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The composite photograph on the front cover illustrates a few of the topics that will be covered in the Second International Conference on Isotopes (2ICI) and the Second Conference on Nuclear Science & Engineering in Australia (ANA 97) to be hosted in Sydney in October by the Australian Nuclear Association (ANA). The background shows the research reactor HIFAR at Lucas Heights. The inserts reading clockwise from the top right hand corner are: the Cyclotron at the National Medical Cyclotron Facility at Camperdown, NSW; ANSTO’s SMV Tandem Accelerator - one of the new big science facilities at Lucas Heights; an AGINSE postgraduate research student working on neutron scattering equipment at Lucas Height (all courtesy ANSTO); the Ringer uranium processing plant (courtesy ERA). For details of the conferences, see page 80 of this issue.
PRESIDENT’S COLUMN

A Busy Time

In thinking about what to write for this President’s Column I started to wonder why we have such a column, and what it should contain. Of similar journals that I know Physics Today, Physics World and Physics in Canada do not have such a column whereas Chemistry in Australia and Acoustics Australia do. What should a President’s Column be? Should it be a homily or sermon? A battle cry? A witty essay about physics and physicists? An account of activities and deliberations of the Executive and President? Probably at times it will contain elements of all of these, but in each issue I will certainly include some information on what I and the other members of the Executive are doing for our Society.

The last few months have been busy. In April I prepared the AIP submission to the West Review, the text of which is included in this issue. In doing this I encountered a dilemma which occurs in such situations. While purporting to be a submission from the AIP in reality it only contains input from the Executive and Science Policy Committees. Ideally one should circulate a draft document to the membership at large and include their input but in practice, with short time-scales and lack of resources, this would be difficult.

A second dilemma concerns how direct such a submission should be. Some of the issues are naturally sensitive and controversial and any statements made can be easily taken out of context. On the other hand I do not believe the membership would support a totally bland set of membership statements.

The first week of June was particularly hectic. On the Wednesday I travelled to Canberra to meet with Erich Weigold, Chair of the National Committee for Physics of the Academy of Science. The AIP and the National Committee will take joint action in presenting the case for Physics to University Vice-Chancellors and in arguing against decisions and policies which could further threaten Physics in our Universities. For this purpose I am gathering current data from Department Heads. We hope to have a document, signed by a number of eminent public figures both within the Physics Community and outside, ready by August. I will also be attending a joint forum of the Higher Education Council/National Academies to put the case for Physics.

The following day we had meetings of the Science Policy and Executive Committees in Melbourne. Some of the issues under consideration at the present time are:

- careers for young physicists
- the role of physicists in industry
- changes to physics departments
- High School physics issues
- the 1998 Congress in Perth
- improving the range of services to members
- the AIP Web page and the Physicist.

Finally on the Friday there was a full day meeting of the FASTS Board in Sydney. The Federation of Australian Scientific and Technological Societies plays a vital and effective role as a promoter and lobbyist for science and technology, and has excellent contacts with politicians, the government bureaucracy in Canberra, and the media. I am currently a member of the FASTS Board, representing a group of six professional societies in the physical science area, including the AIP.

FASTS, who sponsored the recent Careers Forum reported in my last column, has made submissions to the Stocker and West Reviews and the Senate Enquiry on the Status of Teachers and have issued a press release critical of the lack of any science and technology focus in the recent Federal Budget. These documents and other FASTS information are available on their Web site

http://binho.pharmacol.su.oz.au/asts/fastshome.html. It was a busy week.

I would like to alert members to the 1998 AIP Congress which will be held in Fremantle at a very attractive venue during the week 28 Sept - 2 Oct. The organizers have promised reduced fares from Sydney/Melbourne, a scintillating program and fantastic weather. I would strongly encourage members to start planning for this. A well supported biennial congress is important for Physics in Australia. More on this later.

Jaan Oitmaa
aip@phys.unsw.edu.au
Popular Science

From time to time CSIRO commissions a poll on what the public thinks of science. A recent such poll shows a further increase in interest, to the extent that twice the number of Australians now prefer to read about science rather than politics or sport. Science is more popular than crime or employment stories! There are some interesting gender variations in the poll. For example, the numbers representing "very interested" on a Women : Men basis are: Sport 19:47 (not surprising); New Medical Discoveries 64:45; Scientific Discoveries 39:48; New Technologies 40:52. These last two sets of numbers should interest the mass media. Science and technology have a wide and similar appeal to both men and women, unlike sport, yet where are the daily science pages in your newspaper?

Joe Baker, the president of FASTS, is drawing these results “to the attention of the editors of Australia's top media outlets urging them to give greater coverage to science”. This is a worthwhile thing to do, but it will not produce instant conversion. The media often quote polls, and even run their own, which, surprisingly frequently, produce findings which coincide with the views of the newspaper owner or editor. We must therefore expect a certain amount of cynicism from editors. We should hence emphasise that this popularity of science is not an isolated result but a further increase in a trend which has developed over many years.

Practical considerations also inhibit change. What does an editor do with a staff of sports and political writers and none who can recall Newton's laws of motion? We have all seen the results of sending sports journalists out on science stories. "Scientific Breakthrough" type articles conjure up images of a group of white coated thugs with a battering ram crashing through the door to the room in which the secret formula is hidden. Do we want the public to see us like that? ‘Australian First' science stories are better and perhaps a necessary way to attract the attention of sporting readers. The image of the lone Australian scientist standing moist eyed on a dais while the national anthem plays in the background or perhaps, for technological triumphs, shaking a magnum of champagne and squirting it over the crowd. Not really accurate is it, but nearer the mark. Many of us have joined in the consumption of alcoholic beverages and general feelings of euphoria when great results have been obtained or significant problems overcome. However the only potential waste of champagne that I can recall on such an occasion was accidentally letting a bottle slip into a Dewar of liquid nitrogen. Even then, we fished out the snap frozen champagne, removed most of the slivers of shattered glass, thawed it and drank it.

Of course science has always had sales appeal, mostly for the label rather than the reality. The name is invoked to sell pills and potions and support some religious groups. There is Domestic Science, Creation Science and, I recently heard, Real Estate Science degrees available in Florida. Even Economics has been called the Dismal Science. Dismal it may be but surely not a science, more a theology. A theology whose God is commerce. Where are its respect for dissenting views, its accurate predictions, its steady progress over the years towards more refined and reliable theories? Rather it has dogmatic assertions based on doubtful concepts, simplistic icons like the sacred bottom line, intolerance for heresy, appeals to faith: "we are having short term problems but persist with the policy and the future will be prosperous". Clearly it is the writings of economics journalists rather than the sports pages that we need, for the good of the nation, to replace with science articles.

This will not happen quickly. Even 200 years ago Edmund Burke was complaining: "But the age ofchivalry is gone. That of sophisters, economists, and calculators, has succeeded; and the glory of Europe is extinguished for ever". A bit over the top but then he was upset about the French Revolution. We can't return to an age of chivalry but perhaps, with the increasing support of a scientifically enlightened public, we can move ahead to a more rational age.

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1997 FEES

If this isn’t your copy of the ANZ physicist then you are not a member. You should join, not only to get this journal every month and find out what is happening in Australasian physics and physics education, but to support the many activities that the AIP and NZIP carry out on your behalf. Most of the work is done by people who give considerable time and effort to advance physics. But we still need funds and every new membership helps. If you are already a member, why not make an effort to recruit others?

AIP FEES

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AIP CONGRESS 13

The 13th National Congress of the Australian Institute of Physics will be held from the 27th September to 2nd October, 1998 at the Esplanade Hotel, Fremantle, Western Australia.

The AIP National Congress is the sole opportunity we have to meet with fellow Physicists from around Australia to discuss important professional issues as well as topics of current scientific interest. The Programme Committee will ensure that the Congress is of value to Physicists from all areas; industry, education, academic and government. It will offer a blend of information, expertise and opportunity.

The Congress location is Fremantle the port city of Western Australia, which is located a short distance from the city of Perth. The venue is the Esplanade Hotel, in the heart of Fremantle’s business, commercial and entertainment district.

