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Schematic diagram of a 050 absorption spectrum. See Fig. 2 of the article by Michael Murphy.

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PRESIDENT’S COLUMN

Do you want the good news first or the bad?

By now most of you will have received an email from me asking for your help in promoting awareness of the enabling sciences (Physics, Chemistry and Mathematics) to the politicians. Before I continue I should say that if you haven’t received an email from me then the AIP does not have your correct email address and I ask you to update that information when you renew your subscription.

The call for assistance was associated with a joint launch by the Australian Institute of Physics, the Royal Australian Chemical Institute, the Australian Mathematical Sciences Council and the Institution of Engineers Australia aimed at injecting some debate on our enabling science education in the upcoming election. This has taken some months of negotiation, review, discussion and lobbying.

We have the full support of the Academies and in particular Tim Besley, the President of the Academy of Technological Sciences and Engineering agreed to make the presentation in Parliament House.

We have put together a document which has the combined agreement of all the bodies mentioned above (see end of this issue: ed). Each person may not agree with each point, but the main issue is that we need a national initiative. Support that call!

One most encouraging aspect is the overwhelming support we have received from every branch of the community that we have approached for support. We have received many letters of support from a broad range of companies and institutions and as I write this column they are still flowing in.

I want to particularly thank the Institution of Engineers Australia for supporting this campaign. Initially we sought a letter of support but they considered it to be of such significance that they wanted to join the call. All too often the engineers are seen to be the competition. In this they are clearly our allies.

This form of activity only works if the politicians are made to realise that there are lots of people concerned. So if you have not already done so, contact at least two politicians and two hopeful candidates for the next election and insist that they explain what they plan to do about it.

It is a national issue and it is central to our future.

Now I know many will look at the graphs, get really despondent and ask what is the use? My response is to ask you to look at what FASTS has already achieved in a few short years of ‘Science Meets Parliament’ days in getting both major parties to come up with science initiatives. It won’t take as many years to get them to take up this call we are making as it is central to our high technology future. However they will only take action if we maintain the pressure. The AIP will help to maintain this pressure but to be really effective we need the numbers.

DON’T BE APATHETIC! If you really believe that you have a role in society as a physicist then don’t deny our future society access to the same skills and training! Just talk to 4 politicians before the election. I will also ask you to talk to the successful candidates after the election as well.

Be positive - we can make a difference! We will make a difference! There are enough physicists, chemists, mathematicians and engineers to swamp them with pressure. How do the successful lobbyists work? Constant contact and pressure. If we cannot learn by observation, modelling, experiment and refinement then we are not who we claim to be!!

John O’Connor
EDITORIAL

Election Reflections

By the time this issue goes to press, the Federal election campaign is likely to be well under way. The AIP under John O'Connor is launching a 'Science and Mathematics Initiative for the New Millennium' to rebuild the enabling sciences in Australia - see his President's Column and supporting material this issue. Major aims are to mount a publicity campaign to improve the poor public perception of careers in science, to encourage more qualified personnel into teaching secondary science, and to lure more students to do tertiary science. We urge every member to think seriously about writing to their local candidates in support of this campaign.

The physicist as voter is likely to face much the same decision as last time. The Howard government stands for economic rationalism, financial discipline, and a strong economy. Many voters were probably persuaded last time by arguments that the GST was necessary to modernize the Australian tax system, and gave the Coalition a charter to carry it through. In the event, the associated paperwork has caused enormous heartburn in the small business sector. The government has actively slammed down the public sector, including education, by keeping any funding increases below the inflation rate. Physics at the universities and the CSIRO has been withering on the vine under this treatment.

The Labor party under Kim Beazley, on the other hand, promises some restoration of social services in health, education and welfare, and they have made 'Knowledge Nation' a central plank in their platform, forecasting very large increases in funding for research and innovation.

At the time of writing, the terrorist attack on the World Trade Centre has made the result seem a foregone conclusion. But many things can happen during an election campaign.

Decision at Yucca Mountain

The United States will decide shortly whether to proceed with a repository for high-level nuclear waste at Yucca Mountain in Nevada - see *Nature*, 30 August 2001. The proposal has been under study for some 20 years, at the enormous cost of $7 billion. Present plans are to store the waste 300 metres below the desert floor, but 300 metres above the water table, in multilayered metal canisters. The canisters will lie on the floor of a tunnel, possibly protected from drips by a titanium 'umbrella'. They can thus be continuously monitored, and if necessary retrieved. The proposal has had to satisfy a criterion that no member of the public should be exposed to a dose of more than 15 millirem per year for the next 10,000 years.

The nearest community is a truckstop called Lathrop Wells, consisting of two filling stations and a house of ill repute. It would be exposed to only one millihertz of the recommended maximum dose, on the most pessimistic estimate.

President George W. Bush is due to announce his decision on the proposal by the end of the year, and is expected to approve it. The two houses of Congress will also have to vote on it.

Only one credible source of risk has been identified: the possibility of a volcanic eruption nearby, in which the repository might be breached by lava flow. The risk has been estimated somewhere around 1 chance in 10 to 100 million per year; but this still might be enough to derail the project.

In these circumstances, perhaps Australia should think again about the Pangea proposal for a repository in the Australian outback (The Physicist, March/April 1999). Australia is the oldest, driest and most stable continent on Earth, and we should be able to find a site at least as good as Yucca Mountain, where the risk of volcanic activity is negligible. - in other words, where there is no credible source of risk. The waste has to be stored somewhere; and the possible economic benefit to Australia is a phenomenal $200 billion over 40 years. As for danger to local communities, I recall reading in "Too Long in the Bush" that there is an area of 60,000 square miles out there where only one family lived - and they moved out the next year.

Chris Hamer
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Fundamental Constants Changing?

A team at the University of New South Wales made the front page of the New York Times with their claim that the fundamental constants of nature may be changing with time. The team consists of astronomer John Webb, graduate student Michael Murphy, and theoreticians Victor Flambaum and Vladimir Dzuba at UNSW, together with colleagues at Cambridge, Pennsylvania State University, the Carnegie Observatories and UC San Diego. They have tentatively evidence that the "fine structure constant" of electromodynamics has grown by 1 part in 100,000 over the past 12 billion years, which was obtained from an analysis of spectra from distant quasars obtained at the Keck observatory in Hawaii. If true, this discovery is "potentially revolutionary" according to Nobel Laureate Sheldon Glashow. The result is presently a four standard deviation effect - for more information, see the lead story this issue.

MOT Trap at Griffith

Metastable neon atoms have been trapped using a magneto-optical trap (MOT) in the Laser Atomic Physics Laboratory at Griffith University. The laboratory is part of the Centre for Quantum Dynamics in the School of Science. This is the first lab to create a neon trap in Australia, and only the third in the world. Metastable atoms are atoms that are in long-lived excited states and are usually difficult to perform experiments on as they are hard to produce in significant numbers. A MOT is a state selective trap so only neon atoms in the metastable state of interest are trapped. The MOT can serve as a source of these atoms enabling detailed experiments to be performed on them. The Griffith group intend to use the trapped atoms for investigations on ultra-cold atom collisions within the MOT as well as electron-atom collision processes.

Howard Wiseman

Fusion Advance

Prospects for a nuclear fusion reactor have received a significant boost, with the news that researchers at the US National Fusion Facility in San Diego have discovered a way to quadruple the rate of fusion in a tokamak. It is well known that the stability of the hot plasma (100 million degrees) inside the tokamak is improved if you set it spinning inside the cavity, to prevent 'bulges' forming. But the spinning plasma tends to slow down and become unstable again. The San Diego team have discovered that this is due to tiny imperfections in the magnetic field that contains the plasma. They have installed feedback loops to correct the imperfections (which may be as weak as one gauss), and have managed to ramp up the pressure to twice the previous limit, and quadruple the rate of fusion. This will brighten the prospects for the new international ITER enormously.

Eugenie Samuel, 'New Scientist', 14 July

Major Facilities Funds Awarded

The Commonwealth Government has announced the winner in the competition for Major National Research Facility funds of $155 million over the next five years. The largest grant, $23.5 million, went to the Gemini and Square Kilometre Array (SKA) proposal to integrate and develop Australia's research capability in optical/infrared and radio astronomy. AAO Director Brian Boyle said the grant would enable two $5 million instruments for the Gemini telescopes to be built, in exchange for increased observation time. Australia's access to the telescopes will increase to 10% of the total.

Part of the grant will also be used to attract building of the SKA to Australia. SKA will be a billion-dollar internationally-funded project to build a radio telescope 100 times more sensitive than any now existing.

Another $14.8 million went to support Australian researchers' access to state-of-the-art synchrotron facilities overseas, prior to the completion of the new $157 million synchrotron to be constructed by the Victorian Government at Monash University around 2005. The new 3 GeV source will be 60m in diameter and will include 9 beamlines, with space for a further 12. It will have annual running costs of about $10 million.

The Australian Photonics Cooperative Research Centre has also been awarded $9.5 million to establish the Bandwidth Foundry, a national facility for the provision of photonic integrated circuits. The aim is to produce low-cost, mass-producible photonic chips that will enable optical fibres to be connected to homes and offices, and ensure Australia's position as a world leader in the field is maintained.

A national microscopy network was awarded $11.5 million, including two new high-tech microscopes in Sydney to maintain Australia's status in the new areas of biotechnology and nanotechnology.

Julian Lee, 'ANU Reporter', 31 August 2001

Lining Up the Qubits

A team from the Centre for Quantum Computer Technology at the University of New South Wales have demonstrated a key technique in the race to build a quantum computer. They have been able to embed individual phosphorus atoms on a silicon surface in a precise array. Jeremy O'Brien and his team started with a clean, atomically flat silicon surface; covered the surface with a layer of hydrogen atoms; then used an STM (scanning tunneling microscope) to pluck out hydrogen atoms at precise intervals. Then they exposed the surface to phosphine, so that one phosphine molecule bonded at each hole. The next step is to find a way of removing the hydrogen and growing more silicon over the phosphorus atoms to lock them in place - the team are confident this can be done. Each phosphorus atom will act as a 'qubit', according to Bruce Kane's design for a quantum computer.

Melanie Cooper, 'New Scientist', 8 September

Computer Telecommunications Breakthrough

UNSW engineers and scientists have made a breakthrough in silicon technology that could revolutionize the global microchip and telecommunications industries. A team led by Professor Martin Green, one of the world's leading photovoltaics engineers, has reversed the performance of a solar cell so that, instead of using sunlight to generate electricity, the new device uses electricity to generate light. This raises the probability that microchips will be able to send light signals directly to adjacent microchips, so avoiding costly circuitry and wiring that must presently be used to allow chips to communicate with each other.

The other members of the team are Drs Jianhua Zhao and Aihua Wang of the Photovoltaics Special Research Centre, and Professor Michael Gal and PhD student Peter Reece of UNSW's School of Physics. The group's results have been published in the foremost science journal Nature.

The UNSW group was able to use its expertise gained in about 25 years' intense research into how silicon performs under controlled conditions to combine two quantum physics processes inside silicon crystals. According to the Nature paper: "Each feature individually is shown to improve the emission efficiency [of light] by a factor of 10, which accounts for the improvement by a factor of 100 on the efficiency of baseline devices."
Nortel Facility closes
As part of widespread cuts following the firm's mammoth loss last year, Nortel has closed its photonics research facility in Sydney that had employed 200 IT specialists.

Astronomy in the deep freeze
Astronomers are going to the coldest place on Earth to search for the heat radiated by distant objects in the universe. The extreme conditions that make life so difficult for the early explorers are now attracting astronomers to Antarctica. Australian researchers are proposing to build a permanent telescope on Antarctica's high inland plateau.

Most of us know that Antarctica is the coldest continent, but few know that it is also the highest and driest continent. These extremes of temperature, elevation and aridity are assets to those who study a particular branch of astronomy known as infrared astronomy. Infrared astronomy is the detection and study of infrared radiation emitted by objects in space. Over 200 years ago a British astronomer, William Herschel, discovered that the sun emitted infrared radiation. Since then, infrared astronomy has increased in importance as more sensitive instruments to detect infrared radiation have been developed.

Astronomers have found that infrared telescopes are better suited for studying certain types of objects than traditional optical telescopes or the relatively new radio telescopes. Australian astronomers have been using a small infrared telescope operated by US astronomers at the South Pole - the telescope has already produced some of the sharpest infrared images ever taken. Now Australian astronomers are proposing to build a telescope three times larger than the American one, which would enable astronomers to scan much larger sections of the sky. Australia's Antarctic telescope is to be known as the Douglas Mawson Telescope.

In addition to the astronomical advantages, a facility such as the Douglas Mawson Telescope would promote international cooperation and help strengthen the Antarctic Treaty. On another level, operating a facility in such extremely harsh conditions could be a dress rehearsal for eventually establishing an outpost on the moon or on a planet such as Mars.


