in South Australia.

Enhancing governance arrangements - Australian Research Council

Minister Dr Brendan Nelson announced changes to the governance arrangements of the Australian Research Council (ARC).

The decision is informed by the recommendations of Mr John Uhrig’s Review of the Corporate Governance of Statutory Authorities and Office Holders which developed governance principles for Australian Government authorities that will improve performance and accountability. Two models for governance were recommended; one where governance is best provided by executive management, and the other where it is best provided by a board.

The functions of the ARC are best suited to the executive management template developed by Mr Uhrig so the Minister has decided to strengthen its arrangements so that it is fully consistent with this model. The existence of a board is inconsistent with the executive management model and ARC Board is to be retired by early 2006.

The revised arrangements will maintain the ARC’s independence and expedite the ARC’s funding processes. This will provide greater certainty to researchers about the future of their ARC funding and allow the ARC to respond quickly and flexibly to emerging priorities. The ARC, under the guidance of CEO Professor Peter Hej, will retain its vital peer review processes and the College of Experts will continue to be a vital source of independent advice to Government.

The ARC will remain a statutory agency and will not return to the Department of Education, Science and Training. These enhancements will be implemented as soon as legislation permits.

The Minister thanked the Board Members, and in particular the Chair, Mr Tim Besley, for their contribution to the ARC, and to the Australian scientific community in general.

$33 million boost for science and maths teaching in Australia

Mathematics and science in Australian classrooms will be revitalised as part of a $33.7 million Australian Government initiative.

In the first round of the Australian Schools Innovation in Science, Technology and Mathematics (ASISTM) Project, the Australian Government will provide $9 million to directly target the teaching of science, technology and mathematics and promote innovation in our schools.

Initially, 103 school clusters, comprising 623 schools and partner organisations (from the scientific community, universities, industry, education authorities, and the wider community), will receive grants of between $20,000 and $120,000 to develop new approaches to science, technology and mathematics education. The initiative will ultimately employ around 1,300 teacher associates (university students, researchers and other specialists in these fields).

The ASISTM Project is a key element of the Government’s response to the independent 2003 Review of Teaching and Teacher Education. The Government will fund an estimated 500 ASISTM projects over the seven years to 2010-2011.

For a complete list of successful Round One projects and further information about ASISTM visit www.asistm.edu.au
Scientists welcome progress on Radioactive Waste Repository

The announcement of three possible sites for a Commonwealth radioactive waste repository is a welcome step forward in resolving the stalemate on establishing a safe national facility to store and dispose of radioactive waste.

The President of FASTS, Professor Snow Barlow, said the scientific, engineering and technological issues around site selection, and radioactive waste storage, disposal and transportation are well understood.

“A national facility needs to deal with both historical waste accumulated over the past four decades and future waste”.

“Currently there is 3700 cubic metres (4,000 – 5,000 tonnes) of waste stored in Australia and future waste is projected to be approximately 30m3 per annum.”

“The prime responsibility for managing radioactive waste lies with the Commonwealth as about 95% of existing and future waste is generated by Commonwealth agencies, mainly ANSTO but also CSIRO and Defence.

“The volume of waste generated by States and Territory licences for medical, industrial and research purposes is small. However, this waste is currently stored in over 100 locations around the country in metropolitan and regional sites.”

“Dispersed storage of radioactive waste is not a viable long-term disposal strategy and is potentially hazardous, inefficient and impossible to secure.”

“FASTS urges the States and Territories to join with the Commonwealth to ensure the proposed site is a comprehensive national facility.

“Selection of the final site must take account of seismic stability and hydrological (ground water) risk and utilise the considerable scientific expertise that exists in Australia”.

“A credible, national policy needs a national radioactive waste facility that is state of the art in terms of environmental safety, efficiency and security”, concluded Professor Barlow.

Third Stream Funding Forum

Registrations for FASTS Third Stream Funding Forum on 12th of October 2005 are now open (go to www.fast5.org)

Third stream funding is on the political agenda and there is a prospect that funding will be announced at the next budget.