Accommodation to suit all budgets is available near the venue from A$45 – A$135 per night. Special rates will be available for delegates and their partners. If you wish to be included on our mailing list for the next information circular, please contact the Congress Secretariat

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Queensland Physics

As former Heads of Department, we write to express our grave concern about the damage that has recently been done to the Physics Department of the University of Queensland by administrative actions. While Physics Departments are under pressure worldwide and some staff reductions are seen as necessary by university administrations, the manner in which this problem has been addressed at the University of Queensland has sown the seeds of long-term distrust and insecurity, one effect of which is to inhibit the expression of dissent.

If reductions are to be made it is essential that established transparent processes, which include open consultation, be followed. In the case of the University of Queensland, a new Head of the Physics Department was appointed from the beginning of this year and although the person concerned was an appropriate appointee, the long-established processes of open departmental consultation were not followed by the Vice Chancellor.

In addition, again without open consultation or review, five members of the tenured staff in the general area of Laser Physics were told that their positions would be continued while eleven tenured academic staff members were told that they could apply for six full-time positions or their equivalent which would be advertised within the university – the unsuccessful applicants would be offered “voluntary” termination packages. A selection committee was established to consider applications for three senior positions, but before it met, the new Head of Department issued a list of teaching duties for 1997 which already omitted the names of some whose appointments were subsequently terminated. This must cast grave doubt on the integrity of the process.

Having spent most of our working lives in the University of Queensland we wish to see the Department prosper. A major concern is that able scientists will be reluctant to apply for either staff positions of Fellowships unless they believe that the University has well-understood and acceptable procedures which are consistently applied in all matters relating to appointments.

RW Parsons
Head 1971-78
Deputy Vice-Chancellor 1986-90

FD Stacey
Head 1979-81

JD Whitehead
Head 1982-89
EXECUTIVE SUMMARY

1 A coherent national policy for universities needs to be established and enunciated.

2 This policy needs to recognize and reaffirm the importance of the basic sciences and mathematics, within the teaching programs of all our universities.

3 There needs to be a redirection of resources within the University System in order to maintain the strength of those technological disciplines on which Australia's future competitiveness depends.

4 Funding for research in universities needs to be increased to allow them to maintain internationally recognized quality research programs.

5 Mechanisms need to be established to allow entry of our brightest young people to continuing academic careers.

6 Incentives and rewards need to be developed to attract bright graduates into the secondary teaching profession especially in the science and mathematics areas.

7 The private sector must be encouraged to contribute to the support of university programs of teaching and research.

The Australian Institute of Physics is the primary professional society that represents physicists in Australia. Its membership of approx. 2500 includes academics, scientists in public and private research organisations and industry, and some secondary teachers.

The AIP is vitally interested in promoting and enhancing the contributions that science and technology, and in particular physics, can and must make in the national interest. We view with great concern recent trends in secondary education, university funding and policy decisions, and other developments which are harming Australia's capacity to develop a high technology based economy able to compete with the technology based economies of East Asia and the rest of the World.

We welcome the establishment of the Review of Higher Education Financing and Policy, and the opportunity to make this submission. While we often refer specifically to the discipline of Physics, it should be understood that most of our recommendations refer to science and technology as a whole.

The AIP wishes to stress the importance of a good university system to a prosperous, equitable and harmonious society. An educated and rational society is not something we can take for granted.

Universities exist and are supported by the government and the community to serve a number of roles:
- Through research and scholarship, to create, develop and apply new knowledge.

Submission on behalf of the Australian Institute of Physics by Professor Jaan Oitmaa, PhD, DSc, FAIP, President, AIP.
email aip@phys.unsw.edu.au
To maintain our society's base of existing knowledge and understanding in the major disciplinary areas, so that it is able to respond promptly and appropriately to new discoveries and developments.

- Through their teaching programs, to produce a body of highly educated citizens who are able to assume the positions of leadership and responsibility in society and in the professions.

- Through their higher level teaching and research training programs to produce graduates needed for the essential research and development programs of both the private and public sectors.

- To maintain and enhance Australia's contribution to the international research effort, to maintain an awareness of international developments, and to retain a credibility and acceptance in the international scene.

- While Universities need to embrace the best quality and management practices they cannot and should not be seen simply as corporations to produce and market a product at lowest cost.

Universities in Crisis

Australia's system of Universities has undergone massive upheaval during the last decade and the rate of structural change is, if anything, increasing.

The initial “Dawkins” restructuring was driven mainly, it seems, by a philosophy to equalise all universities and to make them accessible to a large proportion of the nation's youth. Current restructuring is driven largely by government budget cutbacks.

There is a lack of a coherent national policy for universities. Each institution is reacting to market forces in order to establish its own profile. This has led to proliferation of courses. The system cannot be allowed to develop with student preference as the sole criteria for determining the course mix of universities. Such a system tends to proliferate intellectually less demanding courses at the expense of science and engineering, without any consideration of the needs for strong and viable departments offering disciplines such as physics.

We would submit that, in the national interest, there needs to be a redirection of resources and priorities to those fundamental disciplines which educate students in the broadest sense and to the high level professions. This requires leadership from governments, both at the federal and state levels.

Over the last five years, because of reducing budgets, Physics Departments in Australian Universities have found themselves in situations where 90% or more of their income is committed to salaries. This means that it has become impossible to maintain essential research equipment, much less allow for updating or development of new programs. Postgraduate research students cannot be adequately supported from recurrent funds but must depend on support through ARC and other external research grants.

Recent surveys have shown that over the 1996-1997 period Physics Departments in the 19 “pre Dawkins” Universities have lost, or will lose, 30-40 academic staff positions and a comparable number of support staff. This represents a loss of about 12%, whereas the student load taught has remained essentially constant. Further massive staff losses appear inevitable in view of salary increases through current enterprise bargaining. The situation in newer universities is similarly grave.

Because of budget pressures on Universities, Vice-Chancellors are looking to cut programs in expensive areas of relatively low student demand. Thus at least one University (Ballarat) has closed its Physics Department and in at least 6-8 others threats of closure have occurred and have resulted in amalgamations and staff losses. The AIP views with alarm the prospect that, in the near future, students will be unable to take even an undergraduate Physics degree in many of our Universities.

Funding Mechanisms  
Level and Priorities

It seems likely that the present mix of funding, from government, HECS and overseas student fees will remain and will largely determine the total budget available to higher education. It also seems likely that, even with the possibility of some local full fee students, the overall level of funding will not increase substantially.

In these circumstances there is a need to review the whole basis of government funding to Universities. The “DEET Funding Formula” has been adopted almost universally down to departmental level. There is little possibility in the present system, of any department arguing for “preferred status” on the basis of superior performance and hence none of our Universities, despite the rhetoric, is able to be considered in the top band of international institutions of higher learning.

The AIP strongly supports the principle that all subjects in Universities should be taught by experts in the discipline. The current funding mechanisms within institutions work against this. For example an Engineering Faculty can increase its student load and funding by either reducing or taking over the basic science and mathematics components of its programs. This is not in the best interests of either the students or the community.

The AIP supports policies which encourage universities to concentrate their teaching and research in areas in which they can demonstrate strength and quality. Only the largest universities would be expected to maintain a broad range of research disciplines and a broad range of research within a particular discipline. The AIP also supports any moves by Universities in a given city or region to share resources and cooperate in teaching and research programs where this will lead to evident benefits.

Research & Funding and Careers

There have been a number of recent reviews of research funding and the lack of career paths for young researchers, for example, “Waiting in the Wings: A Study of Early Career Academic Researchers in Australia” (ARC/NBEET Report N>
50, Sept 1996). Some of the salient facts are:

The success rate for new grants from the ARC and NH&MRC programs is of order 20%. There is much top class research that is not getting funded.

There are a large number of outstanding young researchers employed in Universities on "soft money", i.e. fixed term research grants with uncertain renewal.

The decline in real funding levels per student in universities, together with the abolition of age retirement, has meant that there are virtually no job prospects for these people in the academic sector.

There is an urgent need for a regular inflow of young people into University academic positions to maintain the vitality and vigour of departments and to provide staff closer in age to undergraduate students. This is also the bottleneck preventing the recruitment of more female staff in science departments. In the UK this problem was addressed some 15 years ago with "new blood lectureships".

### The Secondary School Problem

The Minister for Science and Technology, has declared that Australia "needs more scientists, technologists and engineers and fewer accountants, doctors and lawyers". Yet fewer students in years 11 and 12 of high school are studying the more rigorous science subjects and fewer of our brightest students are choosing to study these subjects at Universities.