[Marian Heard]

Australian Space Venture
Australia has signed a co-operative agreement with Russia to use Russian rockets to send satellites into orbit. About $100m will be spent on infrastructure for a "spaceport" on Christmas Island. Construction may begin this year, overseen by the Sydney-based Asia Pacific Space Centre (APSC).

The company plans to launch Russian-built three-stage Aurora rockets to deliver satellites up to 12 tonnes into geostationary orbits. It has so far managed to raise about half the US$1 billion that it needs for up to 15 launches each year by 2006.

['Physics World', August 2001]
SCIENCE MEETS PARLIAMENT

On the 22nd of August, 177 scientists, visited Parliament House for Science Meets Parliament Day. A number of representatives from the AIP attended the day, including John O'Connor (president), Cathy Foley (treasurer), Pal Fekete (NSW chair), Ann Roberts (Victorian chair), Kate Wilson (NSW publicity officer), Paul Dastoor and David Booth.

The day is an annual event organized by FASTS, the Federation of Australian Scientific and Technological Societies. Over 150 parliamentarians took part in the event, and FASTS matched parliamentarian's interests to the participating scientist's areas of expertise or interest to set up meetings between scientists and parliamentarians. The meetings were generally between two scientists of different disciplines and one parliamentarian.

On the Tuesday preceding the event a briefing session was held and the scientists were provided with a booklet called "Four big issues before Australia". A copy of this booklet was left with every parliamentarian at each meeting. The four big issues outlined were innovation and commercialization, education (at school, in industry and in the general population), higher education and initiatives within government.

As well as the meetings between individual scientists and parliamentarians there was a panel discussion about electorate and science issues on the afternoon preceding the event. The panel members were Senator Natasha Stott Despoja, Mr Martyn Evans and Senator Grant Chapman. Issues such as the role that both government and scientists need to play in promoting science to the public were addressed, and both major parties innovation packages - "Backing Australia's Ability" and "Knowledge Nation" were discussed.

On the Wednesday morning opposition leader Kim Beazley addressed the scientists and outlined some of the funding initiatives in the "Knowledge Nation" package, including increased spending on innovation and doubling the number of post doctoral positions at universities.

Dr Pal Fekete, NSW AIP chair (left) and Dr Kate Wilson NSW AIP publicity officer (right) meet Senator Nick Minchin at Science Meets Parliament Day.

Senator Nick Minchin, Minister for Industry, Science and Resources, hosted a morning tea. The scientists were addressed by the senator and the government's innovation plan was described.

Science meets parliament day is an annual event organized by FASTS, and is the biggest event of its type in Australia. No other interest group sends so many representatives to see so many parliamentarians on a single day, and the event has helped to raise the profile of science in government and provide links between the scientific community and policy makers.

Kate Wilson,

NSW AIP publicity officer.

The Hon Kim Beazley addresses the scientists.

(Photo courtesy Ray Strange, News Ltd.)
FORGET TAX - SCIENCE HOLDS THE FUTURE

Australia's scientists have called for a greater national investment in science, research and higher education. Professor Peter Cullen, President of FASTS, released FASTS' policies for the next election. He said the most important things for Australians were jobs and the quality of their environment.

"Science and technology can deliver both, but only if Australia builds up its investment in these areas," he said. "Getting back on track will require a significant national investment, to breathe life into our universities, and lift Australian spending on science and research to the average figure for OECD countries. That's a big decision for the electorate, but there comes a point when people get sick of poor services, never-ending queues on phone lines and limited public services. People are prepared to forgo tax cuts if it means quality outcomes. At the moment, we live in a pot-holed society."

Professor Cullen said Australian politicians spent too much time arguing about tax, and not enough debating issues which will make a real difference. He called for decisive action to address the chronically low number of scientists working in industry. FASTS is proposing a program to encourage industry to employ more young scientists with post-graduate qualifications.

"It's good enough for Singapore, and it has brought new high-technology industries to that country," he said. "It would help bring our industries up to speed with the possibilities of new technologies, and would be a powerful selling point in attracting new research-intensive industry to Australia."

He said Australians did not enjoy the perception that they lived in a country that was becoming increasingly irrelevant to the twenty-first century, except for its sporting achievements. "We might smile on the outside when they describe the Australian dollar as the 'Pacific peso', but inside it hurts," he said. "It hurts even more because of the implication it carries, that important people in the world see Australia as a country fading away after a great start."

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Academy of Science highlights the plight of science education.

The Australian Academy of Science has expressed concern at the state of science education in Australia. The President of the Academy, Professor Brian Anderson, said "A strong education sector at all levels is vital to creating and sustaining a knowledge-based economy. We are seeing some very disturbing signs."

'The declining share of enrolments in the enabling sciences of physics, chemistry and mathematics in universities and secondary schools is of great concern,' he said. 'We must reverse this trend. Otherwise Australia will not have the capacity to support the skilled workforce necessary to survive and prosper in an innovative and competitive global environment.'

Professor Anderson went on to say that even if we address the issue of enrolments in the enabling sciences, there remain policy issues that must also be addressed. 'The absence of a system that provides proper indexation to universities to reflect the community-wide salary movements is a major concern,' Professor Anderson said.

'A second policy issue is that the current arrangements that purport to reward quality do not in fact reward quality at all, but rather numbers. If university A produces four PhDs who get jobs driving taxis, it receives twice the funding that university B receives for producing two PhDs who go on to distinguished research careers.'

A third concern is that the price that universities receive for each trained student is dictated, and not arrived at by any process of arbitration or consultation. These shortcomings in policy have resulted in increased stress loads on universities and caused our talented people to depart for overseas. This is the scientific equivalent of losing our Ian Thorpes and Grant Hacketts. The future also looks bleak with the Department of Finance projecting that Commonwealth expenditure on higher education as a percentage of GDP will decline from 0.59% in 02/01 to 0.52% in 03/04.

The President went on to say 'Many departments in our universities are in crisis, and the crisis will continue to deepen unless these policy issues are addressed as a matter of urgency.'

AROUND THE TRAPS

Red Faces All Round

Physicists at the Lawrence Berkeley Laboratory in California have had to retract claims that they had discovered two new 'superheavy' elements in 1999. They had claimed new elements of atomic number 116 and 118, whereas the previous heaviest element was at 114. They were thought to have reached a new 'island of stability'. But nobody has been able to reproduce their results, and a re-analysis using different software revealed little sign of the new elements.

Meanwhile, it appears that the possible sighting of the Higgs boson at CERN last year may also have been premature. Early analysis saw an effect at 115 GeV with a 0.42% chance that the signal was due to background fluctuation (a three standard deviation effect); but the latest analysis puts the probability at 3.4% the signal is a fluke - only about a two standard deviation effect. CERN policy says you need five standard deviations to claim a discovery.

Honours

Professor Kurt Lambeck, of the Research School of Earth Sciences at the ANU, has won the Prix International Lemaître for 2001 for "his outstanding contributions to the understanding of the Earth's rotation and its internal constitution". This major international prize is awarded by the Georges Lemaître Foundation at the Catholic University of Louvain to commemorate the eminent Belgian astrophysicist Georges Lemaître.

[ANU Reporter, 31 August]

Promotions

Congratulations to Rob Elliman, Vice President of the AIP, and Peter Johnston, Registrar, for their recent promotion to Professor. Well deserved recognition in both cases.

[John O'Connor]
New 2001 Physik Instrumente Catalogue Released

Warsash Scientific is pleased to announce the arrival of the latest 2001 Micropositioning, Nanopositioning and Nanoautomation catalogue from PI of Germany.

Featuring new and improved ranges of linear and rotary stages, piezo positioners and motor controllers, this new catalogue is full of solutions for applications including static and dynamic positioning, smart structures, adaptive mechanics, fibre optic instrumentation and alignment, micromachining, test equipment and metrology.

The catalogue also includes a piezoelectric tutorial outlining the basics of piezoelectric technology and nanopositioning.

As representatives of Physik Instrumente for more than twenty years, Warsash has the expertise to help you find a positioning solution for any application. To have a copy of this catalogue sent out to you, please contact Warsash Scientific.

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New Miniaturised MPC 4 IM Pockels Cell

LINOS has recently unveiled its highly compact Pockels Cell, the MPC 4 IM. This cell is available in a variety of different versions for wavelengths ranging from 248 nm to 1,064 nm. Its aperture is 4 mm. The MPC 4 IM’s compact housing allows easy use in Q-switches and laser systems. As a result, the new cell enables compact laser systems to be configured in sizes that have been considered unfeasible until now. Because of the immersion liquid used in the cell, the MPC 4 IM has an extremely high transmission of 98% at 1,064 nm. Its extinction ratio is 1:3,000 (at 1,064 nm and with a 1/2 voltage applied). The cell’s maximum power is 500 MW/cm.

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Warsash Scientific Announces New Reflective Material

Avian Technologies has developed a new sintered PTFE (polytetrafluoroethylene) material with the highest diffuse reflectance of any known material. Produced by an entirely new process compared to previously produced sintered PTFE products, Fluororol-99TM offers 99% reflectance in visible region of the spectrum and >97% over most of the UV-NIR range (300-2200nm).

Fluororol-99TM is easily machined into diffusely reflective components, is hydrophobic, chemically inert and stable to >340°C. This durable and cleanable material has many applications, including sensor display backlights, illuminator panels, small integrating spheres, reflective diffuser panels, remote sensing targets, lamp housings and calibration targets for radiometry and reflectance systems.

For further information about the use of Fluororol-99TM and other reflective materials and accessories please contact Warsash Scientific.

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New High Resolution UV and N-IR Beam Profiler

Improving on their current beam profiler designs, Coherent Auburn Division has recently released higher resolution and accuracy models of the BeamMaster™ Knife-Edge Beam Profiler system series.

New UV-enhanced models provide more accurate beam shape and dimension measurements via a choice of three and seven knife-edge design models (other models available on the market are typically only of dual knife-edge or slit design). Beams from 3mm to 9mm in diameter can be profiled over a wavelength range of 190nm - 1100nm to a resolution of 0.1mm.

New BeamMaster near-IR profilers also incorporate this multiple knife-edge design, offering improved resolution over the 800nm - 1800nm wavelength region. These models are suitable for profile measurement of beams of up to 3mm and 5mm in diameter.

All BeamMaster beam profilers accept output from a number of laser sources including laser diodes and fibre-coupled sources making them a versatile and precise option in laboratory instrumentation.

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SEPIA, the new Multi-channel Picosecond Diode Laser from PicoQuant

PicoQuant GmbH presents a new multi-channel picosecond pulsed diode laser system called “SEPIA”. Up to 8 laser heads can be driven in parallel: synchronously, delayed or in a user defined sequence with up to 80 MHz repetition rate. Laser wavelengths between 395 and 1550 nm are available.

Based on the technology of the well established PDL 800-B picosecond diode lasers the new laser system provides maximum flexibility for simultaneous and multiple wavelengths applications. As in the single channel PDL 800-B the wavelength is chosen by changing the laser heads. Pulse widths below 70 ps can be achieved. The “SEPIA” system gives the user the possibility to drive up to 8 laser heads in parallel or to fire them in a user defined sequence. The system consists of a mainframe with a power supply and a set of user configurable modules.

An oscillator module delivers the repetition frequency of up to 80 MHz. This triggering signal is fanned out by a signal splitter or sequencer module and fed into each of the laser driver modules. The signal path is established by external cabling. This allows a maximum flexibility (even across multiple racks) also easy and jitter-free delay insertion as well as manifold synchronisation options. All lasers can be fired either simultaneously, with a fixed time separation or in a rotational regime.

With the open frame concept future enhancements as well in the triggering modes (e.g. multichannel bursts) as in pulse shapes (e.g. rectangular with variable pulse width) are possible. Applications are: fluorescence spectroscopy, optical tomography, quantum cryptography and many more.

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The Physicist  Volume 38, Number 5, September/October 2001 113
A VARIABLE FINE STRUCTURE CONSTANT?

MICHAEL MURPHY

School of Physics, University of New South Wales

The fundamental coupling constant of quantum electrodynamics is under siege.
Three years ago, Webb et al. (1999) found tentative evidence for a smaller fine structure constant \( \alpha = e^2/\hbar c \) in extremely distant, ionized gas clouds. This article will describe how that result was achieved and what has been done about it since. In particular, I will describe a new, complementary set of astronomical data and results which seem to agree with the Webb et al. result.

Is a variable \( \alpha \) all that bizarre?