FASTS have pulled together an impressive line up of speakers and this high level forum will be an important step in the sector and Government developing policy and design of a third stream fund.

Speakers include:

- David Murray – Business Council of Australia
- Professor Peter Hoj – CEO, ARC
- Professor Alan Pettigrew – CEO, NHMRC
- Professor Ian Chubb – Vice Chancellor, ANU
- Dr John Howard – Principal, Howard Partners, author of The Emerging Business of Knowledge Transfer
- Dr Geoff Vaughan – Industry R&D Board, AusIndustry
- Roberta Brazil – Chair, Land and Water Australia ltbcl
- Dr Steve Garlick – Director, Regional Knowledge Works
- Professor Snow Barlow, President of FASTS
- Professor Margaret Alston – Director, Centre for Rural Social Research, Charles Sturt University
- Professor Malcolm Gillies – President, Council of the Humanities, Arts and Social Sciences

The 2005 Science Fiction Short Story Competition

Physics: the next 100 years and beyond...

In celebration of the "World Year of Physics" the Physics Society of the University of Newcastle and the School of Mathematical and Physical Sciences (UoN) in conjunction with their partners are proud to invite entries in the inaugural Science Fiction Short Story Competition (SFSSC).

Submissions must be no more than 2,000 words in length and must be received by October 14, 2005.

Entries must be a science fiction short story in English and no more than 2,000 words. It can explore any aspect of where Physics might take us in the next century and/or beyond.

Prize money offered for the best two entries is:

- 1st: $200
- 2nd: $100

The first and second place getters will be invited to read their winning story at the Annual Science Ball run by the Physics Society in Newcastle on the 25th of November.

If deemed of sufficient quality the winning stories will also be published in the Australian Institute of Physics' magazine Australian Physics* and/or the Newcastle University Students Association's magazine Opus.

The two winners will be announced two weeks prior to the Science Ball, with the final placings (1st and 2nd) announced at the event.

*Stories accepted for publication will be subject to standard editing procedures.

The entered story(ies) must not have won a money prize in previous competitions or have been published at the date of close of entries.

For more details, see the website nano.newcastle.edu.au/sfssc
Product News

Toptica Photonics appoint Lastek as distributor for Australia and NZ

We are delighted to announce that Lastek has been appointed representatives for Toptica Photonics, of Munich, Germany, in Australia and New Zealand.

Toptica’s tunable grating-stabilised laser diode systems are well known to Australian researchers, but there is much more to Toptica’s product range of innovative solid state lasers.

Recently released is the FFS series ultrafast mode-locked erbium-fibre laser systems. Merging the performance of traditional Ti:S oscillators with the advantage of an all-fibre laser source, the FFS series offers highly stable, linearly polarised sub-100fs pulses in a compact user-friendly package. Toptica also offer the iBeam and iPulse series of diffraction limited and stabilised cw diode lasers at a range of wavelengths, including blue and UV, which can effectively replace ion lasers in many applications.

More info: http://www.toptica.com

Precitec Optronik: Non-Contact Measurement of Distances and Layer Thicknesses

Precitec are world-leaders in optically-based systems for contactless measurement of distances and layers, with the capability to measure thicknesses with resolutions to just 10nm and ranges of mm. High precision, rapid layer thickness determination is accomplished by white-light interferometry. At the heart of the Precitec product line is the CHRecodile family of sensors with up to 14kHz scan rate and USB interface.

Available for 2D, 3D or profiling applications, these systems are available with a universal software platform for contactless measurement and analysis of topographies, roughness values, profiles, contours and layer thicknesses.

More info: http://www.precitec-optronik.de

Please contact us, or check our website for further details.

Lastek Pty Ltd
Phone: +61 8 8443 9668
Tollfree: 1800 882 215
NZ: 0800 441 005
email: sales@lastek.com.au
web: http://www.lastek.com.au

Newport Single-Axis Motion Controller

Newport’s new model SMC100CC is a single axis motion controller/driver for low power DC servo motors. It provides a very compact and low-cost solution for driving most of Newport’s DC motor stages, including the popular ILS linear stages, URS rotation stages, CMA and LTA actuators.