There are many factors which contribute to this:

- A scarcity of well trained science teachers with adequate knowledge of the discipline base.
- A perception by students, following on from this, that science is hard, uninteresting and largely consists of unconnected facts.
- Lack of societal recognition and adequate remuneration for scientists and technologists.
- Inadequate information to employers of the skills of science graduates and lack of a tradition in Australia of employing science graduates in non laboratory positions.

### Turning Things Around

**Recommendations and Suggestions**

The Executive of the Australian Institute of Physics has presented, in the material above, a brief summary of its views on a number of aspects of Australia's higher education system. We would raise for consideration the following recommendations/suggestions:

- The role of Universities needs to be enunciated, including an indication of which disciplines and courses should be encompassed and which are more appropriately assigned to the VET/TAFE sector;
- The Review should examine whether Australia's population can support the present number of universities, each seeking to encompass most major fields;
- Australia needs universities which offer strong programs in the fundamental sciences and humanities as well as those professions requiring an intellectual research base. The funding formula for these institutions needs to include more than just student numbers.
- Incentives should be provided to the private sector to contribute to the support of universities, eg by establishment of endowed chairs, joint research programs, etc.
- Programs need to be developed to ensure a continuing inflow of young people into academic careers to maintain the vigour of Universities and to improve the gender balance.
- Incentives and rewards need to be developed to encourage bright science and mathematics graduates to enter the secondary teaching system.
- Government support of research and research infrastructure needs to be maintained at or near the best OECD levels.

### THIS MONTH'S FRONT COVER

The Australian Nuclear Association is hosting two major nuclear conferences in Sydney in October 1997 (see front cover).

**The Second International Conference on Isotopes 2IC1**, with the theme "Isotopes for Industry, Health and a Better Environment" will be held at the Hyatt Regency Sydney from 12-16 October. It will be co-sponsored by the IAEA, American Nuclear Society, European Nuclear Society and many nuclear societies overseas. The technical sessions are on 13-15 October and optional local technical visits on 16 October. The five main session topics are: production and applications of isotopes for nuclear medicine; environmental applications of isotopes; industrial applications of isotopes; research applications of isotopes; and applications and safety of radiation.

**The Second Conference on Nuclear Science and Engineering in Australia, ANA 97**, will be at the Hyatt Regency Sydney on 16-17 October. It is co-sponsored by ANSTO Australasian Radiation Protection Society, Australia & New Zealand Society of Nuclear Medicine, AINSE, Nuclear Panel of The Institution of Engineers, Australia, CSIRO Minerals Division, and the Uranium Information Centre. Poster papers are invited and abstracts must be sent to the address below by 30 June.

For brochures contact

Mrs M Lanigan
Conference Manager
PO Box 505
Crows Nest NSW 2066

Tel 02 9437 4879
Fax 02 9439 6561

The deadline for early registration for 2IC1 and ANA97 is 1 August.
The Budget for Science

On first view, S&T based portfolios had done pretty well in the 1997–1998 budget. It had managed to avoid any further big cuts, and some even suggested that it was “steady as she goes”. But with the release of supplementary papers, the real position of the Budget is becoming clear. “Steady as she sinks!” – Ian Lowe’s description might be more appropriate, particularly if one looks at the Forward Estimates.

Nothing the Treasurer said on Budget night indicates that the Government has accepted the role of S&T in solving major economic and environmental challenges facing Australia. Not once in his speech did he use the words “science”, “technology”, “education” or “innovation”.

The Prime Minister has made some strongly supportive speeches in recognition of the value of research in Australia’s development objectives, and Peter McGauran has been obviously successful in protecting factors in his own budget sector against big cuts but when one looks across the major portfolios dependent on S&T, the future is not secure. We are still waiting for a clear articulation of the role of S&T in Australia’s future.

The Budget, on close analysis, recorded a steady chipping away at funds available for S&T, with the Science and Technology Budget Statement showing an overall reduction in real terms of 1.3 per cent. The CRCs have been cut, the universities have had further reductions to their operating grants, CSIRO has been hit with an “efficiency dividend”. This has been offset to some extent by small increases to ARC and the NH&MRDC, funded for rural R&D, and targeted Higher Education and Research.

The Australian Geological Survey Organisation has been cut, as has Defence Science. The Energy R&D Corporation has quietly been abolished, a move which should have attracted more industry comment than it did. The worst news is reserved for the Forward Estimates. These figures set out the Government’s long-term intentions, and they show reductions in all areas.

Australia plans to enter the new millennium spending less on CSIRO, less on the ARC and NH&MRC, less on the CRCs and international and other research. In some cases these estimated cuts are massive. In health research, current spending of $174 million is projected to be cut to $131 million in 2000-2001.

The challenge that now emerges is for industry, the education sector, scientists and technologists and society as a whole to convince Government – within this next 12 months – that there must be justifiable increases in the S&T Budget.

The argument has to be taken more widely than Minister McGauran and the portfolio of Industry, Science and Tourism, to the other portfolios directly dependent on science and technology based knowledge.

Careers in Research

Minister Peter McGauran has agreed to launch the proceedings of the Careers Forum which FASTS and the NTEU hosted at the National Press Club. The booklet will contain the speeches delivered at the Forum and recommendations for future action. We plan to make this an occasion for the Minister to sit down with some of the young scientists finding it difficult to establish worthwhile careers in research. A copy of the proceedings will be mailed out to all Forum registrants.

PMSEC

The PM demonstrated genuine enthusiasm for the PMSEC meeting last week. He expressed his interest both publicly and privately, and said at lunch that he had gained a new appreciation of the long time it takes for research to come to fruition. Major topics on the agenda were the telecommunications revolution, skin cancer and the Great Barrier Reef. There was also a Ministerial response by John Anderson and Robert Hill to the recommendations from last year’s session “Managing Australia’s inland waterways” and on S&T teaching in primary schools.

I attended the meeting as FASTS President, as one of the six ex officio members. FASTS is consulted about possible topics, and Member Societies should forward suggestions to the FASTS office.

Council on November 20

The Minister, Shadow Minister and Democrat spokesperson have all expressed interest in addressing FASTS Council in Canberra on November 20. All Member Societies are invited to send representatives and to contribute to the makeup of FASTS “Top Ten Policies” for 1998. The Chief Scientist will also be in attendance.

Enrofloxacin and the Minister for Health

I have written to Dr Michael Wooldridge to express the concerns of the Australian Society for Microbiology about moves to use enrofloxacin as a growth promoter in the chicken industry. This has significant implications for human health and the use of enrofloxacin in this way could render ineffective those drugs used in the standard treatment of serious complications of salmonellosis (such as blood poisoning) in humans. The matter is currently before the National Registration Authority. The FASTS’ Board expressed concern that the NRA may not be giving adequate consideration to the expert scientific advice being offered by the ASM and other authoritative bodies which have the expertise to advise Government on this issue.

Science Bodies Compare Notes

Top administrative figures from nine S&T organisations met this month at their regular quarterly meetings hosted by FASTS. The discussions bring together representatives from groups like the Deans of Science, the CRCs Association, the AV-CC and CSIRO.

A major discussion point was the proposal from Australian Science Communicators that science organisations should combine to run a new showcase for science, aimed at bringing the best Australian science to public attention through the media. The event would be part of National Science Week in May 1998. Discussions are continuing.

Mail from the Ministers

Minister John Moore wrote to advise FASTS of PIP, the watered-down successor to the Factor (D) scheme. Minister McGauran sent the proposed scope of the marine S&T plan for Australia and invited comment. He also invited scientists from non-English speaking backgrounds to register for possible appointment to Government bodies.
DISCOVERY OF AN ELECTROMAGNETIC MOMENT VIOLATING FUNDAMENTAL SYMMETRIES
The Nuclear Anapole Moment

VICTOR FLAMBAUM AND DOUGLAS MURRAY

A nuclear anapole moment - an electromagnetic multipole violating parity and charge conjugation invariance - has recently been observed. We describe the anapole moment and how it can be produced. The anapole moment creates a circular magnetic field inside the nucleus. The interesting point is that measurements of the anapole allow one to study parity violation inside the nucleus in atomic experiments. We use the experimental result for the nuclear anapole moment of $^{133}$Cs to find the strength of the parity violating proton-nucleus and meson-nucleon forces.