The question of varying constants is not a new one. Milne [1] first suggested that the Newtonian gravitational constant, \( G \), may vary with cosmological time. He proposed a gravitational theory in which different physical 'clocks' - 'ticking' according to different physical processes - 'tick' at different rates as time progresses. Later, Dirac's [2] Large Numbers Hypothesis attracted considerable interest. The ratio of the age of the universe to the atomic light-crossing time, is \( \frac{1}{(e^2 m c^3 - 10^9} \) and the ratio of the electromagnetic to the gravitational force between a proton and electron is \( e^2/(G m_p m_e) = 10^9 \). Dirac maintained that this numerical similarity was no coincidence, that the quantities were actually equal up to trivial factors of low order. Since the former is varying, so must one of the constants and Dirac selected \( G \) to avoid clashes with quantum mechanics. The desire to place Dirac's idea of varying \( G \) on a firmer theoretical footing led to the development of scalar-tensor generalisations of General Relativity like Brans-Dicke theory.

Current motivation for a search for a varying \( \alpha \) comes from modern theories which attempt to unify gravity with other interactions. In particular, many theories (e.g. string and M-theory) require many extra dimensions of space. To obtain a 3-dimensional quantity in these theories (like \( \alpha \), one must integrate over all the extra dimensions. Intuitively, one can see that quantities like \( \alpha \) will be functions of simple powers of the scale lengths of the extra dimensions. If these scale lengths vary with time then we should observe varying 3-dimensional constants.

At present, there seems to be no mechanism for keeping these extra dimensions static: varying constants may be a natural result of grand unification.

Another motivation for a varying \( \alpha \) comes from varying speed of light (VSL) theories. One appeal of a VSL is that it provides alternative potential solutions to a range of cosmological problems such as the flatness, horizon and monopole problems. Barrow & Magueijo [3] have even developed a particular model in which a varying \( c \) is related to the cosmological constant, \( \Lambda \).

\( \alpha \) determines the spacing between components of doublet transitions in alkali-like atoms/ions (e.g. Si IV, C IV, Mg II etc.). This is illustrated in Figure 1a. In 1956, Svedov [4] began searching for variations in \( \alpha \) by observing alkali doublet emission lines from distant galaxies. Absorption lines in intervening clouds along the line of sight to quasars are substantially narrower than intrinsic emission lines and therefore provide a more precise probe of \( \alpha \). This method is illustrated in Figure 2. One appeal of this method is the huge time span (~10 billion years) probed by high-redshift observations.

\[ \text{Figure 1: (a) Schematic diagram of a Si IV doublet. The difference between the relativistic corrections to the two transition energies is very small since they share a common ground state. (b) If one can calculate the relativistic corrections for any given transition then comparing different species and multiplets allows one to probe larger energy shifts with greater statistics.} \]
Varshalovich, Potekhin & Ivanchik [5] have recently analysed 16 Si IV absorption systems (towards 6 quasars) using the AD method. They find a mean $\Delta \alpha / \alpha = (-4.6 \pm 4.3 \pm 1.4) \times 10^{-4}$ at a mean redshift $z \sim 2.8$. The negative sign here indicates a smaller $\alpha$ at the mean redshift of the Si IV absorption clouds. The first error term is statistical only, while the second represents a systematic component due to uncertainties in the Si IV laboratory transition wavelengths. More recently, using improved laboratory measurements and higher quality data, we analysed 21 ADs (towards 8 quasars) and obtained a much improved result: $\Delta \alpha / \alpha = (-0.5 \pm 1.3) \times 10^{-4}$ with a similar mean $z$ [6]. Figure 3 shows a plot of one of our high resolution Si IV systems.

The many multiplet method and the Webb et al. result

Recently, Dzuba et al. [7] and Webb et al. [8] suggested a new many multiplet (MM) method that offers an order of magnitude improvement in precision over the AD method. The method is based on measuring the wavelength separation between the resonance transitions of different ionic species with no restriction on the multiplet to which the transitions belong. The AD method is simple in that only the variation in the doublet separation with $\alpha$ is needed. To use the MM method, the variation of any transition wavelength with $\alpha$ must be known. We briefly explain how this was obtained below.

Consider a many-electron atom/ion. The relativistic correction, $\Delta$, to the energy of the external electron can be written as

$$\Delta \propto (Z_e \alpha)^2 \left| E \right|^3 \left[ \frac{1}{j+1/2} - C(j, l) \right],$$

where $Z_e$ is the nuclear charge, $E$ is the electron energy ($E < 0$, $|E|$ is the ionization potential) and $j$ and $l$ are the total and orbital electron angular momenta. The contribution to the relativistic correction from many-body effects is described by $C(j, l)$. For $s$ and $p$ orbitals, $C(j, l) = 0.6$ and is of similar magnitude for $d$ orbitals. Equation 1 therefore provides a general strategy for probing the relativistic corrections in resonance transitions.

For example, consider comparison of the transition energies of two $s$-$p$ transitions, one in a light ion, the other in a heavy ion (i.e. low and high $Z_e$, respectively). The $Z_e^2$ term dominates so the relativistic corrections to the transition energies will differ greatly. Thus, comparison of the spectra of light and heavy species is a sensitive probe of $\alpha$.

As a further example, consider an $s$-$p$ and a $d$-$p$ transition in a heavy ion. The corrections will be large in each case but will be of opposite sign since the many-body corrections, $C(j, l)$, begin to dominate with increasing $j$. This situation also allows tight constraints to be placed on $\alpha$.

Thus, comparing spectra of transitions from different multiplets and different atoms or ions, provides a sensitive method for probing variations in $\alpha$. In comparison, the fine splitting of an $s$-$p$ doublet will be substantially smaller than the absolute shift in the $s$-$p$ transition energy since the excited $p$ electron, with relatively small $|E|$, will have much smaller relativistic corrections than the $s$ electron. Therefore, the AD method is relatively insensitive to variations in $\alpha$.

More formally, the energy equation for a transition from the ground state, within a particular multiplet, at a redshift $z$ can be written as

$$E_z = E_c + Q_1 Z_e^2 \left( \frac{\alpha_2}{\alpha_0} \right)^2 \left[ \frac{\alpha_2}{\alpha_0} - 1 \right] + K_1 (LS)^2 Z_n^2 \left( \frac{\alpha_2}{\alpha_0} \right)^2 + K_2 (LS)^2 Z_n^4 \left( \frac{\alpha_2}{\alpha_0} \right)^4,$$

where $E_c$ is the ground state energy and $Q_1, Q_2$ are model-dependent constants.
where $\alpha_f$ may or may not be equal to the laboratory value, $\alpha_\phi$. Here, L and $\Sigma$ are the electron total orbital angular momentum and total spin respectively and $E_0$ is the energy of the configuration centre. $Q_f$, $K_f$, and $K_2$ are relativistic coefficients which have been accurately computed in Dzuba et al. [7] using many-body calculations. Equation 2 forms the basis of the MM method since it can be applied to any resonance transition observed in the QSO spectra – another advantage it has over the AD method.

For our purposes, the most convenient form of equation 2 is written as

$$\omega_f = \omega_0 + q_1 x + q_2 y,$$

where $\omega_f$ is the wavenumber in the rest-frame of the cloud, at redshift $z$, $\omega_0$ is the wavenumber as measured on Earth and $x$ and $y$ contain the information about a possible non-zero $\Delta \alpha/\alpha$:

$$x = \left( \frac{\alpha_f}{\alpha_0} \right)^2 - 1 \quad \text{and} \quad y = \left( \frac{\alpha_f}{\alpha_0} \right)^4 - 1.$$ (4)

The values of the $q_1$ coefficients are typically an order of magnitude larger than the $q_2$ coefficients. Therefore, it is the relative magnitudes of $q_1$ for different transitions that characterize our ability to constrain $\Delta \alpha/\alpha$. The form of equation 3 is very convenient since the second and third terms only contribute if $\Delta \alpha/\alpha \neq 0$: errors in the $q_1$ and $q_2$ coefficients cannot lead to an artificial non-zero value of $\Delta \alpha/\alpha$.

From equation 2 we can see that $q_1$ will be much larger in heavier ions due to the $Z_f^2$ dependence. Webb et al. [8] used the combination of the Mg II doublet and five Fe II lines from three different multiplets (see Figure 1b) to constrain $\Delta \alpha/\alpha$ in 32 absorption systems. The Mg II transitions have very small positive $q_1$ values while those of Fe II are large and positive. As a result, the Mg II transitions act as anchors against which the larger Fe II wavelength shifts can be measured. Webb et al. obtained an unprecedented precision in $\Delta \alpha/\alpha$ and reported the first tentative evidence for a slightly smaller $\alpha$ at a mean $z = 1.0$: $\Delta \alpha/\alpha = (-1.09 \pm 0.36) \times 10^{-3}$. It is the comparison of spectra from different ions that allows the order of magnitude increase in precision.

The main advantages of the MM method over the AD method are:

(1) By including all relativistic corrections (i.e. including those for the ground state) there is a sensitivity gain of around an order of magnitude compared to the AD method.

(2) In principle, all transitions appearing in a quasar absorption system may be used. This provides an obvious statistical gain and a more precise constraint on $\Delta \alpha/\alpha$ compared to using a single AD alone.

(3) A further advantage of using many transitions is that the velocity structure of the absorption system is determined much more reliably due to the larger range of transition strengths (see Figure 4).

(4) A very important advantage is that comparison of transitions with positive and negative $q_1$ coefficients minimizes systematic effects.

New results

The Webb et al. analysis concentrated only on transitions of Mg II and Fe II. However, many additional transitions are available in more dense, higher redshift systems. Transitions of Zn II, Cr II and Ni II are particularly interesting. The $q_1$ coefficients for the Zn II transitions are very large and positive whereas those of Cr II are large and negative. This allows us to place strong constraints on $\Delta \alpha/\alpha$ and also helps us avoid systematic errors. For Ni II, within the same species (but different multiplets), we have both positive and negative values for $q_1$. This unique case is due to the very complicated multiplet structure of Ni II as discussed in detail in [9].

We obtained high resolution quasar spectra of 18 of these high redshift systems using one of the Keck 10m telescopes on Mauna Kea in Hawaii, the largest optical telescopes in the world. The same telescope and spectrograph were used to obtain the original Webb et al. data. A good example of these dense absorption systems is shown in Figure 4. Note the wide range of line strengths and the widely differing atomic masses. We fit the data with multi-component Voigt profiles to determine the best fitting value of $\Delta \alpha/\alpha$ and many other parameters simultaneously.

![Figure 4: Heavy element absorption lines from a damped Lyman-$\alpha$ system. This system shows both saturated and unsaturated transitions. In this case, the Fe II and Si II lines provide constraints on the velocity structure while the Ni II, Cr II and Zn II are strong enough to provide tight constraints on $\Delta \alpha/\alpha$.](image)

This new data yield a startlingly similar result to that of Webb et al. [8]. We find $\Delta \alpha/\alpha = (-0.76 \pm 0.28) \times 10^{-4}$ for the new sample. A re-analysis of the Webb et al. sample yielded $\Delta \alpha/\alpha = (-0.70 \pm 0.23) \times 10^{-4}$ and so the two samples together yield a 4.1σ result: $\Delta \alpha/\alpha = (-0.72 \pm 0.18) \times 10^{-4}$. Figure 5 shows how the results from the 49 absorption systems are distributed in redshift and look-back time to the absorption clouds [10].
Acknowledgments

The "we" in this article refers to a group headed by John Webb (UNSW) including Victor Flambaum and Vladimir Drzuba (UNSW), Chris Churchill (Penn. State), Jason Prochaska (Obs. Carnegie Inst. Washington), John Barrow (DAMTP, Cambridge) and Arthur Wolfe (Uni. California, San Diego).

References


Conclusions

This is an exciting time for tests of the constancy of the constants. Many modern theories predict possible variation and astronomical observations can probe some constants, particularly $\alpha$, to high precision and to high redshift. Our recent results are tantalising and a larger, more recent data set is beginning to reveal a similar effect. We are left with no doubt that some effect exists in the data and, at present, no one can provide a simpler explanation than a varying $\alpha$.

Several other methods exist for testing the variability of $\alpha$. The most promising of these is the comparison of absorption spectra of the H$_2$121cm hyperfine transition and optical transitions (like those used already). Such an analysis would provide another order of magnitude improvement in precision. However, not many QSO absorption systems are currently known which exhibit the Hydrogen hyperfine absorption. We are now planning a targeted search for these systems which may lead to constraints on $\Delta \alpha/\alpha$ over a similar range as in Figure 5. Other tests include analysis of future cosmic microwave background anistropy data and laboratory spectroscopy experiments. At the moment though, spectroscopic QSO observations are providing an exciting and potentially fundamental result.
A PROFESSIONAL STUDIES UNIT FOR THIRD YEAR UNIVERSITY STUDENTS

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For three years now all of the third-year physics students at Monash University have participated in a unit of work aimed at giving them an appreciation and understanding of the role of physicists in industry and the value of physics to society. As well, we aim to increase the students' awareness of physics-related careers and their suitability for such careers and to help them prepare to win their first job. In this article we outline the content of the unit and present some analysis of student responses both to this content and to the various assessment tasks employed.