Communication with the SMC100CC is achieved via the integrated RS-232-C interface, or from a USB port using the external SMC-USB adapter (requires Windows® operating system). Intuitive, Windows-based software supports all configurations and enables basic motion. Advanced application programming is simplified by an ASCII command interface and a set of two-letter mnemonic commands.

When used with Newport’s ESP enhanced positioners, the SMC100CC will detect the connected device and automatically optimise the systems configuration. This exclusive Newport feature does not only reduce configuration time, but also provides the best protection for your equipment against any accidental damage.

Up to 31 controllers can be networked through the internal RS-485 communication link. This internal multi-drop, full-duplex serial link simplifies communication to several units, without the need for sending “address selection commands”.

This results in enhanced multi-axes management with improved program readability and faster communication, compared to alternative systems based on a RS-232-C chain. The SMC100CC also features advanced “multi-axes” commands, such as “Stop all” or “Start a motion of all axes”, and performs at a 57,600 baud rate communication speed.

Key Features
- Affordable single-axis control of low power DC motors (up to 48 VDC @ 1.5 A rms)
- Very compact design with central hole for mounting and stacking
- RS-232-C or USB communication for easy user interfacing
- Internal RS-485 link allows networking of up to 31 controllers
- Convenient multi-axis programming
- Enhanced system safety by reading parameters from Newport ESP compatible devices

For more information please contact: Neil McMahon [Tel: 08 8273 3040, neil.mcmahon@newspec.com.au]

Plane Ruled Reflection Gratings

Newport

With the extensive technical expertise and years of experience of Richardson Gratings, Newport now offers customers the largest selection of plane ruled gratings. Designed for use in first order, these gratings are blazed for specific wavelengths and generally have high efficiency at those wavelengths. Flexibility in substrate material, size and coating type allow you to select a specific grating for your requirements.

Newport has three ruling engines in full-time operation, each producing high-quality master gratings. These ruling engines provide gratings with triangular groove profiles, very low Rowland ghosts, and high resolving power. Mechanically ruled, individual grooves are burnished with a diamond tool against a thin coating of evaporated metal. Utilizing a high fidelity cast replication process (developed and enhanced through years of research and manufacturing experience) Newport has the ability to provide
Product News

duplicates of master gratings that equal the quality and performance of the master grating.

Key Features
- Extensive selection of groove frequencies ranging from 1.99 to 5800 g/mm
- Aluminium coating standard on all plane ruled gratings. Gold, MgF₂, protected silver and other enhancement coatings are available upon request.
- Efficiency and wavefront testing available for most gratings.

Newport also offers an extensive range of holographic and other specialty gratings.

For more information please contact:
Neil McMahon (Tel: 08 8273 3040, neil: mcmahon@newspec.com.au)

BURLE Scientific Detectors

BURLE (formerly Gaileaf) offers a very broad range of detectors, including Channeltron Electron Multipliers (CEMs), Multichannel plates (MCPs) and Photomultiplier Tubes (PMTs), for use in ambient air and high vacuum environments for a wide variety of photon and particle detection applications.

Channeltron Electron Multipliers (CEMs) can be used in a variety of applications including mass spectrometry, with exclusive designs providing the highest sensitivity, superior signal collection and noise reduction, with sustained output for low, long-term cost of ownership. For high vacuum use only, BURLE supplies standard CEM models for most commercial mass spectrometer models. Simply contact us with your mass spectrometer make and model.

Long Life Microchannel Plates (MCPs) are commonly used in time-of-flight mass spectrometry or other particle detection applications where particles over a large area are to be detected with accurate timing resolution. Information relating to spatial location of particle impact with the detector is also possible to collect with the addition of BURLE’s phosphor screens and other complimentary detector accessories.