### Description of the Anapole Moment

The notion of the anapole moment was introduced by Zel'dovich [1] just after the discovery of parity violation. He noted that a particle may have a parity violating electromagnetic form factor, in addition to the usual electric and magnetic form factors. The first realistic example, the anapole moment of the nucleus, was considered in Ref [2] and calculated in Ref [3]. In these works it was also demonstrated that atomic and molecular experiments could detect anapole moments. Subsequently, a number of experiments were performed in Paris, Boulder, Oxford, and Seattle [4] and some limits on the magnitude of the anapole moment were established. However, it was not until recently that a nuclear anapole moment has been unambiguously detected - this year a group in Boulder detected a nuclear anapole moment in $^{133}$Cs (using atomic experiments) to an accuracy of 14% [5]. The leader of this group, C Wieman, is already famous for his experimental discovery of Bose-Einstein condensation in an atomic gas.

Multipole moments arise from expansions of the electrostatic and vector potentials as a series in $R^{-1}$, where R is the distance from the centre of the charge distribution. Examples of multipole moments which obey the three discrete symmetries of charge conjugation invariance, parity conservation and time reversal invariance (C, P and T) are the electric monopole (ie, charge), magnetic dipole, electric quadrupole and magnetic octupole moments. There are also multipole moments which violate both parity conservation and time reversal invariance, ie, they are both P- and T-odd. These moments are the magnetic monopole, electric dipole, magnetic quadrupole, electric octupole, and so on.

There are also other electromagnetic multipole moments, which are not usually dealt with in multipole moment expansions as they give rise to contact, rather than long-range, potentials. The anapole moment is such a moment. It obeys time reversal invariance but violates parity conservation and charge conjugation invariance (ie, T-even and P- and C-odd).

We will show how the anapole moment arises out of an expansion of the vector potential - the following is based on Refs [6,7]. Consider the usual expression for the vector potential in terms of the current distribution, $j(r)$

$$ A(r) = \int \frac{j(r')}{|R-r'|} d^3 r' $$

When we expand this as a series in $R^{-1}$ the first term that we get is the vector potential of the "normal" (ie, T, P-even) magnetic dipole moment. The second order term is $

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A current circle that produces an anapole moment.

\[ A^{(2)}(R) = \frac{1}{2} \int j(r) r_m r_n d^3r \sqrt{\frac{1}{R}} \]

Since \( j_m r_n \) is a reducible tensor (its trace is not zero) the vector potential contains two irreducible contributions, that of the \( T \) even magnetic quadrupole moment and that of the \( T \) odd, \( P \) odd anapole moment. The vector potential due to the anapole moment is

\[ A^a(r) = a \delta(r) \]

where

\[ a = -\pi \int r^2 j(r) d^3r \]

can be taken as the definition of the anapole moment. The \( \delta(r) \) is a result of \( \partial_r \partial_r (1/R) = -4\pi \delta(r) \). Note that even though the anapole moment vector arises in the second order of the vector potential expansion, it is a rank one tensor. Notice the contact form of the potential – this is true for any \( T \) even, \( P \) odd moment; see, eg., [2,7] for a proof.

Now to see what an anapole moment actually looks like, we have to find what kind of a current distribution can give a non-zero value in Eq (4). Let’s begin by considering a current distribution comprising of current going around a single circular loop. A current circle whose centre is the origin would give a zero value in Eq (4) since the value of \( r \) is constant for this circle and so all the currents from different parts of the circle will cancel each other out. It turns out that for a current circle to give a non-zero value of the anapole moment it must be displaced from the origin, with the normal to the plane of the circle being at right angles to its displacement, Fig 1.

The current distribution in Fig 1 will give an upward pointing anapole moment, as the side of the circle with the downward going current is further from the origin (and so has larger values of \( r^2 \)) and so it dominates in Eq (4); note the negative sign in the equation. If we take many of these current circles and connect them together so that the current flows through them all continuously we get a current distribution as in Fig 2, i.e., a toroidal solenoid. (This is the same current distribution as in a tokamak.) The anapole moment corresponding to this current distribution points in the upward direction. A magnetic field is produced inside the current distribution, as shown in the figure.

The expression for the anapole moment (4) contains the current vector \( j \), which changes its sign under reflection of co-ordinates (when \( r \to -r \), \( j \to -j \)). According to the Wigner-Eckart theorem the anapole moment vector must be directed along the nuclear spin \( \hat{I} = -\pi \langle r^2 j \rangle = a \hat{I} \). However, the spin \( \hat{I} \) does not change its sign under co-ordinate reflection (similarly to the orbital angular momentum \( \hat{L} = r \times \hat{p} \)). The different behaviour of the right and left hand sides of the relation \( \langle r^2 j \rangle = a \hat{I} \) under reflection of co-ordinates means that the existence of the anapole moment violates parity, i.e., symmetry under the reflection of co-ordinates (but it does not violate time reversal invariance).

How An Anapole Moment Can Be Produced

Now that we have seen what an anapole moment is, we turn to the question of how such a thing can be produced. A \( T \) even, \( P \) odd object like the anapole can only arise if there is some kind of \( P \) odd force present; for this the weak interaction is needed. The potential for the \( P \) odd weak interaction between

\[ a \]

The anapole moment, \( a \), the toroidal current that produces it, \( j \), and the magnetic field that the current creates, \( H \).
The spin helix that occurs due to the parity violating nucleon-nucleon interaction. The degree of spin rotation is proportional to the distance from the origin and the strength of the weak interaction.

A valence (ie unpaired) nucleon and the nuclear core can be written as

$$\hat{W} = \frac{G}{2\sqrt{2m}} \left[ \sigma \cdot \mathbf{p} \rho(r) + \rho(r) \cdot \mathbf{a} \right]$$

where $G = 1.0 \times 10^{-5} m_e^2$ is the Fermi constant of the weak interaction, $m$, $p$ and $\sigma$ are the mass, momentum and twice the spin of the unpaired nucleon, $\rho(r)$ is the number density of core nucleons, and $g$ is a dimensionless strength constant. For the $^{133}$Cs atom the unpaired nucleon is a proton and so $g = g_p$.

This interaction perturbs the wave function of the unpaired nucleon, resulting in the mixing of opposite parity states $\psi = \psi_0 + \delta \psi$, where $\psi_0 \equiv |0\rangle$ is the unperturbed wave function and $\delta \psi = \sum_{n} n'|\psi_0\rangle (E_n - E_0) |\psi_n\rangle$. An approximate analytical solution for the perturbed Schroedinger equation $\left(\hat{H}_0 + \hat{W}\right)\psi = E\psi$ (which assumes that the nuclear density is constant) gives (see, eg, [3])

$$\psi = e^{i\hat{a} \cdot \mathbf{r}} \psi_0$$

where $\hat{a} = -\frac{gG}{\sqrt{2}} \mathbf{r}$. What this means is that the spin ($\sigma = \frac{1}{2}\gamma$) of the unperturbed wave function will be rotated around the vector $\mathbf{r}$ by an angle of $2\gamma r$. If, for example, the unperturbed wave function was in a spin up state, the spin at different points for the perturbed wave function will be as shown in Fig 3. Thus we have a spin helix, with a definite chirality, i.e. right- or left-handedness. This means that the particle symmetry has been broken. Let’s see what the current and magnetic field produced by such a spin helix are.

The electromagnetic current of the unpaired nucleon can be written as

$$\mathbf{j} = -\frac{ie}{2m} \left( \psi^* \nabla \psi - (\nabla \psi^*) \psi \right) + \frac{g_\mu}{2m} \nabla \times (\psi^* \sigma \psi)$$

where $g = 0(1)$ for a neutron (proton) and $\mu$ is the nucleon magnetic moment in nuclear magnetons.

The first term comes from the orbital motion of the nucleon, while the second term is a magnetic moment current term, which produces the dominating contribution. The current distribution and the magnetic field produced by the wave function $\psi$ of Eq (6) have been calculated in Ref [8]. Cross-sections of these are shown in Figs 4 and 5. Note their toroidal shapes; this means that they will produce an anapole moment.