Introduction

The terms “profession of physics” and “professional physicist” possibly mean many different things to as many different people, each of whom may have graduated from a University with a degree in which he/she would have studied a significant amount of undergraduate physics. Indeed, it is now the common experience for the careers counsellor in a secondary school or the academic adviser in a university to be asked the question, “If I study physics, what employment will be available to me when I graduate?” There is no easy, specific answer to this question.

An ongoing series of articles by John Prescott for the Australian Institute of Physics1, (AIP) has highlighted the range of employment opportunities for “physicists”. The data have been based, for the most part, on positions advertised in The Weekend Australian and the Higher Education Section of The Australian on Wednesdays. Other advertisement sources are also included, for example, since 1996, an e-mail employment service sponsored by the AIP (Prescott 2000). Positions included represent those for which a degree or diploma in physics or applied physics is a suitable training. Table 1 from Prescott (2000) provides the spread of areas for this employment, which confirms the point made already that there is no specific answer to the question raised in the first paragraph. If one adds to this spread all the positions into which graduates from “physics” courses may have gone, which were either not advertised or for which an advertisement could not have been interpreted as a “position for which a degree or diploma in physics or applied physics is a suitable training”, then this spread would be even larger. One concerning statistic in Table 1 is that a significant employment of “physics” graduates is for the advancement of research in tertiary education institutions.

<table>
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<td>90</td>
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Table 1. All jobs advertised in The Australian for which a degree or diploma in Physics or Applied Physics provides a suitable starting point. All subdivision figures are percentages (taken from Prescott, 2000).

1 The results of annual surveys on the employment of “physicists”, which commenced in 1980, have been published by John R. Prescott The Physicist and its predecessors, Aust. and NZ. Physicist and Aust. Physicist.
which, from one point of view, represents the self-propagation of "physics" training for this ongoing, ill-defined, job market. Nevertheless, the overall size of this physics job market has been seen in Figure 1 (Prescott 2000). The peak in the total number of "physics" job advertisements annually (the heavy solid line) of about 800 occurred in 1990, and in recent years it has hovered around 500. It is worthwhile noting that the overall trends in this measure of job availability of "physicists" follow those in both "Trades" (dashed line) and "All Professionals" (dot-dash line).

In the context of this information on professional physicist job availability, and bearing in mind that the number of graduates from Australian universities undergraduate physics courses was in excess of 600 in the late 1990s (Jennings et al. 1996), it is clear that supply exceeds demand and that the physics job market is a competitive one. Thus, it is reasonable for undergraduates to expect to learn something about their profession and some aspects of employability enhancement, as an integral part of their undergraduate training.

The unit of "Professional Studies" which was introduced at Monash University in 1998, has both occupational information and employability enhancement as part of its objectives. In addition, prior to its introduction, a review of the BSc at Monash University had highlighted the need for further "emphasis on generic skills, disciplinary knowledge and professional, world real-world competencies". In this paper we present an outline of the course unit and document some data from student feedback on its success. A limited scan of the physics course details available on various websites for Australian universities, has failed to find any similar activities in other universities. So, while we believe that our activities in this area may be unique, we should be very pleased to hear from other tertiary educators who undertake similar studies.

Course Unit Outline

The unit was introduced as a component of the third-year physics program. Debate occurred concerning the appropriateness for a unit of "professional studies" at either the third or honours year. The general consensus was that the majority of our graduates attempted to join the workforce at the end of their BSc (Pass) degrees so that it was here that such a program was most appropriate to the needs of the students.

Although a small fraction of "physics majors" choose to study a full year of physics as their third year (i.e., 48 credit points in the Monash BSc) by far the majority couple physics (24 points) with another subject, commonly Mathematics, Materials Science or Chemistry. Thus Professional Studies was offered as a compulsory activity for all students undertaking at least 12 points of "physics" per semester. It was given the credit rating of approximately 1 credit point per semester so that the majority of students the credit value for Professional Studies is 2 points for the year of study in physics, which totals 24 points (i.e., 8% of studies).

The aims of the unit are:

- to introduce students to previously unexplored aspects of a professional physicist's work;
- to give students the opportunity to see physics at work outside the University;
- to give students an understanding of, and an appreciation for, the value of physics to society and the contributions physics (as a profession) makes to technological progress and to universal knowledge;
- to increase physics students' awareness of physics-related careers and their suitability for such careers; and
- to help them prepare to win their first job.

The first semester program comprises four formal lecture presentations in the following areas and a visit to a "physics workplace".

(i) the social responsibilities of physicists;
(ii) the organisation of the "Profession of Physics" in Australia;
(iii) the funding of physics research in Australia; and
(iv) the need for scientific innovation in physics research.

The precise detail of the presentations under item (i) have depended to some extent on the particular interests in this area of professional activity on the part of the lecturer available. In the first two years of the program, these lectures involved working through a number of examples available in the physics literature, addressing questions of the philosophy for undertaking scientific research, the social responsibility of the author of a scientific paper for the authenticity and/or repro-

2 Science Ahead - a review of the Faculty of Science at Monash University, 1998
Ibid., pp 1-12
ducibility of the results and the responsibility for the communication of scientific discovery (specifically physics), as currently based on the scientific literature. For 2000, for this aspect of the unit, the lectures were based on a “good” and a “poor” example of literature to illustrate “the social responsibilities of a scientist”.

To provide the students with an opportunity to express their own opinions on the “social responsibilities” issue, each student is required to write a critical essay, worth 20% of the total assessment for Professional Studies, Semester 1) addressing a question selected by the student from a range of questions posed by the lecturer. Questions have included:

- Does the community of physicists have its own interests, and with what effects?
- Are there valid criticisms of science, or only its misuse?
- Can scientists produce objective knowledge in a world where their research is increasingly directed towards making money or meeting social needs?
- What were the issues involved in the “Cold Fusion Controversy” and the responsibility of scientists to two communities and the possible influence of those communities on the reception of Fleischmann and Pons’ claim to have produced “fusion in a test tube”?

Lecture presentations on the profession, funding and innovation comprise a detailed outline of the background and the structure of the Australian Institute of Physics and its role in the Australian physics community, the methods through which physics research is funded in Australia, within the University, CSIRO and Government sectors, some discussion of science policy issues, some examples of scientific innovation from within Australian physics research, and the steps which must be followed in attempting to bring these innovations from discovery to the market place. In 2000, in the innovation area in particular, there was some discussion of the National Innovation Summit held in Melbourne early in the year. Again the students were required to prepare an essay (worth a further 20% of the assessment for Professional Studies, Semester 1) following their own reading from the reference material provided. Examples of topics proposed are:

- What sort of new “social contract” do you think the physics community should seek with government, university administrations and the community, as we enter the 21st century?
- It has been said that the 20th century belonged to physics but that the 21st century will belong to IT and biotechnology. What is your view?
- Physics, along with mathematics and chemistry, is sometimes referred to as an “enabling science”. If this is true, what will be the importance of physics in the 21st century in contributing to our understanding of the world in which we live?


Figure 2. A group of physics students on the roof of the Bureau of Meteorology, Melbourne, inspecting a Dobson spectrophotometer, used for atmospheric ozone measurement.

The workplace visits are structured around organisations away from the University but with which there are established relationships, usually because one (or more) physics graduates from Monash University have been employed with the participating organisations. To enable such visits to lead to a useful exchange for the students on the precise role and responsibilities of physicists in that organisation, the group visiting any one organisation is limited to no more than six students, accompanied by a supervising academic. Visits are approximately four hours in length and arranged to be most convenient to the organisation. For example, “medical physics” is an important employment area for physicists in Melbourne (e.g., the Peter MacCallum Cancer Institute and The William Buckland Radiotherapy Centre at the Alfred Hospital). In order that visits by students to such places should be meaningful, it is essential that the visit not overlap the busiest times for patient treatment.

For each organisation, careful planning takes place between the academic coordinator of the unit and the contact in the organisation. For all organisations comparable sets of general principles for the conduct of the visit, apply. These are:

- the detailed physics behind the operation of critical items of equipment used by physicists in the organisation;
- the role of physicists within the organisation and their particular areas of responsibility; and
- to what extent they have brought particular skills to the organisation by virtue of a training in physics.

Some vastly different organisations have participated in this aspect of the program, as listed in the acknowledgments. (Figure 2 shows a small group at the Bureau of Meteorology inspecting a Dobson spectrophotometer used in the measurement of atmospheric ozone.) In some cases the organisation supplies the students with a set of notes on aspects of the work by the organisation and associated physicists. In other cases students have been referred to relevant literature. But in each case a specific set of guidelines for reporting on the visit has been prepared beforehand, through collaboration between the academic coordinator and the contact physicists in the organisation. The assessment of this report (providing the
remaining 60% for Professional Studies, semester 1) is based on both the generic, report-writing skills and the physics covered during the visit. In some cases this physics is not an area familiar to the students from their other units so that the workplace experience serves to broaden the knowledge base in the professional discipline.

It has been our experience that organisations are very keen to host such visits to the “physics workplace” by small groups of our third-year students. In fact the students themselves have often remarked on the obvious amount of effort which has been put into the preparation for their visit by their respective host and/or their colleagues.

In semester 2 the program comprised six one-hour sessions as follows:

(i) “Physics and Technological Innovation” - discussion in a lecture format of the details of physics-based inventions or discoveries and their transfer into the “market place”

There are many examples to be found across various branches of physics: energy conversion, transport, electronics, communications, instrumentation, materials, etc. An understanding of issues other than the background physics underlying the invention, such as marketing and financing, is crucial to successful innovation. In the last two years the lecturer has used as a real example, the “Glass Log” Project from the X-ray Computed Tomography group [Davis et al., 1996] involving basic research on X-ray attenuation, scanning and image reconstruction techniques. As the result of this basic research a prototype mobile X-ray Tomography instrument was developed and applied to measurements on power poles for the Electricity Supply Industry and growing trees for the Forestry Industry. Considerable effort followed in an attempt to market the device, but to date the final step of sufficient industrial funding to achieve a marketable innovation has not been made on account of insufficient industrial support.

The remaining five sessions include a sequence of tasks within career management. They are conveniently summarised as in Figure 3.

(ii) “Self Awareness and Decision Making” - a workshop-style presentation by a professional psychologist aimed at identifying and highlighting students’ occupational interests, values, aptitudes, abilities and skills. The workshop involves an interactive card sort of skills into a grid involving five subjective “like scales” from “totally delight in using” to “strongly dislike using” and three levels of competence: “highly proficient”, “competent” and “little or no skill”. This “game” has led on to a discussion of career decisions and the ways and means of making oneself employable.

(iii) “Opportunity Awareness” - an overview of the occupations and careers available to physics students conducted by various members of the academic staff and based on current information made available for student reading

(iv) “Job Search Techniques, Resumé Writing and Self-presen-

- [Figure 3. Schematic representation of the career management generic skills covered in the Professional Studies unit.]

Table 2. Questions supplied to members of the student audience prior to the commencement of the “mock” job interview, on which a critical appraisal of the interview is based.

1. First impressions are very important. What did you think? Help or hinder getting the job?
2. A confident Body Language helps. What was your impression? Help or hinder?
3. Range of the panel. Any comments?
4. Do you have any comments or any questions? (e.g., style, helpful/unhelpful)
5. Any other questions you might have expected which were not fielded by the interview panel?
6. Do you have any comments about any of the interviewee’s responses?
7. Did the job applicant show a knowledge of and an interest in the position and organisation for which he/she was applying?
8. Should the applicant have asked any other questions of the panel?
9. What was the chief anxiety of the applicant?
10. What was the chief concern of the interview panel?
11. Could you tell from the way the interview was closed, whether or not the applicant got the job?

6 Activity adapted from Dick Knowdell Motivated Card Sort
7 See footnotes 1 and the Report on the Forum entitled “Do Physicists Have a Future”, held at the AIP National Congress of Physics, University of Tasmania, Hobart, July, 1996 (Australian & New Zealand Physicists, 33, 252-76 (1996)).
8 L. Raszotszky, Notes: Professional Studies: third year physics, (Monash University, 1998)
ious experiences in the workplace, including the initial transition from university to employment. (In 2000, these presentations were supplemented with a recent publication by MONSEACS*, which featured career profiles for many Monash University graduates covering many disciplines, including physics. It also included a discussion by a Ph.D. student on the transition to doing "research physics")

(vi) "The Job Interview" - a "mock" interview conducted by staff on one specific, short-listed job applicant chosen from the work for assessment set under (iv) above, with the remainder of the student group acting as a critical "audience" using preliminary questions. (See Table 2.)