BURLE offers MCP’s in configurations ranging from bare MCP's to advanced performance detectors incorporating tested Z-stacks with phosphor screens and other accessories, flange mounted and with interchangeable MCP cartridges. Please contact us with your application requirements.

For those customers interested in light detection, BURLE offers PhotoMultiplier Tubes (PMTs) with a wide variety of window transmission/reflection configuration options, and even integrated photodetection or MCP-based photomultipliers for excellent detector response times, good gain and extremely high pulse linearity.

PMT applications include:
- Fluorescence spectroscopy
- High speed detection applications such as LIDAR
- Cherenkov counting
- Specialised medical imaging

For more information, please contact Margaret Davies (Margaret: Davies@coherent.com.au).

Coherent Scientific Pty Ltd
116 Sir Donald Bradman Drive
Hilton, South Australia, 5033
Tel: (08) 8150 5200
Fax: (08) 8352 2020
Web: www.coherent.com.au

Four Pocket e-beam evaporator

Just when you thought single wavelength colour couldn’t get any easier...

The new CUBE laser series from Coherent Inc. is a high-performance, full-featured laser system including laser head, 2.5 A/6 VDC power supply, cable and control box, with all electronics, optics and thermal management systems built into the laser head itself. The system is designed to be extremely easy to set-up and use, with Windows 2000 and XP software interface providing multiple pages of status, control and configuration options.

Versatility is another key feature of the CUBE lasers. It can be used as a CW laser (with a convenient autostart model, modulated up to 150MHz via TTL through the digital input connector and also analog modulation up to 350kHz. All electronics, optics and thermal management of CUBE lasers are built into the laser head. Every CUBE laser has a built-in photodiode for measuring the output power of the laser and providing closed-loop power stability. CUBE lasers are also equipped with dual-temperature probes, which provide thermal management by monitoring both the diode and baseplate temperature.

The CUBE lasers are presently available at 785nm, 635nm, 440nm, 405nm and 375nm in output powers from 8mW to 45mW with circular or elliptical beams (model dependant).

For more information on the Coherent Inc CUBE laser series, please contact Gerri Springfield (Gerri: Springfield@coherent.com.au) or Dr Paul Wardill (Paul.Wardill@coherent.com.au).

Coherent Scientific Pty Ltd
116 Sir Donald Bradman Drive
Hilton, South Australia, 5033
Tel: (08) 8150 5200
Fax: (08) 8352 2020
Web: www.coherent.com.au

A new four pocket e-beam evaporator, the OSVP-4, is now available from Oxford Scientific. Building on the success of its single pocket predecessor, the OSVP-4 now allows up to four different materials to be evaporated sequentially from a single NW3SCF flange mounted instrument and is ideal for surface science and other compact systems where space is at a premium.

The temperatures achievable with electron bombardment heating (~5000K) mean that small quantities of almost any material can be evaporated direct from rod or small crucibles as appropriate.

Both models use the unique custom designed 2” linear motion feed-through which in addition to allowing long rods to be evaporated also permits our
Product News

unique thermocouple option as well as a fully shielded and non-flexing high voltage connection for long term reliability.

Ruggedly designed and easily serviced power supplies along with user replaceable filaments for negligible running costs, continue to make this instrument a popular and reliable choice.

For more information contact:
Andrew Young & Co Pty Limited
18 Bowrman Place
Cherrybrook NSW 2126
Fax: (02) 9980 8920
e mail: a.young@pacific.net.au

Optical Tables
Kinetic Systems Inc.'s 5100H series vibration-damping optical tables are available in a variety of configurations and in sizes with widths of up to 1.8m,

the tables incorporate a 3/16-inch thick ferromagnetic stainless steel top skin and carbon steel bottom skin, and a proprietary steel honeycomb core design that protects against spills.

Options include alternative core and skin materials, special shapes, cutouts and notches, and various accessories.

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

lengths of up to 6m, and thicknesses of up to 0.9m.