Using the expression for the electromagnetic current (7) in Eq (4), the operator of the anapole moment $\mathbf{a}$ ($a = \langle \psi | \mathbf{a} | \psi \rangle$) can be written as

$$\mathbf{a} = \frac{\pi e}{m} \left[ \mu (\mathbf{r} \times \sigma) - \frac{g}{\beta} (\mathbf{p}^2 + r^2 \mathbf{p}) \right]$$

where $r$ and $p$ are the position and momentum operators of the nucleon. The dominant contribution to the nuclear anapole comes from the first, spin term and so we can express the anapole moment operator in terms of the magnetic dipole moment operator

$$\mathbf{a} = \frac{1}{e} \frac{G}{\sqrt{2}} \frac{K}{I(I+1)} \kappa_a$$

where $K = (I + \frac{1}{2}) (I + \frac{3}{2})$ ($I$ is the orbital angular momentum of the external nucleon) and $e$ is the electric charge of the proton. Note that the anapole moment is directed along the nuclear spin, $\mathbf{I}$.

A cross-section (in the $x - z$ plane) of the current distribution due to the spin helix (the anapole moment points along the $z$ direction).
Nuclear Anapole Moment

Calculations of $\kappa_a$ in terms of $g_p$ have been done in Refs [3,9-13]. In Ref [3] an approximate analytical formula was obtained by using the wave function (6) to calculate the mean value of the anapole moment operator (8). The result is

$$\kappa_a = \frac{9}{10} \frac{\alpha \mu}{m r_0} A^{2/3} g_p = 0.08 g_p$$

(for the mass number, $A = 133$), where $\alpha = 1/137$ and $r_0 = 1.2fm$ is the internucleon distance. The most complete numerical calculation, which takes into account many-body corrections, was done in [13] with the result

$$\kappa_a = 0.05 (g_p - 0.05).$$

The Detection of the Nuclear Anapole in Atomic Experiments

The nuclear anapole moment interacts with an atom's electrons due to its magnetic field. The interaction is [using Eqs (3) and (9)]

$$V_\alpha = e \alpha \cdot A = e \alpha \cdot \vec{a}(\vec{r}) = \frac{G M}{\sqrt{2}} \frac{K \cdot \alpha}{I(I+1)} \kappa_a \delta(\vec{r}),$$

where $A$ is the anapole vector-potential and $\alpha$ is the relativistic velocity operator (Dirac matrices).

The anapole moment can be detected by observing transitions between atomic levels that violate parity. In the case of the Boulder experiment [5], it was an electric dipole (E1) transition between the $6S$ and $7S$ states of the cesium atom. The problem is that the anapole moment is just one small $P$-odd effect and there are other parity violating effects present, such as that caused by the weak interaction between the atomic electron and the weak charge of the nucleus (due to Z-boson exchange). To solve this problem we can use the fact that the nuclear anapole moment's interaction with an atomic electron depends on the nuclear spin $I$ [see Eq (12)] unlike the other effects (in fact, there are $P$-odd effects that do depend on the nuclear spin, but they are small compared to the anapole moment, and can easily be taken into account). The nuclear spin has different relative orientations in the different hyperfine states $F=3$ and $F=4$, where $F$ is the total angular momentum of the atom ($F = \text{j}_e + \text{l}$, where $\text{j}_e$ is the electron's angular momentum). Therefore, if instead of observing just a $6S \rightarrow 7S$ transition, we resolve the hyperfine structure of the atomic levels and observe the two different hyperfine transitions $6S_{F=3} \rightarrow 7S_{F=3}$ and $6S_{F=3} \rightarrow 7S_{F=4}$, we should be able to see the effect of the anapole moment. This is what was done in the Boulder experiment [5], with the following result:

$$\text{Im}(\beta_{\text{E1,pc}}) = \frac{1.6349(80) \text{ mV/cm}}{1.5570(77) \text{ mV/cm}} \rightarrow \kappa_a = 0.364(62).$$

The Strength of the Parity Violating Nuclear Forces Derived from the Anapole Measurement

Using the estimate of $\kappa_a$ and Eq (11) we can obtain an estimate for $g_p$, the dimensionless strength constant for the parity violating interaction of an unpaired proton with the nuclear core:

$$g_p = 7.3 \pm 1.2 \text{(exp.)} \pm 1.5 \text{(theor.)}.$$"
superscript indicates whether it is an isoscalar, isovector or isotensor interaction (0, 1, or 2). As stated in the recent review [21] the \( p \) and \( \omega \) constants (ic, the \( h_p \)'s and \( h_\omega \)'s) are well known and can be taken to be those values listed as the 'best' values in [20]. However there is uncertainty about the value of \( f_p \). Using our estimate of \( g_p \) from [20], the above equation and the 'best' values of the \( h_p \)'s and \( h_\omega \)'s we can obtain an estimate of \( f_p \):

\[
(17) \quad f_p = h_\omega^2 \approx [9.5 \pm 2.1 \text{ (exp.)} \pm 3.5 \text{ (theor.)}] \times 10^{-7}.
\]

Now we will compare this estimate of \( f_p \) with other estimates in the literature. This seems to be in contradiction with the limit on \( f_p \) derived from a \(^{133}\)PNC measurement: \( |f_p| < 1.3 \times 10^{-3} \) (see, eg, the review [22]), but note that \(^{133}\PNC\) is a nonspherical nucleus with a complex shape and this makes the interpretation of the experiment complicated. The above result (17) does agree with QCD calculations of \( f_p \) which give \( f_p \approx 0.5 - 6 \times 10^{-7} \) [23,24]. It is also in agreement with the 'best' value of \( f_p \) in Ref [20]: \( f_p = 4.6 \times 10^{-7} \).

Analyses of nucleon weak interactions, based on the experiment [5], have been done in [25,26].

Conclusions

The observation of a nuclear anapole moment in \(^{133}\)Cs is the first observation of an electromagnetic moment that violates fundamental discrete symmetries. The atomic experiments in which this was measured have allowed accurate determinations of the strengths of the nucleon-nucleus and \( \pi \)-meson-nucleon parity violating weak interactions.

Acknowledgement

We wish to thank Cathy Faust for preparing our figures.

References

1 Ya B Ze'ldovich, Zh Eksp Teor Fiz 33 (1957) 1531 [Sov Phys JETP 6, (1958) 1184]. (This reference also contains a mention of analogous results found by V.G. Vaks.)


PH.D. GRADUATE STUDENTS WANTED

EXPRESSIONS OF INTEREST are invited for PhD graduate student positions working in the following fields of physics: Structure Determination of Nano-sized Particles; Theoretical Particle Physics involving Higher Twist Calculations; Dielectrophoresis; Impedance Imaging. Students interested in enrolling for the PhD degree in 1998 should write to the address below giving some information about their background, their qualifications and their specific interests. Full applications will then be invited as results of these enquiries.

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Further information can be obtained from Professor Paul Callaghan, Department of Physics, Massey University, Palmerston North, New Zealand, Fax 64-6-3540207 (e-mail pcallaghan@massey.ac.nz) or from our web site (http://www.massey.ac.nz/~wphysics).

EXPRESSIONS OF INTEREST along with accompanying information should be sent to Professor Callaghan, by 30 August 1997.

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ANAPOLE MOMENT

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Uniform Light Sources

LabSphere, the world's leader in integrating sphere and diffuse reflectance technology, have now extended their wide range of uniform source systems. Used as radiometric standards, their product line has grown from standard white light sources to include high-intensity, color and sensitometer sources. System hardware and software designed to support applications in remote sensing, electronic imaging and thermal imaging.

Integrating sphere uniform light sources provide perfectly uniform, high-intensity illumination for imager calibration. Large aperture uniform sources are standard equipment for calibrating aerospace remote sensing radiometers and imagers. Smaller aperture sources provide illumination for correcting CCD camera response, back illumination in film digitizers and for front illumination in document scanners.

Warsash Pty Ltd is the sole Australasian Distributors of the Laser Raman Microscope and Imaging Systems of the Transducer Division of Renshaw plc, are pleased to announce that Renshaw has been granted key patents for its technology by the European and US Patent Offices.

European Patent No. 0543578 and US Patent No 5,442,438 relate to Renshaw's use of a holographic filter at a lower angle of incidence as a beamsplitter. This has the dual purposes of injecting the illuminating laser light into the optical path, and rejecting scattered light of the laser wavelength from the resulting Raman spectrum.