The work completed by each student, which forms part of the assessment, comprises (under item (i)) an essay (1000 words) on a physics-based innovation, the physics behind it and a discussion of other issues relevant to successful innovation (Bennett, 1988) (25% of the total assessment for Professional Studies in semester 2). Following (ii) each student completes an essay (not less than 800 words) addressing his/her own career goals for the first five years after leaving the University (15%) but guided by such questions as:

- "What cluster of occupations always interested you and why did you choose to write about a particular one?"
- "Do you have interests that will be met outside paid employment?"
- "What aptitudes do you have that will be used in your particular scenario?"
- "What skills are you mainly motivated to use, and which would you prefer to avoid?"
- "In your scenario, how have you ensured that your main values have been maintained?"
- "What is your opinion of the five-part, decision-making model of career management" - refer to Figure 3 - "and to what extent do you think it will help you manage your career?" etc., etc.

During item (iii) the students are referred to numerous, recent position advertisements for physicists. As an additional component (15%) of the assessment, each student is required to write a letter of application for a real position, either one chosen from the collection of recent advertisements provided in item (iii) or one which he/she has found for him/herself following some formal instruction on job search techniques (covered in item (iv)).

As further assessment components, each student is required to prepare a personal résumé (40%) and find five suitable job advertisements, documenting the procedures used for each of these (5%). There is no formal assessment associated with the "mock" interview but the student competitively chosen for interview, is given a small assessment bonus. The series of questions mentioned above (Table 2) serves as a basis for the constructive debriefing of the interview.


Appraisal of the Course Unit

The enthusiasm with which most students have approached this unit during the three years during which it has been a compulsory component of the third-year physics course at Monash, has itself been a qualitative measure of its success. The concerns originally expressed by some staff that such an activity was "not physics" in that in order to introduce something new in any course, something else must be removed, and that proper assessment of the unit would present a difficulty, have not been apparent. Quite a number of the academic staff have become involved, particularly in the supervision of workplace visits and have been able to judge for themselves the success of these in meeting their objectives. In addition, the requirement by the Faculty of Science at Monash for there to be a focus on generic skills has become a priority in recent years and this unit has embraced such a priority successfully. Finally, there has normally been a mark distribution in this unit comparable to those in other units taken by the majority of physics students, indicating that the assessment, despite its multiple components, has been valid.

During 2000, the opinions of the students (about 30 in all) on the course content and the assessments, were sought via evaluation sheets on which students were not required to identify themselves. Each component was appraised using qualitative, four-level measures. In addition, the various components of the assessment for the semester 2 were also appraised by inviting student opinion on each of these on a four-level scale from "very useful" to "no use". These response data, as percentages of the total number of responses received (about 17 in all) are summarised in Figure 4 from which the following observations can be made.

For the semester 1 content (Figure 4(a)), there is a clear consensus that all aspects of the unit were "useful". A comparable leaning towards "helpful" in appraising the semester 2 course items (Figure 4(b)), is evident. Note that no student had an "extreme negative" (i.e., "no use" or "most unhelpful") for any aspect of the unit content. It is important to appreciate the links between course items and assessments in drawing conclusions from the student opinions on assessments (Figure 4(b)). The most significant opinion of "very useful" for assessment items 3, 4 and 5, is consistent with the strong expression of "most helpful" for the implementation aspect (iv) of the course content. It is interesting to observe the "little use" opinion on the assessment I concerned with innovation. Is this consistent with the difficulties experienced by many professional physicists in developing research ideas into commercial products? It suggests to us that this is an important area in which there is scope for the introduction of a postgraduate course.

Conclusions

The conclusions drawn from the introduction of a unit of Professional Studies into our third-year physics course and its presentation to classes of students during the last three years, can be summarised as follows:
(i) There is an increasing need for professional awareness in science degrees, in general, and physics majors, in particular.

(ii) The unit introduced at Monash University covers both broad, generic, employment-enhancement skills, applicable to any science student and physics-discipline specific aspect, which could be readily adapted to other science disciplines.

(iii) The students have responded favourably to most aspects of the unit presented. The strong positive responses to aspects concerned with the implementation of generic skills and the less-than-favourable response to the aspect concerned with technological innovation are noteworthy.

Acknowledgments

We acknowledge the assistance of several academic colleagues, staff of MONSEACS and some Monash Physics graduates, in the presentation of this unit. The success of the workplace visits relied on the willing and enthusiastic inputs of staff from the Bureau of Meteorology, Dulux Australia, Kodak Australia, Peter MacCallum Cancer Institute, William Buckland Radiotherapy Centre and Varian Australia Pty. Ltd. We also acknowledge the assistance of Mrs. Julia Barnes in the preparation of the manuscript.

References


JOBS IN PHYSICS IN 2000; LOOKING UP TOWARDS THE NEW MILLENIUM?

JOHN R. PRESCOTT
Department of Physics and Mathematical Physics
University of Adelaide SA 5005

This is the twenty-second in the series of annual surveys carried out by the author for the Australian Institute of Physics. As the country "recovered" from the recession of the '90s, employment opportunities for physicists appear to have settled down to a level of about $500 per annum, to be compared with around $700 that applied for the decade to 1990. In 2000 they went up to $540 from $470. To the extent that there was a discernible pattern within this total, it tended to repeat that of recent years.

It has been the practice in the past to publish a fairly detailed annual analysis in The Physicist. The data for the first decade were summarised in Prescott (1988) and for the first two decades in Prescott (1998). The data for year 1999 are to be found in Prescott (2000). The present report is in abbreviated form.

THE SURVEYS

The surveys are based on positions advertised in The Weekend Australian and in the Higher Education Section of the Australian on Wednesdays. Positions within Australia and New Zealand are included from John O'Connor's email address at: physics-employment-request@cc.newcastle.edu.au if they are not also advertised in the print media. One hundred ARC Fellowships at various levels were offered in 2000. These are not advertised and a national twelve were included in the survey, based on past experience.

Most of the advertisements in The Australian call for an honours degree or a post-graduate qualification. Positions for which an ordinary degree or diploma in physics would be suitable are mostly to be found in the "local" press. Estimates based on sampling of capital city newspapers suggest that there were at least as many positions advertised there as in the Australian. Many of these local advertisements are for jobs in local commerce or industry or for school teaching.

In general, the positions are those for which a degree or diploma in physics or applied physics is a suitable training, even though this may not be explicitly stated in the advertisement. In many cases further training would be expected, e.g. for teaching in secondary schools or where a higher degree qualification is stated or implied in the advertisement. In any case, it is good, timely advice to physics graduates to add such further training.

Some firms recruit on campus and do not advertise. For example, this is currently said to be the case for optoelectronics. The present survey, therefore, represents a lower limit to the opportunities for employment for physics graduates, although it probably accounts for most of the positions which would be regarded as for "professional" physicists, in the sense that the AIP would recognise.

No positions are included that call for membership of the Institution of Engineers, Australia, even when it is clear that a physicist would make a suitable appointee. It is now common for an advertisement to state alternative qualifications, such as "physicist/engineer", "engineer/scientist", or the like. Often, qualifications in "physics" per se are stated in the body of the advertisement but not in the heading. While a statement of alternative qualifications means that there is competition for the positions, they are nevertheless positions suitable for physicists. At the risk of stating the obvious, in presenting themselves as applicants for such jobs, physicists should give prior thought as to why their particular physics training makes them more suitable than some other possible applicant.

THE DATA

The statistics for 2000 are shown in table 1, which also includes those for the previous four years. The 1997 figures are interpreted as a statistical low. The twenty-year trends are shown in figure 1 where annual physics jobs are compared with weekly advertisements for all positions as recorded by the ANZ Bank Employment Series, and with those for trades and (grouped) professionals from the DEET Skilled Vacancy Surveys.

We turn now to some of the details:

In the organisations for which the Commonwealth Government has direct responsibility: CSIRO, Defence, Bureau of Meteorology, ANSTO and the like, job advertisements continued at about the same level as the previous year. As has been usual for many years, about one third of all jobs are in this group. CSIRO was down in both relative and absolute terms within the group. DEFENCE held steady with perhaps more emphasis on situation analysis than hardware development. In the "not CSIRO/not DEFENCE" group there was strong emphasis on environmental monitoring. The new Australian Greenhouse Office continued to seek staff at the managerial level.

State and Territory Governments were recruiting strongly (for them), mostly for monitoring air, water and radiation.

The areas with which Universities are associated, teaching, research and technical positions, improved marginally. There were more teaching positions on offer, including two tenable Professors and five Deans of Science. Limited term research positions in Universities continue to be the biggest single group at 28% of all positions. In absolute numbers this is one hundred and fifty positions - as large as it has ever been. ANU advertised strongly, particularly in the second half of the year;
it is now heading its advertisements, "Australia's National University", and The University of Adelaide is now "trading under the name of Adelaide University", both, doubtless for commercial reasons.

The demand for school physics teachers was steady. Although these are nearly all in the independent schools, both the South Australian and New South Wales Departments of Education were placing targeted advertising. Although it strictly belongs in 2001, it is worth recording an unique event: The NSW Department has advertised financial incentives for teachers to be retrained for Physics and Chemistry teaching.

An encouraging improvement was an increase in jobs in Industry and Commerce to the best level in over five years. About one third of these were in optics or optoelectronics. There is talk around the tea rooms that the demand for graduates in optoelectronics is growing beyond our capacity to provide them and that we are heading for shortages. The advertised demand is still modest but the signs for an increase may be there. Geophysics barely rose from what had been its lowest level in twenty years. The mining firms are not out there looking for new prospects at the moment.

Most Hospital and Medical posts are in state hospitals with an occasional post in private practice. The demand has been traditionally small but steady and so it was last year.

A National Innovation Summit, jointly sponsored by the Commonwealth Department of Industry, Science and Resources and The Business Council of Australia was held in Melbourne in February 2000. Its Implementation Group reported late in the year. At about the same time the report, Chance for change, by the Chief Scientist, Dr R. Batterham, was released. Both reports analysed Research and Development and made recommendations. In a nutshell, Australia stands near the bottom of the OECD table for industrial R&D although we do better in Government-supported areas. This has been a familiar theme of the present surveys for some years. The Government announced its response to both reports early in 2001. They include incentives to Industry and additional financial support for the ARC. At the same time, support for government agencies (except defence) has been reduced and they will have to compete for funds with the Universities. The proposals for encouraging Industrial R&D appear little different from the unevenly successful New Start programme. It is easy to be cynical, or at least skeptical, about the eventual outcome. However, there is no doubt that even if no more of the recommendations are implemented, it will be good for the employment of physicists.

Overseas positions are, of course, only those advertised in Australia. They were all academic posts in our immediate Pacific neighbours. For the first time in some years, there was no physics job in New Zealand.

Across the board, a PhD was a stated or preferred requirement for more than half the positions advertised. About half of these were permanent.

A record was kept of the salary range for each position, in those cases where it was given. This is shown in table 2 where the numbers are for the second half-year.

A list of all positions surveyed, classified by fields, and giving the employer, the job classification, the salary range (where stated), a brief job description, whether a PhD is specified, whether the position is indefinite or limited-term, and the month of the advertisement, will be sent to all Australian physics departments, to careers officers in tertiary institutions and to employment agencies. Copies are available to interested persons from the author.

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**SOURCES OF FURTHER INFORMATION**

Annual and monthly summaries are available on the internet at [http://www.physics.adelaide.edu.au/jobs/jobs.html](http://www.physics.adelaide.edu.au/jobs/jobs.html) where other web-site addresses can be also be found.

There are now many outlets for job-lists on the internet. The pattern of advertising is changing and will undoubtedly change further. Already a large fraction of positions in the IT Industry are listed there for preference.

Employment information is available on e-mail, sponsored by the AIP. Employers can advertise their vacancies directly to physicists looking for employment. It carries both Australian and overseas vacancies. To receive this information send an e-mail message to:

```
physics-employment-request@cc.newcastle.edu.au
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and include in the body of the text the line:

```
subscribe physics-employment
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Do not sign your name in the body of the text since it will probably be misinterpreted.

At the time of writing, the status of The Australian Institute of Physics Employment Advertisement service was uncertain.

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**ACKNOWLEDGMENTS**

Gillian Robertson provided valuable help. Derek Leinweber created and maintains the Web site.

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**REFERENCES**

*ANZ Bank Employment Advertisement Series* (monthly, on the internet)


*Skilled Vacancy Survey*. Department of Employment, Education, Training and Youth Affairs. (monthly, on the internet)
ANNUAL RECORD OF EMPLOYMENT ADVERTISEMENTS

The heavy solid line shows annual physics employment advertisements (right hand scale). The thin solid line shows seasonally corrected average weekly employment advertisements for all classes of employment (left hand scale). The dashed line and dot-dash line are the DEET figures for "Trades" and "All Professionals" respectively. The two latter are index figures and have been normalised to the other data at 1983.

All jobs advertised in The Australian for which a degree or diploma in Physics or Applied Physics provides a suitable starting point. All subdivision figures are percentages.

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Table 1

126 The Physicist Volume 38, Number 5, September/October 2001
SAALY RANGEES FOR ADVERTISED POSITIONS AS OF LATE 2000.

Most of the positions advertised had salaries lying in the range quoted, occasionally smaller or larger.