Fabricated employing a proprietary epoxy formulation, the tables feature a stiff, damped surface with a natural frequency of 270 Hz, a core shear modulus of 225,000 psi and an overall flatness of 0.177.

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Conferences

2005

Sep 27-30
29th Annual Meeting - Australian Society for Biophysics
Canberra, Australia
www.biophysics.org.au

Oct 14-15
Theoretical Problems in Fundamental Neutron Physics
Columbia, SC, U.S.A.
www.physics.sc.edu/TPFNPNP

Oct 17-21
Asia-Pacific Symposium on Radiochemistry
Beijing, China
www.ihep.ac.cn/apssrc2005

October 23-27
EPSM 2005 [Engineering and Physical Sciences in Medicine]
Adelaide, South Australia

Nov 2-4
Materials Characterisation 2005
Portland, USA
www.wessex.ac.uk/conferences/2005/mc05index.html

November 3-5
Asia-Pacific Space Agency Forum
Canberra, Australia
www.aprsaf.org/

November 6-11
Society of Exploration Geophysicists
International Exposition & 75th Annual Meeting
Houston, Texas, USA
www.seg.org

November 9-11
Acoustics 2005: National conference of the Australian Acoustical Society
Busselton, Western Australia, Australia
www.acoustics.asn.au

November 13-17
Greenhouse 2005: Action on Climate Change
Melbourne, Australia
www.greenhouse2005.com

November 21-23
International Conference on Sensing Technology
Palmerston North, NZ
icst.massey.ac.nz/

Nov 16-18
International Conference on Future Power Systems
Amsterdam, Netherlands
www.fps2005.org

November 27 – December 2
International Conference on Neutron Scattering
Sydney Convention Centre, Australia
www.icns2005.org

Dec 15-22
Einstein’s Legacy in the New Millennium
Puri, India
www.iopb.res.in/~einstein/

2006

Jan 1 – Dec 31
International Year of Planet Earth Global
www.esfs.org/

Jan 6 – 9
14th International Conference on Photoacoustic and Photothermal Phenomena
Cairo, Egypt
www.icppp.org/

Jan 21 – 26
Sir Mark Oliphant Conference on Quantum Nanoscience
Brisbane, Qld, Australia
milburn@physics.uq.edu.au

February 7-10
30th Australian and New Zealand Institute of Physics 2006 Annual
Condensed Matter and Materials Meeting
Wagga Wagga, NSW, Australia

March 13-14
Gravity Concentration 06
Perth, Western Australia
www.min-eng.com/
gavityconcentration06/index.html

April 29-May 1
Australian and New Zealand Society of Nuclear Medicine Annual Scientific Meeting
Perth, Australia

May 17-20
9th International Conference on Public Communication of Science and Technology
Seoul, South Korea
www.pcs2006.org

Jun 25-30
NIC IX - International Symposium on Nuclear Astrophysics
CERN, Geneva, Switzerland
nic-ix.web.cern.ch/NIC-IX/

Jul 22 – 26
International Symposium on Gas Kinetics
Orleans, France
www.gk2006.org

December 3-8
17th Biennial Australian Institute of Physics Congress
Brisbane, Queensland, Australia
OSVAP-4
The Oxford Scientific OS-Vap-4 is a mini electron beam evaporator capable of evaporating small quantities of almost any material, four of which can be mounted simultaneously and evaporated sequentially. Co-evaporation models are also available. (The material either in rod form, or in a crucible, is heated by electron bombardment from the surrounding filament. The focusing of high energy electrons in a confined area, allows temperatures in excess of 3000K to be reached)

APPLICATIONS
- Thin films, coatings
- Surface science, atomic surface preparation
- Doping, growth
- Metallising, contacting
- Microscopy sample preparation

FEATURES
- Four pockets - one with linear rod feed and three fixed.
- 2" Linear rod feed as standard
- Integral water-cooled shroud
- No flexing wires in vacuum for reliability
- Wide e-beam power range
- Rugged and durable design
Two industry leaders are now one

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