Professor David Pitt, Managing Director of Renshaw's Transducer Systems Division, commented: "The patented holographic filter arrangement is a result of the collaboration over several years between

Melcor Introduces Two New Product Lines

High Temperature Thermoelectric Modules for Cooling and Power Generation

MELCOR introduces a new family of thermoelectric coolers (TEC), designed for high temperature cooling, packaging or power generation applications operating at up to 200°C and greater. Designed specifically for cooling applications requiring higher...

ThermaTEC High-Temperature Thermoelectric Cooler from Melcor.
PRODUCT NEWS

temperature operating and assembly conditions, the TermatEC™ modules feature a patent-pending process that offers reliable performance in the most demanding thermal conditions. By expanding the operating range to temperatures above 200°C, ThermaTEC is targeting cooling applications in biomedical equipment, calibration instruments, high-temperature electro-optic packaging, temperature-sensitive microprocessors and electronics operating in harsh thermal environments. The expanded operating temperature range of ThermaTEC increases the power-generating potential for thermoelectric products.

The first in the series, the HT-16-12-40, has a heat-pumping capacity of 52 watts, with 14.4 volt and 6.0 amp max values.

MELCOR Thermoelectric coolers are solid-state heat pumps that utilise the Peltier effect to provide cooling (or heating), and the Seebeck effect for power generation. Features include reliable solid-state operation, precision temperature control capability, no acoustical/electrical noise and DC operation.

Moisture-Resistant Thermoelectric Coolers for Use in Condensing Environments

MELCOR, the pioneer and world's leading manufacturer of thermoelectric cooling devices, offers its most popular thermoelectric coolers (TECs) with a perimeter seal to protect them from the damaging effects of wet applications and condensation.

The SealTEC™ Series of thermoelectric coolers provides maximum protection from water condensation that often occurs when operating at or below the dew point or in humid conditions. The SealTEC™ barrier prevents water or gases from contacting the thermoelectric elements and electrical conductors, eliminating corrosion, thermal and electrical shorts. It is also an effective barrier for foam-in-place insulation techniques.

Thermoelectric devices are solid state heat pumps that utilise the Peltier effect to provide cooling (or heating). Features include reliable solid-state operation, precision temperature control capability, no acoustical/electrical noise, DC operation, and long life (in excess of 200,000 hours).

For more information on the MELCOR ThermaTEC series of thermoelectric coolers for high temperature applications or SealTEC™ thermo-electric coolers, contact Graeme Jones at Lastek Pty Ltd

Tel (08) 8443 8668
Fax (08) 8443 8427 or email lastek@saschools.edu.au

MELCOR Introduces Low-Cost Thermoelectric Cooler for High Volume Commercial Applications

MELCOR introduces a new family of thermoelectric coolers (TEC), designed specifically for consumer products and other low-cost, high-volume applications and priced up to 20% less than comparable TECs.

Targeted specifically for consumer products such as the portable cool box, beverage can coolers, water coolers and small refrigerators, the PolarTEC™ modules feature strong, porch style lead wire attachments and the lowest prices, ever. The series includes both PolarTEC versions of our most popular TECs, covering a full range of size, power and heat pumping needs.

The first in the series, the PT-16-12-40, has a heat-pumping capacity of 52 watts, with 14.4 volt and 6.0 amp max values. Other PolarTEC versions of our most popular TECs are planned for subsequent releases.

MELCOR Thermoelectric coolers are solid-state heat pumps that utilise the Peltier effect to provide cooling (or heating). Features include reliable solid-state operation, precision temperature control capability, no acoustical/electrical noise and DC operation.

For more information contact Graeme Jones at Lastek on Tel (08) 8443 8668 Fax (08) 8443 8427 or email lastek@saschools.edu.au

Fixed Imaging Compact Spectrographs

Looking for compact, economical, efficient spectrographs? Oriel's FICS™ - Fixed Imaging Compact Spectrographs - family of four, all with ion-etched holographic concave gratings, is the answer.

Oriel's FICS™ family provides spectral resolution with precise imaging of the input slit in the flat output field. Each spectrograph features a corrected output focal plane that is between 23.3 and 25.6mm long in the spectral direction, depending on the model you choose. Each FICS™ has a focal plane matched to Oriel's popular InstaSpec™ ICDD, CCD, and PDA Multichannel Detection Systems.

If you need efficiency, you'll find it in the FICS family, large concave gratings mean high throughput. This large grating design gives you highly efficient 1/2, 1/4, 1/8, or 1/16 optical performance. The low f/# was chosen as a close match to the ca. f/2.2 emergent cone from fused silica fibres. No f/# matching is required to prevent overspill, and the fibre ends can act as the input slit.

For more information contact Lastek Pty Ltd at Tel (08) 8443 8668 Fax (08) 8443 8427

90 Australian & New Zealand Physicist Volume 34, Number 5/6, May/June 1997

CG-7 RGB Colour Framegrabber

Scion Corporation announces a scientific RGB colour frame grabber for the PCI bus - the CG-7. The CG-7 will provide optimum performance and resolution with three chip CCD RGB output cameras. The CG-7 will work in either Macintosh or Pentium PCI computers and will feature:

- Three independent digitisation channels
- Real-time video display on the computer monitor in 24-bit colour, for scientists who do not want or need an external monitor,
- RGB output for connection to external monitors or video printers

- High resolution capture mode, achieved through horizontal over sampling and vertical interpolation to create 1280 x 960 (NTSC) or 1536 x 1152 (PAL) images.
- NTSC or PAL compatible, with resolutions of 640 x 480 or 768 x 576,
- Two RS-232 serial ports, eight digital I/O lines and two analog outputs to provide flexibility for external device control.
- External trigger and integration support through NIH Image and Scion Image for both Mac and PC.
- Independent digitisers provide for excellent performance for grayscale and dual camera applications.

Scion Corporation develops, manufactures, and markets a complete line of grayscale and color video frame grabbers and compatible image acquisition software for scientific imaging and inspection.

For more information contact Graeme Jones at Lastek Pty Ltd Tel (08) 8443 8668 Fax (08) 8443 8427 or email lastek@saschools.edu.au
OBITUARY

EDWARD NORMAN MASLEN

1935-1997

The communities of Australian and international physics and the community at large were shocked and saddened to learn of the death of Ted Maslen, who collapsed and died during a veteran's run on Sunday February 2nd. Ted, who was a Reader in Physics, was currently Head of the Physics Department at UWA.

He came to UWA and St George's College as a science student in 1952 with a general exhibition from his schooling at St Patrick's College in Geraldton, WA. Ted was a more than able student and took out the prize in Geology I in his first year going on to complete Honours in Physics, win a Hackett Scholarship and the Rhodes Scholarship and was awarded a DPhil from Oxford in 1960. In his student days Ted was very active on many fronts and was elected Guild President for 1957, he was a prime mover in the very successful student part of the appeal to raise funds to establish a Medical School in WA. During this period he achieved much public attention following a very serious infection with tetanus and the diversion of traffic around Royal Perth Hospital to remove sources of noise. Miraculously he survived and his Rhodes Scholarship was awarded – surely some power was watching over him at that time, maybe it was the prayers of his family and friends at a very moving service held in the Chapel at St George's College.

Ted was not only an academic but also for all his life a keen and competitive sportsman and athlete as well as being deeply committed in many community affairs. Always superbly fit, his day at work invariably ended with a run, often in company with members of his research group, who usually were left well behind. At university he rowed, ran and played cricket, he was a member of the 1965 WA Kings Cup crew, Secretary of the WA Amateur Rowing Association in 1964-65, President and Life Member of the UWA Athletic Club, member and Secretary of the WA Rhodes Scholarship Selection Committee, member of the St George's College Council and served for some fifteen years as an elected member of the South Perth City Council between 1976 and 1995. He was also an office bearer in fourteen professional bodies including the Australian National Committee for Crystallography, the Cancer Council of WA, the CSIRO State Committee and the International Union of Crystallography Executive. In 1997 he was to have become a co-editor of the international journal Crystallography Reviews. Always a supporter of the AIP and its functions Ted was a regular attendant at Branch meetings and served as WA Branch Chairman in 1968-69.

Ted studied for his DPhil from 1957-60 at St John's College, Oxford under the supervision of Dorothy Hodgkin, who subsequently won a Nobel Prize in Chemistry for work which included material produced then in collaboration with Ted. He returned as a staff member to the Physics Department in 1960 as a Lecturer and immediately set about reviving the X-ray crystallography group. In this he was highly successful, attracting many excellent postgraduate students and ultimately founding what is now the internationally important Crystallography Centre. He was instrumental in the university acquiring it's first computer, the IBM 1620, and subsequently the DEC PDP-6 which was reputedly the first time shared machine in the southern hemisphere.