Teacher .............................................. $30k-52k (small sample)
Professional Officer, Technical Officer, Research Officer, Research Assistant .............................................. $34k-47k-68k
Analyst ............................................. $50-75k
PDF $34k-50k
ARC PDF ............................................. $40k-43k
ARC Research Fellow/QEII Fellow .......................... $45k-53k
Research Fellow/Research Associate ......................... $45k-50k
Senior Research Fellow ................................ $55k-64k-75k-83k
Tutor/Associate Lecturer ................................ $36k-49k
Lecturer $51k-61k
Senior Lecturer ....................................... $62k-72k
Reader, Associate Professor ............................. $72k-85k
Professor ............................................ ca$95k
Senior/Research Scientist DSTO ......................... $48k-64k;$68k-82k
Experimental Scientist CSIRO ......................... $35k-52k
Senior/Research Scientist CSIRO ...................... $45k-55k;$60k-80k
Other Commonwealth ................................ similar
Engineer/Scientist .................................... $37k-60k
Modeler ................................................ $45k-60k
Science-based Managers ................................ $70k-80k

In round figures, first degree graduates start at about $34k, first post-doctoral appointments at about $44k, professionals with some experience at about $50k.

Table 2

WAGGA WAGGA

2002

26th Annual Condensed Matter (ANZIP) Meeting
Charles Sturt University, Wagga Wagga, NSW
29 January – 1 February 2002

Dates

Second and Final Notice: distributed late October 2001
Registration Deadline: 14 December 2001
Abstract Submission Deadline: 14 December 2001
Formal notification of registration and paper oral/poster allocations: 31 December 2001

wagga@ph.adfa.edu.au
"Physics and Industry Working Together"
The 15th Biennial Congress of the AIP - incorporating ACOFT and AOS

Monday 8th to Thursday 11th July 2002

Change of Venue:
The 2002 AIP congress will be held at Darling Harbour Convention Centre. The venue has been changed to accommodate the participation of two new groups, Australian Conference on Optical Fibre Technological (ACOFT) and Australian Electronic Equipment Manufacturers Association (AEIMA).

The participation of these new groups provides the opportunity for greater sharing of ideas across a wider range of disciplines than previously available at AIP congresses. Together with these new groups we now have 14 participating groups in Congress 2002. These are:

- Applied/Industry
- Australian Optical Society (AOS)
- Australian Society of General Relativity and Gravitation (ASGRG)
- Condensed Matter Physics (CMP)
- Medical Physics (MP)
- Physics Education Group (PEG)
- Science Teachers Association of New South Wales (STANSW)
- Vacuum Society Australia (VSA)
- Women in Physics (WIP)
- Atomic Molecular Physics and Quantum Chemistry (AMPQC)
- Australian Institute of Nuclear Science and Engineering (AINSE)
- Nuclear and Particle Physics Group (NUPP)

The sponsorship coordinator, Mark Ainsworth, is now seeking both sponsorships and companies interested in trade displays. If you have ideas or suggestions to find sponsorship to help make this the best congress the physics community has ever seen, please contact Mark: marka@ics.mq.edu.au.

Please contact Pal (p.fekete@physics.usyd.edu.au) if you have any suggestions, queries or contributions, and don’t forget to keep an eye on the website at www.aip.org.au/Congress2002.

Kate Wilson
Publicity Officer, Congress 2002 and NSW AIP

AUSTRALIAN INSTITUTE OF PHYSICS

The Institute is a professional and learned society of some 2100 physicists and physics teachers. It exists to serve the needs of physicists and the community, and advance the profession and practice of physics.

MEMBERSHIP GRADES

Fellow

FAIP Recognizes a position of eminence in the profession.

Member

MAIP Open to any physicist or teacher with a recognized graduate qualification.

Graduate

Available for 5 years post B.Sc. to graduates in physics.

Student

Available to those undertaking an approved undergraduate degree, associated with physics.

Associate

Open to graduates with degrees other than physics, or school teachers.

Subscriber

Open to any individual with an interest in physics, or library that wishes to subscribe to the Institute journal, the 'Physicist'.

Company Subscriber

Open to companies which wish to support the Institute, and receive the journal, the 'Physicist'.

ANNUAL SUBSCRIPTIONS, 2000

Fellow: $193.20; Member: $162.75; Graduate: $102.90; Student (undergraduate): $24.15
Associate: $44.10; Subscriber: $102.70; Company Subscriber: $409.50

Notes:

1. A range of significant discounts and special rates are available to postgraduate students, recent graduates, members living overseas, spouses etc. For full membership information see www.aip.org.au, or contact the AIP National Office on (03) 9326 6669.
2. All applications for membership or upgrades must be approved by the Membership Committee.
3. Application forms are available for downloading from the web site or by contacting the office.

NATIONAL SECRETARIAT

1/21 Vale St, North Melbourne VIC 3051, Ph (03) 9326 6669  Fax (03) 9328 2670, email aip@raci.org.au, website http://www.aip.org.au
TASMANIA

August Lecture:
A crisp, clear Thursday night on 23rd August, with the southern stars shining bright away from the lights of Hobart, was an unusual occasion for some 700 people of the Tasmanian Branch and interested members of the public to gather and hear an insightful, illustrated talk by Professor Roslynn Haynes entitled "Dreaming the Stars. What is aboriginal astronomy? How does it challenge western science?"

Professor Haynes explained how knowledge of astronomy was not an optional extra for aboriginal communities as it is to us today, but was used as a calendar of seasonal variations in food and trade and, by association with stories, a continuing reference for guidance on tribal mores and the tribe's place in a holistic view of the world.

Examples presented of the use of astronomy for trade and food included indicators for the trading season with Timorese and Indonesians in Northern Australia, seasonal variability in the availability of wildlife and plants, and using the phases of the moon as a tidal indicator associated with fishing.

Stories told by the stars linked directly to the world the tribe lived in. They provided explanations or moral guidance. Interesting distinctions between aboriginal stories from the stars included: there is no story of separation from, or rejection by, the creator (e. f. expulsion from the garden of Eden); there is no astrology equivalent (outcomes from actions are predicted by aboriginal star stories, but each person retains choice of action); aboriginal interest was in pragmatic use related to regular occurrences (not transient phenomena such as supernovae).

Differences between Aboriginal astronomy and western science include the following:
- a holistic view of the world where nature is to be cooperated with, contrasted with a reductionist approach which seeks to control the natural world;
- a relationship with Nature that seeks parallels in natural phenomena contrasted with an objective view of the scientist observer as distanced from the observed;
- regulated knowledge contrasted with the optimistic belief that knowledge is always 'good for us';
- conceptual knowledge acquired through initiation, contrasted with rationalist knowledge from observation and measurement.

An enthusiastic discussion followed the presentation. Eventually, an audience pleased with their choice of how to spend a Thursday evening, wandered out of the theatre to look at the night sky with added interest.


Gary Burns

Annual Year 11 and 12 Physics Quiz:
The Tasmanian branch held its annual Year 11 and 12 physics quiz on 1st September in the north of the state. The Don College in Devonport acted as hosts for the event at which 11 teams from 6 schools vied for medals and the perpetual shield. The event involved 6 rounds of 10 questions with an afternoon tea break after round 3 and special questions between the other rounds for boxes of chocolates.

The questions were a little tougher than in previous years but the students still managed reasonable scores. The winning team of Ben Weidmann, Joshua Tompson and Joshua Woolan was from The Friends' School. Runner up was a team of two students, Shaun Fitzmaurice and Matthew Wade, from Hellyer College and third place went to a second team from The Friends' School of Shavan Naido, Robert Kirkby, Tom Lorimer and David McCann.

Because the event is well sponsored it was possible to offer subsidies of $50 per team from Hobart and lesser amounts from other centres closer to the venue to offset the cost of travel.

The enormous success of the annual quiz is only possible through the generous sponsorship of local Tasmanian businesses and organisations. The Tasmanian Branch gratefully acknowledges the assistance received from Comalco, CSIRO Marine Science, The Australian Antarctic Division, The Faculty of Science and Engineering at the University of Tasmania, The Queen Victoria Museum and Art Gallery, Sky and Space Magazine and the Bureau of Meteorology.

A report on the event with some photos and a listing of the questions is on the Branch web site which can be accessed via the AIP national web site.

Next year the quiz will be held in Hobart which often leads to a bigger event as more schools find it possible to organise teams when less travel is involved.

Marc Duldig

VICTORIA

August Branch Meeting

The T.H. Laby Medal is awarded annually by the Victorian Branch of the Australian Institute of Physics to the outstanding Victorian Physics Honours student of the previous year. It is named in honour of the memory of Professor Thomas Laby, Professor of Physics at the University of Melbourne from 1915 to 1944. On August 16, the 2000 Laby Medal was presented to Ben Toner who completed his Honours year at the University of Melbourne. Ben was presented with his medal by Dr Jim Davidson, AO, nephew of Professor Laby. The Branch was also honoured to have Professor Laby's daughters, Dr Jean Laby and Miss Betty Laby, in attendance. Ben's Honours project explored the Higgs sector of the Exact Parity or Mirror Matter Model of particle physics (an extension of the Standard Model) which preserves an unbroken symmetry in nature.

Ben Toner and the 2000 Laby medal pictured with, from left to right, Dr Jean Laby, Miss Betty Laby and Dr Jim Davidson.

The medal presentation was followed by a talk entitled 'The Scientific SETI - fact or fiction' given by Dr Frank Stootman of the University of Western Sydney and Chair, SETI. Building on humankind's natural curiosity about things unknown, the search for extraterrestrial intelligence (SETI) has existed, at least in a serious scientific form, for over 40 years. Dr Stootman spoke of those years, the challenges that such a project faced and the role that Australia, through the Parkes Radio Telescope, was playing in that search to a wide-ranging audience of members of the Victorian Branch of the AIP and their guests.

By pointing out the challenges of ever travelling to even the closest stars he indicated that, given current knowledge and technology,
the only way in which we, on earth, may ever learn of the existence of extraterrestrial intelligence is via indirect means such as radio emissions from other civilizations. The challenge of detecting such transmissions was, however enormous, in terms of the probability of our detection devices being sensitive enough and oriented correctly to receive what are expected to be very weak signals. Dr Stootman showed, using simple mathematics, that it was necessary for us to assume that an extraterrestrial life form wanted to communicate with us and was using directional transmissions which favored Earth for us to have any hope of detecting signals which were sufficiently above noise for us to differentiate them.

Were such signals likely? Dr Stootman argued that the answer to this question involved some metaphysics and impinged on one's view of life and its creation. A strict evolutionist, for example, would argue that our current state of development is the result of processes with no pre-visions of their outcomes. It would thus be highly improbable that life forms such as our own could exist, even under similar developmental conditions. In this respect the SETI was important to prove the null hypothesis. Another view, which accepted that human development was guided by teleological principles, would perhaps come to the opposite conclusion. In either case the SETI was significant.

Using the Southern SERENDipity Experiment Spectrometer attached to the Parkes Radio Telescope SETI was able to 'piggyback' on other astronomical experiments being conducted and log signals on 58.8 million channels with 0.6 Hz resolution. The SETI looks at frequencies surrounding the Hydrogen Alpha transition. This line is chosen because it is universal and allows the study of the mass distribution in the universe. Its very universality also means that a 'speculative' argument can be advanced that any other intelligent civilisation might attempt to transmit radio frequencies with an artificial signature near to this spectral line in the hope of being seen. Using fast Fourier transform methods the researchers were looking for 'repeated occurrences of interesting events' which start with a 'hit' which is a channel which has a signal strength greater than at least 12 times the mean of 3,000 or so channels which surround it. To have a candidate for evidence of communication from an ETI a graph of these hits would form a narrow but sloped line. So far the only evidence of such lines have come from Earth-produced artificial satellites!

Dr Stootman concluded his interesting and entertaining presentation by indicating the future directions of the project which included the completion of a square kilometre array of detectors which would significantly improve sensitivity and by answering questions from the appreciative audience. Meanwhile we keep looking and listening.

2000 Bragg Medal presentation
On August 29 the Branch also hosted the presentation of the 1999-2000 Bragg Medal to Dr Mark Oxley of the University of Melbourne. The medal commemorates the Australian physicists Sir Laurence Bragg and his father Sir William Bragg and is awarded to the best PhD thesis in physics from an Australian university. Dr Oxley's thesis was entitled 'Inner-shell ionisation by fast electrons in a crystalline environment' and described first principles calculations based on realistic atomic models. Such calculations are computationally complex and Dr Oxley developed simple parameterisations during his doctoral research, making the tools for accurate modelling of experimental data generally available for the first time. This has allowed popular materials analysis methods, based on electron microscopy, to include detailed correction terms describing the ionisation interaction and hence greatly enhances the accuracy of these methods. The medal presentation was followed by a colloquium where Dr Oxley described the research that earned him this prestigious award.