Ted's crystallographers made extensive use of the neutron diffraction facilities at Lucas Heights and later of synchrotron radiation at the Photon Factory at Tsukuba in Japan as well as home based conventional X-ray sources. He supervised some forty postgraduate students and an inspection of the impressive list of titles of the 175 published articles bearing his name shows an interest in the structural and electron density distributions in a very wide range of materials ranging from proteins through to high temperature superconductors. His major interest was in the precise determination of electron density distributions. He and his group were the recipients of many major research grants from the ARC and other sources and he was co-organiser, chairman, invited speaker and participant in many international...
OBITUARY

conferences including the position of
Organising Chairman for the XIVth
International Union of Crystallography
Congress in Perth in 1987. Ted’s
outstanding scientific achievements
were acknowledged by his election in
1996 as a Fellow of the Australian
Academy of Science.

He held many important positions
within the University serving as an
elected member of the Professorial
board and then the Academic Board
for over fifteen years. He served on the
Research Committee and as member
and chairman of the Physical Sciences
Research Grants Sub-Committee and
as member of the Radiation Safety
Committee, from 1974 being Newell’s
class chairman from 1977 to the present.

Within the Physics Department Ted
always played a leading and creative
role in important decision making and
played a major part in the teaching of
Quantum Mechanics, Group Theory
and related topics to Third Year and
Honours. He was a fine teacher and a
discerning and friendly postgraduate
supervisor who was able to help his
students bring out the best in
themselves.

These are the facts of Ted’s life which
delineate his career and his enormous
level of activity in so many areas. They
hint at Ted the person who was so
respected and admired by all his
friends and colleagues as a vigorous
man of complete integrity and fairness.
Above all, we who knew him well,
will remember his absolute maximum
effort in everything he undertook -
there were never any half measures, it
was all or nothing for him and this is
reflected in his many successes and
achievements. With all these activities
Ted was very much a family person
and he devoted much time to his
family, of which he was so proud, and
the church.

Farewell Ted! We will no longer see
you in the evenings on your regular
run along the river from the University
to the brewery and back, before
hopping on your bike and pedalling
home that long way to Manning. We
who knew you will always remember
you for your manifold notable qualities
and friendship.

To Ted’s wife Sheila and his eight
children and to his brother and sister
Vic and Sue we extend our warmest
sympathy and our long lasting
memories of a wonderful colleague.

Severin Crisp
sev@albanyis.com.au AMZ

OF INTEREST

AUSTRALIAN JOURNAL OF PHYSICS
New Appointments

The AJP has appointed four new
members to its Editorial Board. They
are Neil Ashcroft (Cornell), Robert
Dewar (ANU), Ann Roberts
(Melbourne) and Peter Szekeres
(Adelaide). They replace Robert
Delbourgo (Tasmania), Bruce Liley
(Waikato) and Geoff Shute
(Melbourne), who have completed
their six-year terms.

Born in London in 1938, Neil Ashcroft
spent much of his early life in New
Zealand. Returning to England he
completed a doctorate at Cambridge
University in 1964 with a study on the
Fermi surface in a number of elements.
He then held a variety of positions
before being appointed Professor of
Physics at Cornell University, where
from 1979 to 1984, he was director of
the Laboratory of Atomic and Solid
State Physics. He has also been closely
involved with the Cornell High Energy
Synchrotron Source and since 1990 has
been its director.

Although he has remained permanently
at Cornell, Neil has held visiting
fellowships in a variety of
centres such as Cambridge,
Los Alamos, Brookhaven,
Grenoble, Christchurch,
including extended visits to
the University of New South
Wales and the Australian
National University. In 1991
he was a member of the
International Review Panel
of the Australian Research
Council. Throughout this
time he has published over
200 papers on a wide range
of topics in condensed matter
physics.

Neil Ashcroft is the recipient of
many honours. He has held
a number of positions with the
American Physical Society,
including chair of its division
of Condensed Matter Physics,
and has served as an editorial
board member of both the
‘Physical Review’ and
‘Journal of Physics
(Condensed Matter)

Robert Dewar graduated with an
MSc from the University of
Melbourne, sharing the
Kernot Scholarship, and then
commenced a PhD at the Princeton
University Plasma Physics Laboratory.
After a year of compulsory
experimental work on the Model C
Stellarator he completed a thesis on the
application of Whitham’s averaged
Lagrangian methods to plasma physics.
This work provided a general formalism
for describing ponderomotive forces
due to waves in plasmas that finds
application in both laboratory and space
physics, and which he has extended to
include chaotic diffusion. This has
developed into an interest in nonlinear
Hamiltonian dynamics which has
continued throughout his career.

The other major strand of his research
work has been in formalisms for the
calculation of the stability of toroidal
plasmas in two- and three-dimensional
plasma equilibria. Working closely with
computational physicists he has
contributed to the development of
computer codes used for predicting and
interpreting ideal and resistive >

Neil Ashcroft
National Research Facilities program to host the National Plasma Fusion Research Facility. The new facility is to be based on the H-1 heliac to the theory of which he has contributed since its conception at Princeton in the early 1980s.

Robert was elected to a fellowship of the American Physical Society in 1980 and the Australian Academy of Science in 1992, is a fellow of the Australian Institute of Physics and also a member of the Australian Mathematical Society. Earlier this year he spent three months as a visiting professor at the National Institute for Fusion Science, Japan. In June and July he will be co-organiser at the Australian National University of a workshop on Two-dimensional Turbulence in Fluids and Plasmas which will explore analogies between phenomena in magnetically confined plasmas and in geophysical flows.

Ann Roberts completed her BSc (Hons) in physics in 1984 at the University of Sydney. She remained there to complete her PhD in 1988 on theoretical and computational studies of the electromagnetic behaviour of apertures and grids in screens. This led to postdoctoral work in the School of Electrical Engineering at Cornell University. In 1990 she took up a lectureship in the School of Physics at the University of Melbourne, where she was promoted to senior lecturer in 1995.

Ann’s current research interests include theoretical and experimental investigations into the basic physics of scanning near-field optical microscopy and, in particular, its application to the characterisation of optical waveguides and fibres. This work complements her studies into the use of focussed MeV ion beams to fabricate channel waveguides in a variety of materials. She has also been involved in the use of non-interferometric intensity measurements to characterise optical wavefields and has theoretically investigated the interactions of atom beams with periodic evanescent optical fields.

Ann is currently a member of the Victorian Branch Committee of the AIP, of which she has been secretary. She is also a member of the council of the Australian Optical Society and has been instrumental in the establishment of the Women in Physics Group of the AIP.

Peter Szekeres was born in Shanghai in 1940 and immigrated to Australia in 1948. After obtaining a BSc with first class honours at Adelaide, Peter was awarded a Commonwealth Overseas Scholarship to work on general relativity and cosmology at Kings College London under Felix Pirani. He obtained his PhD in 1954.

Next Peter took a two-year post doc at Cornell University in the Center for Astrophysics and Space Research under Thomas Gold, before returning to London for a teaching position at Kings College. These were years of tremendous development in general relativity when Penrose and Hawking were discovering many of their famous results and was a very stimulating time to be in London.

Peter returned to Adelaide in 1971 to join the Department of Mathematical Physics (later to be amalgamated with the Department of Physics), where he has stayed ever since. His main contributions have been in the study of exact solutions of Einstein’s equations where he is best known for discovering a new solution representing two gravitational waves in collision. He is also known in cosmology for discovering an exact inhomogeneous solution which sometimes bears his name. In recent years he has worked mainly on the theory of singularities, and is currently writing a textbook on mathematical physics. He was elected inaugural president of the recently founded Australasian Society for General Relativity and Gravitation.

Wagga 97

The 21st Australian and New Zealand Condensed Matter Physics Meeting was held on Pakatoka Island, New Zealand, from 4 to 7 February, 1997. The
meeting was attended by 117 participants, including 19 from the Northern Hemisphere with the balance being in roughly equal numbers from Australia and New Zealand. In addition 20 accompanying persons made the Ferry journey to Patoka Island, to enjoy the sun and sand whilst their partners were immersed in the pleasures of condensed matter physics.