Robert Taylor and Ann Roberts

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Charity Dinner -
12 December 2001

You are cordially invited to a fabulous gourmet dinner at The Novotel on the 12 December 2001 at Brighton-Le-Sands (on Botany Bay). All proceeds to go to the Cancer Care Center at St George Hospital.

A great night is assured and the dinner is tax deductible. Your support for a worthy cause would be greatly appreciated. Please contact Graeme Melville on 02 94761854 or melly@intercoast.com.au.

Graeme Melville
(NSW AIP Secretary)
Reviews

Field Theories for Low Dimensional Condensed Matter Systems - Spin System and Strongly Correlated Electrons

G Morandi, P Sodano, A Tagliacozzo, V Togne (eds.)
Springer-Verlag, Berlin 2000
xii + 275 pp., DM 129 (hardcover)
ISBN 3-540-67177-3

This book contains six chapters, each inspired by mini-courses delivered at the "Workshop with Learning" held in Chia-Laguna (Italy) in 1997.

If you are a researcher in theoretical physics with a background in field theory and condensed matter physics, you will find this book a delight. It contains what a good book should offer: the right insight presented by persons with taste for relevance. After reading a chapter of this book (I recommend the reading of all of them), one can go on and read some of the papers quoted. In my view, even if one knows the subject, it pays to have a look at the book since one can find the personal touch of people who made major contributions to the subject.

Low dimensional quantum systems is a subject of major interest for two reasons. On one side, there are plenty of interesting experimental data related to the quantum Hall effect, high-Tc superconductors, spin ladders and nanosystems. On the other side, there are powerful theoretical non-perturbative methods which work only in low dimensions. Many of them are described in this book.

In order to give a taste of the topics covered in this book, I will only mention the first one - Fermi and Luttinger liquids - and the last one - quantum chaos and transport in mesoscopic systems.

Vladimir Rittenberg
Department of Mathematics and Statistics
University of Melbourne

Nuclear Energy Fallacies - Forty Reasons to Stop and Think

Colin Keay
The Enlightenment Press*, Waratah 2001
36 pages, $5 ($7 posted within Australia)
ISBN 0-9578946-0-0
(* PO Box 166, Waratah, NSW 2298)

Nuclear power plants have been used to generate a substantial component of electricity production for decades in many of the developed countries in the world. Australia is rich in uranium deposits, with substantial exports, but does not use nuclear power for its own electricity production. Why not?

In this short book, Colin Keay, an academic who taught nuclear and reactor physics, critically rebuts misinformation that has either directly or indirectly promoted the case against nuclear power generation in Australia. Forty claims that have been publicised either through the media or as anti-nuclear lobby groups are collected together and shown to be fallacious. These fallacies range from extreme exaggeration to minor misconceptions. For example, $250,000,000,000 was so far died as a result of the Chernobyl tragedy" reported in "Habitat Australia" versus estimates from reports by the United Nations Scientific Committee on the Effects of Atomic Radiation at around 40; "Plutonium was named after Pluto, god of the underworld" in Helen Caldicott's book Nuclear Madness when in fact it was named in planetary sequence following uranium and neptunium.

This is a highly commendable, timely, and inexpensive publication, it should be mandatory reading for all policy makers and others who have followed either side of the nuclear debate in this country. If widely read it could do much to help launch a long overdue informed rational debate about the use of nuclear power in future energy strategies for Australia.

B I Henry
Department of Applied Mathematics
University of New South Wales

Synchrotron Light (Lumiere Synchrotron)

Springer-Verlag, Berlin 2000
Hybrid CD-ROM, DM 98
ISBN 3-540-14888-4

This has been a banner year for synchrotron radiation research in Australia with the Australian Synchrotron Research Program for overseas access being renewed by the MNRF program, and with Victoria announcing that it will construct an Australian synchrotron facility. The release of the CD, "Synchrotron Light" by Springer is thus particularly timely. This has been my first experience with a "book on CD", and I have found it rather novel. The CD is organised with a multitude of levels with a browser style interface to navigate via links: it will seem very familiar to anyone used to the world wide web. Unlike a book, one follows topics of interest, often branching out following further links. However it would be a difficult task to read the CD "cover to cover".
The top level is a series of very basic audio-visual introductions to the concepts of synchrotrons and the science performed at these facilities. Links lead to increasingly detailed and complex treatments of synchrotron technology and science. Much use is made of animated images, in particular explaining the workings of synchrotron storage rings and beamlines. Interactive applications are also scattered through the presentations. I particularly enjoyed the demonstration of X-ray diffraction showing the diffraction pattern evolving from diffuse blobs to sharp spots as the degree of order is increased.

Synchrotron Light is a very comprehensive treatment of the technology and applications of synchrotron radiation. The level varies from general public in the introductions to a general scientific audience as links are followed deeper into the "web". The CD is an excellent introduction to synchrotron science.

Richard Garrett
Synchrotron Research Program
ANSTO

Quantum Mechanics

Julian Schwinger
Springer-Verlag, Berlin, 2001
xiv + 484 pp., DM 98 (hardcover)
ISBN 3-540-44108-8

This unique textbook is based upon the lecture notes that Julian Schwinger wrote up for the students of the quantum mechanics course that he taught at the University of California, Los Angeles (UCLA). The book contains three sections that are based upon the sections of the course that were presented in the Autumn, Winter and Spring quarters respectively. The approach taken in these lectures was somewhat unique, starting, as it does, by presenting an in-depth analysis of the calculus of quantum mechanics rather than the usual mantra of postulates. The development of these laws occurs within the experimental framework of the Stern-Gerlach experiment, with the algebra constructed through logical argument. Within this consistent framework, the basic ideas of quantum mechanics are built: angular momentum, conservation laws, harmonic oscillator, hydrogenic atoms and so on. The level of the text would be appropriate for late Undergraduate, Honours and Postgraduate level courses in quantum mechanics and as such this book would probably make an ideal quantum mechanics reference for lecturers in quantum mechanics rather than as a course textbook. There are a large number of problems included at the end of each chapter, which comprise an excellent resource for any lecturer even though there aren't worked solutions to these problems. In summary, this textbook is a unique resource, which provides an insight into the thoughts and deliberations of one of this century's giants of quantum mechanics.

P C Dastoor
Physics Department
University of Newcastle

Mathematical Methods of Quantum Optics

Ravinder R Puri
Springer-Verlag, Berlin 2001
xii + 255 pp., DM 119 (hardcover)
ISBN 3-540-67802-6

This is not really a book one would read from cover to cover. It provides descriptions of the mathematical methods that are useful for various areas of theoretical quantum optics. Although it seems to have an understandable bias towards areas of quantum optics of particular interest to the author, it is reasonably thorough in its coverage of the basic mathematics. This is exemplified by the fact that quantum optics itself, that is, the quantisation of the electromagnetic field, does not commence until page 121. Until then the book is concerned mainly with more fundamental quantum mechanics.

The initial overview of quantum mechanics is quite useful because of its conciseness and I feel that postgraduate students would benefit particularly from this. The inclusion of some group theory is unusual for books of this genre and I found it particularly welcome, given its increasing use in quantum optics in recent years. Some recently developed topics such as geometric phase are also included.

In view of the large number of books on theoretical quantum optics published in recent years, the question is whether this book adds sufficiently to this store of knowledge to be worth buying. Overall I think it does and I can certainly recommend quantum opticians ordering one for their institutional libraries. Those involved more with the theory on a daily basis may find it handy to have a copy in their office.

D T Pegg
School of Science
Griffith University

Quantum Optics in Phase Space

Wolfgang P Schleich
Wiley-VCH Verlag, Berlin 2001
xx + 695 pp., AS169.95 (hardcover)
ISBN 3-527-29435-X

Quantum optics is a rapidly expanding field. This is reflected in the growing number of books on quantum optics that have evolved from notes prepared for lectures given by the author. In this book, as happens in many books in this area, the subject matter and flavour very much reflects the interests of the author. Nevertheless, there is a large amount of material which the professional quantum opticist and postgraduate student will find interesting and useful. Except in cases where the lecturer has a similar outlook to the author, however, I feel that the book may find more use as a reference than as a text. As the title indicates, much of the emphasis of the book is on phase space representations. Quantum states, both pure and mixed, can be represented pictorially as three-dimensional graphs in various phase spaces. In particular the space associated with the Wigner function is useful for studying the harmonic oscillator, the essential quantum model for quantum optics. The author takes phase space ideas further than most others, using the concept of...
interference in phase space to illustrate, for example, the complex amplitude given by the scalar product of two states. Much of modern quantum optics, as well as some atom optics, is covered.

The book is quite good, well presented and has many excellent illustrations and problems. I can recommend researchers in quantum optics obtaining access to it.

D T Pegg
School of Science
Griffith University

Photonic Analog-to-Digital Conversion
B L Shoop
Springer-Verlag, Berlin 2001
xiii + 330 pp., US$89.95 (Hardcover)
ISBN 3-540-41344-8

I was very keen to review "Photonic Analog-to-Digital Conversion," because I research devices for optical communication and wished to learn about this important field. The book has a readable style unlike others. Let us hope that this trend continues. The book starts off with a simple to read introduction. However it fails to prepare the reader for the subsequent chapters. Consequently I was not so sure what Photonic Analog-to-Digital Conversion precisely was after the first few chapters. I moved on to chapter 4: "Photonic devices" which is a subject area I know well. The text was insufficient to understand these devices without background knowledge or reference to another text. The other chapters have been treated similarly. This light treatment of the subject matter makes it significantly less useful than it could be. It would be useful to people who already had some knowledge in the field and would like an overview, such as an academic wishing to form a new course.

Justin Blow
Optical Fibre Technology Centre
University of Sydney

Understanding the Heavens
Jean-Claude Pecker
Springer-Verlag, Berlin 2001
xiii + 597 pp., DM149 (hardcover)
ISBN 3-540-63198-4

A knowledge of a subject's history can help one to a deeper understanding, and even guide future developments. Perhaps this is nowhere more true than for the rich history of astronomy - which in large part is the history of science itself. The task Jean-Claude Pecker has set himself in this book is to recount the development of humankind's ideas about the cosmos from essentially the earliest recorded history up to the present day. The strongest part of the book deals with the fascinating struggle to make sense of the rather complicated observed motions of the celestial objects, especially planets, from ancient Greek times up to Copernicus, Kepler and Newton. It is all too easy for us to forget what obstacles the early investigators faced, and perhaps we can learn from both their successes and failures. The contributions of many lesser-known people are discussed, presumably righting some of the wrongs of historical selection effects.

The section dealing with modern cosmology, fortunately only about 1/4 of the book, is disappointing. On a subject as important as the cosmic background radiation the discussion is poorly informed, and the author loses no opportunity to advance his doubts about the big bang theory.

The copious illustrations are useful, but the author's hand-drawn diagrams lack the clarity of a professional's use of different lineweights. There are even fewer typos, but I noted several errors of fact. In summary, this book is rather idiosyncratic and not always easy to follow, but contains much interesting and useful material.

J G Robertson
School of Physics
University of Sydney

Rare-Earth Doped Fiber Lasers and Amplifiers (2nd ed.)
Michel J F Digonnet (ed.)
Marcel Dekker, New York 2001
xii + 777 pp., US$225 (hardcover)
ISBN 0-8247-0458-4

That rare-earth ions have proved to be invaluable sources of light for a variety of laser applications is an undisputed truth. The interest in the area addressed by this book is driven by the enormous application, and as yet unrealized potential, of rare earth doped devices for telecommunications. The book's preface makes the point that the erbium doped fibre amplifier was born in 1987 to an engineered module indispensable to telecommunication network in the space of a few years. What is very evident in reading the assembly of notably authored chapters within this monograph, is that the progress in the field is neatly applying the knowledge gleaned from advances in basic scientific studies to technological development. The results from spectroscopy, in a variety of bulk glasses or crystals, have found application in all manner of fibre-based devices.

The spectral characteristics of the particular ions, and the concentration at which they are doped in a variety of host materials, combine to determine the properties of optical devices ranging from the ion-ion exchange up-conversion blue-green laser, through Q-switched and short pulsed devices, narrow and broadband devices to the double clad, co-doped, EDFA.

Details of the devices, their power characteristics and efficiencies may be found within this book and it is a very worthwhile monograph for people who have an interest in lasers, photonics or opto-electronics. The referencing is very detailed and, in particular, the additional two chapters incorporated into the monograph are very much up to date.

For a book of this value I was disappointed at the quality of some scanned graphs and on the whole this is an excellent book for those who need to learn of the devices, their properties and current fields of endeavor.

John Holdsworth
Physics Department
University of Newcastle

The Science of Cooking
P Barham
Springer-Verlag, Berlin 2001
xii + 244 pp., DM 74.79 (hardcover)
ISBN 3-540-67466-7

Late in the 1st-year mechanics course I analyse the wonders of precession to a (generally) fascinated class, describing how, when taking a corner on a bicycle or motorcycle, the leaning of the bike provides a torque that invokes a precession, that takes them round the curve. However the riders rarely know anything about the physics involved.

I believe that cooking is a bit like this: it is natural ability, not scientific knowledge that makes a good cook. Not understanding, as physicists who are always asking "why is it so?", this book is full of interesting and relevant facts that clarify the techniques of cooking that lead to the texture, taste and aroma of good cuisine. As a physicist the author introduces the importance of models in preparing food, and their modification as result of testing (tasting). The first two chapters are devoted to the chemistry involved, and this is clearly presented and well illustrated. After reading the section on the Maillard reactions, which describes critical temperature dependence of the process whereby sugars and amino acids react to produce some thousands of flavour molecules, I am somewhat wary of the consequences of the summer BBQ.

The two chapters on cooking techniques are where the physicist shines through. The physics of heat conduction and its implications for cooking styles are well described and illustrated. For those needing deeper theoretical bases, there are panels with the physics rigor whilst of the experimentalists, each chapter has a number of interesting experiments.

Max Thompson
School of Physics
University of Melbourne
## CONFERENCES & MEETINGS

### 2001

**Nov 25 – Dec 2**
ISES 2001 Solar World Congress  
Adelaide  
Contact: Hartley Management Group Pty Ltd  
PO Box 20 Kent Town SA 5071  
Ph: (61)-8-8363-4399 Fax: (61)-8-8363-4357  
Email: ises2001@hartleymgt.com.au

**Dec 3 – 6**
ACOLS 2001: Australasian Conference on Optics, Lasers and Spectroscopy  
University of Queensland, Brisbane  
Contact: Ms. J. Hughes, Email: acols01@physics.uq.edu.au  

**Dec 3 – 8**
25th International Workshop on Condensed Matter Theories, and 11th Gordon Godfrey Workshop on Recent Progress in Condensed Matter Theories  
Canberra  
Contact: Mukunda Das, Tel: (02) 6125 3066, Fax: (02) 6125 4676  
or David Neilson, Tel: (02) 9385 4553, Fax: +1 (253) 736 8116  
Email: adm105@rsphysse.anu.edu.au

### 2002

**Jan 21 - Feb 1**
‘DynamicSummer’ 15th Annual Summer School of the Centre for Theoretical Physics, ANU, Canberra  
Contact: Dr Rowena Ball, Rowena.Ball@anu.edu.au  
http://www.anu.edu.au/dynamicsummer/

**Jan 30 - Feb 1**
26th Annual ANZIP Condensed Matter Meeting (Wagga2002)  
Charles Sturt University, Wagga Wagga  
Contact: http://www.ph.adfa.edu.au/wagga  
Email: wagga@ph.adfa.edu.au

**July 7 – 12**
FIFTEENTH BIENNIAL CONGRESS OF THE AUSTRALIAN INSTITUTE OF PHYSICS,  
University of NSW, Sydney,  
Contacts: Pal Fekeete (02) 8303 9730 Email: p.fekeete@physics.usyd.edu.au  
or David Neilson Tel (02) 9385-4564. Email: D.Neilson@unsw.edu.au

**July 9 - 12**
Western Pacific Geophysics Meeting  
Wellington, New Zealand

**July 15 - 19**
11th INTERNATIONAL CONGRESS ON PLASMA PHYSICS  
Incorporating the 6th Asia Pacific Plasma Theory Conference, and the 24th AINSE Plasma Science & Technology Conference  
E-mail: icpp@icsaust.com.au  
Telephone: (+61-2) 9241-1478 Fax: (61-2) 9251-3552

**July 21-26**
8th International Conference on New Diamond Science & Technology (ICNDST-8)  
University of Melbourne  
Contact: Bronwen Hewitt, Tel: +61-3-8344-6389; Fax: +61-3-8344-6122.  
Email: icndst-8@unimelb.edu.au  
www.conferences.unimelb.edu.au/icndst-8

**July 22-26**
7th International Conference on the Structure of Surfaces.  
City Hall, Newcastle.  
Contact: John O’Connor (02) 49215439 or john.oconnor@newcastle.edu.au  
Web site www.pc0.com.au/icsos7

**July 22-26**
EXCON '02, Excitonic Processes in Condensed Matter, Darwin  
Contact: Jai Singh, Tel: (08) 89 466 811, Fax: (08) 89 466 667  
Email: jai.singh@ntu.edu.au  
There are serious issues facing Australian Science, Engineering and Technology which, if not addressed, will condemn our country to a never ending fate of 'catch up' with more enlightened countries. Backing Australia's Ability and Knowledge Nation are first steps in addressing aspects of problems with the SET disciplines in general, but there are potentially more devastating problems specific to the mathematical, physical, chemical and engineering sciences which need urgent attention. This joint release by the Royal Australian Chemical Institute, the Australian Institute of Physics, the Australian Mathematical Sciences Council and the Institution of Engineers Australia is aimed at promoting the discussion by the the community and the major political parties of how to address the need for crucial ongoing support of the enabling sciences (throughout this document the ‘enabling sciences’ refers to Chemistry, Physics and Mathematics where ‘Mathematics’ is an inclusive term encompassing Statistics). It is imperative that we address the growing problem of the current shortage of supply of top quality training in the ‘enabling sciences’ for industry.

MAIN STATEMENT

Chemistry, Physics and Mathematics are often called the ‘enabling sciences’. The knowledge contained within these sciences represents the foundations upon which all scientific discoveries are built and technology developed. They are fundamental to the success of a research and innovation culture in the ‘emerging technologies’ such as biotechnology, nanotechnology, photonics and information technology. They are an essential platform to engineering which converts scientific discovery into economic growth as well as playing a key role in most other areas of human endeavour and skills.

The successful progress of Australia’s economy and quality of life for its citizens requires policies for Education and Research that foster the creation of an environment in which the enabling sciences are able to operate and grow in a vigorous manner. This growth should contribute to the formation of an enquiring and innovative culture in science, engineering and technology and thus advances in the ‘emerging technologies’ through provision of a well trained, flexible, and motivated workforce.

Progress can to be achieved through:

Education

Provision of high quality training and a stimulating and rewarding career environment for teachers at all levels of education, together with allocation of resources to the education sector that ensures education of students in the ‘enabling sciences’ at the highest international standard.

Research

A recognition of the synergies between the quality of teaching in tertiary education, research activity in the ‘enabling sciences’, and the future progress of ‘enabling technologies’, requires an allocation and division of resources that emphasises quality at the highest international levels in educational and research outcomes.

The specific issues that need addressing fall into the following general areas:

PUBLIC

There is a serious disparity between the public reliance on science, mathematics and technology and their perception of the roles of training and employment prospects in these areas. Therefore we advocate the launching of a SCIENCE AND MATHEMATICS INITIATIVE FOR THE NEW MILLENNIUM which uses the strategies below to renew the interest, awareness and excitement factors in the enabling sciences, and demonstrate that there are rewarding, challenging and creative jobs for science, mathematics and engineering graduates

1) Its primary goal is a national campaign (similar to advertising for the armed forces) showing the many varied and interesting careers available for Science and Mathematics graduates. There is a growing gap between the supply of science and mathematics graduates in essential areas and the demand for them. This will include creating additional material for careers advisers.

2) Financial support for national Physics, Chemistry and Mathematics professional societies to promote their image as the enabling sciences nationally. This can be channelled through either the Science and Technology Awareness Program or the Australian Academy of Science but must be seen as new funds to target the misconceptions around the role of the enabling sciences. Include programs to focus on gender and minority group issues in the enabling sciences.

3) Put in place long term mechanisms to provide quality data on the number of staff in different mathematical, chemical and physical science and engineering disciplines at the tertiary level and the number of students majoring in these disciplines. This information should then be used as part of a workforce planning process which will identify the long term deficiencies in areas of science and engineering.

EDUCATION

The teaching of science and mathematics in secondary schools is under excessive strain. There is a diminishing resource base
of well trained teachers in the enabling sciences. We need to undertake a comprehensive review of the needs and resources in the education and training of the enabling sciences.

SECONDARY EDUCATION

4) Promote the BSc plus Dip Ed model as the preferred option for teaching staff in senior levels of secondary education in the enabling sciences.

5) Differentiate science and mathematics teachers into discipline specialties at senior secondary school levels.

6) Provide HECS bursaries to students undertaking teacher education programs in priority areas which involve enabling sciences.

7) Develop national standard entry qualification for entry into science and mathematics teacher training programs.

8) Launch a national program to improve teaching resources, support staff and additional scientific equipment to maintain modern laboratories in the enabling sciences. While attention should be paid to the increased demand for computers in secondary mathematics, the need for additional equipment extends well beyond computers in Chemistry and Physics.

9) Provide financial support for extensive in-service training programs in the enabling science disciplines for secondary science and mathematics teachers.

10) Eliminate the differential HECS for science and mathematics based degrees.

11) Provide a salary loading to teachers in the enabling sciences with honours or higher degree qualifications in the enabling science disciplines.

12) Develop national standards for matriculation students which involves compulsory study in English, Mathematics and Science to meet the capabilities and potential of every student through to the end of secondary education.

PRIMARY/SECONDARY EDUCATION

13) Strengthen the enabling science component of teacher training programs and provide financial rewards for successful completion of programs to upgrade skills in the disciplines of the enabling sciences.

14) Increase the awareness amongst primary and junior secondary teachers of the long term importance and effects of the specific and generic skills of the enabling sciences, and of the importance of optimising the development of students and avoiding under-estimation.

15) Establish a national triennial conference on Science and Mathematics curricula and implementation with an aim to bring together the schemes in different states. This has great benefits in the sharing of teaching resources and in the mobility of teaching staff.

TERTIARY EDUCATION

16) Review the DETYA relative funding model for costs of university course delivery.

17) Increase core funding to reverse $/EFTSUs funding decline.

18) Provide targeted research training places and scholarships in the enabling sciences.

RESEARCH

19) Provide staff support for large equipment items and the high level computing facilities necessary for mathematical and scientific research - not just equipment costs.

These issues must be addressed to support a fruitful high technology future.

Professor John White  Associate Professor John O'Connor
President,  President,
Royal Australian  Australian Institute of Physics
Chemical Institute
Judith Mousley  Dr Martin Cole
President  President
Australian Mathematical  The Institution of Engineers
Sciences Council  Australia
Associate Professor Helen MacGillivray
Mathematical Sciences Cluster Representative
Federation of Australian Scientific and Technological Societies

DATA CLARIFICATION

The data on the following pages have been collected by directly querying the heads of departments for each discipline in every tertiary institution in Australia. Not all the data could be used as it would misrepresent the true situation. The reasons include:

- In some institutions there have been amalgamations with other departments and it is no longer possible to separate out discipline specific information
- In some cases the departments have closed down or have been moved to other faculties rendering the statistics meaningless
- In some cases data was incomplete in that it was only provided for part of the period requested.

In all cases the data has been used only in such cases where the data is continuous and there has been no substantive change to the department or school which would bias the data one way or the other.

This typically means that the data represents the situation in ~20 of the 38 institutions around Australia.

The data also only refers only to full time and fractional appointments. The reason is that casual staff don’t contribute to the full range of academic, research and administration activities of departments.
Appendix One - The State of the "Physics Nation"

The following table shows the declining state of Physics Departments around the country. The tally involves about 67% of the departments around the country where there is a clear delineation between the disciplines so that a comparison can be made (response rate = 22 institutions). The delineations are becoming harder to make with the recent restructuring going on in most institutions. The conclusions are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Academic Staff</th>
<th>General Staff</th>
<th>&quot;Students&quot;</th>
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<tbody>
<tr>
<td></td>
<td>361 303 256.7</td>
<td>329 268 244.6</td>
<td>4765 4675 3920</td>
</tr>
<tr>
<td></td>
<td>-16% -29%</td>
<td>-19% -26%</td>
<td>-2% -18%</td>
</tr>
</tbody>
</table>

Over the past 6 years we have been losing physicists at the rate of 5% per annum from our tertiary institutions (to a total of 29%). We have lost almost as many support staff as well (26%). In the first triennium, there was little change in undergraduate student numbers (this is all students which include service teaching), but in the past three years we have seen a decline of 18%. The "Students" were based on the well established "Effective Full Time Student Unit".

It would appear on the surface that the student numbers have not fallen as fast as the staff numbers. It should be noted that in most institutions the departments have developed new courses not focussed on core physics students. While there is nothing wrong with this practice, the inclusion of such numbers in this data masks a decline in students completing a degree with a major in physics.

We have therefore lost almost a third of the physics academics in this country with the consequent loss in skills, research potential and knowledge.

If the current rate of university staff losses continue, there will be no Chemistry, Physics, Mathematics or Engineering to support innovation after 2020AD.

If the current rate of secondary school participation in Chemistry, Physics and Mathematics continues there will be no enabling science in secondary schools beyond 2020AD.