This meeting had a strongly international flavour, enhanced by the large number of overseas invited speakers. Indeed, to the organisers’ surprise, practically every international invitation was accepted, despite there being minimal financial support for those who came such a large distance. The list of invited speakers was:

- Professor Tien Tsong
  Academia Sinica, Taiwan
  A Study of Energetics and Dynamics of Atoms at Surfaces
  Invited by Prof John Pihlaj
  Monash University
  Pulsed and CW EPR in Condensed Matter Physics

- Professor Uwe Happek
  The University of Georgia, USA
  Luminescence Efficiency of Cerium Doped Insulators: The role of Electron Transfer Processes

- Professor Bernhard Blumeich
  Tech Hochschule Aachen
  Spatially Resolved in situ NMR

- Professor Gina Hoatson
  William and Mary College
  Order and Dynamics in Urea Inclusion Compounds

- Professor Bob Vold
  William and Mary College
  Deuteron NMR Studies of Molecular Structure and Dynamics
  Invited by Sir Sam Edwards
  University of Cambridge
  The Equations of Granular Materials

- Associate Professor Ken Jolley
  Massey University
  Molecules, Micelles and Liquid Crystalline Phase Behaviour of Solutions of Salts of Short Chain Perfluorocarboxylic Acids

- Professor Manual Cardona
  Max-Planck-Inst Fur Festkorporschung
  Crystals with Tailor-Made Isotopic Composition

- Dr Jeff Talon
  IRL
  Ten Years of High Tc Superconductivity: What Has Been Accomplished?

- Professor John Loram
  University of Cambridge
  Differential Calorimetry in Condensed Matter Physics

Professor Chuck Irwin
Simon Fraser University
Influence of Doping on the Low Energy Roman Continua of Some Hole-Doped Cuprates

In addition there were 30 short contributed talks and a total of 78 posters spread over two sessions. The standard of the lectures was remarkably high. Of the invited talks, those by Tsien Tsong, Sam Edwards were, at 45 minutes, somewhat longer in allocated duration that the rest, and in both cases the audience was treated to remarkably informative and entertaining presentations. A prize for the best lecture by a young scientist was awarded to Dr Melanie Britton of Massey University, New Zealand, for her contributed talk “Shear Banding on a Cone-and-Plate Rheometer” while the best poster prize for the Wednesday and Thursday sessions went to Scott Thomsen (Massey University) and Chris Andrikidis (CSIRO) for the respective posters “The Rod to Disk Transition in the Perfluorosurfactant System TMAH/PF6/D2O” and “Magnetically induced critical currents in (PbBi)2Sr2Cu2O10/Ag superconducting tapes”.

The final day of the conference was devoted to a session on High Tc superconductivity in which Jeff Talon presented a review remarkably successful work carried out at the New Zealand Institute for Industrial Research (IRL). Not long after the meeting IRL, in partnership with American Superconductor and the Auckland company Alphatech, publicly launched the first commercial high Tc magnet using the proprietary material developed by Jeff and his team.

This conference featured special emphasis in several high profile areas, including superconductivity, nanostructural research and soft condensed matter physics. This latter area was boosted by the participation of just-retired Cavendish Professor of Physics from Cambridge, Sir Sam Edwards. Professor Edwards interacted extensively with a wide range of scientists during the week and, in particular he held extensive discussions with younger scientists working in the field of polymer science and rheology, and in doing so was the source of much encouragement and good advice.

This is the fourth time that we have met on Patoka Island and, as always, this beautiful venue provided a congenial environment for relaxation and informal interaction. When the Wagg meeting is held in New Zealand, every three or four years, our Australian colleagues have additional expenses to meet in order to attend the conference.

Organisers were delighted that so many Aussie colleagues came over, despite the current funding difficulties experienced by many of them. As conference chairman, I also appreciated the advice given before the meeting by Trevor Finalyson from Monash, who ran the last Wagga conference, as well as the help given by many other physicist colleagues in New Zealand and Australia. In that regard I especially thank Joe Trodahl and colleagues at Victoria University of Wellington and Jeff Talon and colleagues at IRL. My team at Massey University comprised Rod Lambert (conference secretary, Bob Parsons (Treasurer), Toni Wilson (Administration) and Blair Hall and Neil Pinder (Program). To all of them I extend my grateful thanks for a job well done.

--

Paul Callaghan
Conference Chairman
p.callaghan@massey.ac.nz

Science Behind the News on NOVA Internet Site

To provide accurate and up-to-date information about the scientific health and environmental issues in the news, the Australian Academy of Science has launched a new World Wide Web site, NOVA: Science in the news, at http://www.science.org.au/nova/.

The Minister for Science and Technology, the Honourable Peter Mazuran MP, recently launched the site at Parliament House. He said that NOVA was a one-stop shop for reliable and up-to-date material, and that it bridged the gap between classroom theory and real life science. He called it 'a potent weapon in the battle to encourage more young people into science careers'.

The Academy consulted with teachers from all over Australia in designing and testing NOVA. For each topic, the site provides the following features:

- **Key text**, which provides a balanced summary of the main points in non-technical language and boxed information that explains Australian research and applications.
- **Glossary** of commonly used scientific terms.
- **Useful sites**, providing annotated links to carefully selected up-to-date, high-quality sites on the Web.
- **Further reading**, listing relevant Academy texts and useful journal articles.
articles that are easily accessible in school or public libraries, with a brief description of each.

- **Student activities**, including discussion questions, practicals and fieldwork. Most activities have accompanying teachers notes.

All material is reviewed by experts in the field before it is added to the site. The Academy also maintains a watching brief to ensure that the key text remains current and that the linked sites are active and relevant.

*Nova* is quick and easy to access, and provides material that has not yet found its way into textbooks and reference books. *Nova* is valuable to anyone with an interest in science, including high school and beginning university students undertaking assignments, parents who want to help their children with homework, journalists seeking background information, and teachers planning lessons.

The *Nova* site was developed with funding from the Australian Foundation for Science; the Science and Technology Awareness Program of the Department of Industry, Science and Tourism; and BHP. Several other organisations, including ACT Healthact, the Walter and Eliza Hall Institute of Medical Research, the CSIRO Division of Plant Industry, the CSIRO Division of Biomolecular Engineering and the Biomolecular Research Institute, the Institute of Advanced Studies at the Australian National University, and the Mazda Foundation have contributed to the development of specific topics.

For more information about *Nova* or sponsoring a *Nova* topic, contact Nancy Lane at (06) 247 5777, fax (06) 257 4620 or email nancy.lane@science.org.au.

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**A REMINDER TO HEADS, CHAIRPERSONS ETC**

This year the annual article on *Opportunities for Post Graduate Studies and Research in Physics* will be shorter than in previous years and consist of web addresses and a listing of research areas.

Could you please send me this information at david@www.ats.au before July 18.

David Whitehead
(07) 3378 3424 or (07) 3409 8084

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**The 1997 Eureka Prizes Incorporating the Michael Daley Awards**

These annual awards acknowledge and reward outstanding achievements in key areas of scientific and environmental research and the promotion of science. Nominations are now invited for all categories for the 1997 Eureka Prizes. The winners of the 1997 Eureka Prizes will be announced at a ceremony at the Australian Museum in November. Details, including nomination and application forms, are on [http://www.austmus.gov.au/](http://www.austmus.gov.au/)

**The POL Eureka Prize for Environmental Research:**
**Value $10,000**
Applications close 11 July 1997.

This Prize sponsored by POL Publishing Co, is awarded for research in any field of the biological, physical, mathematical or biomedical sciences leading to the resolution of an environmental problem or the improvement of our natural environment. The two essential criteria are scientific excellence and some manifest benefit to the natural world.

**The Australian Museum Eureka Prize for Industry (not a monetary prize)**
Applications close 11 July 1997.

The Australia Museum Eureka Prize for Industry is awarded to any business, company or corporation, regardless of size, which, through innovation or outstanding commitment to research, development or training, has sought to elevate corporate responsibility for scientific endeavour to a level consistent with our national capacity and needs. This is not a monetary prize, but an award offering prestige and distinction.

**The Australian Skeptics Eureka Prize for Critical Thinking:**
**Value $10,000**
Applications close 11 July 1997.

This prize is sponsored by the Australian Skeptics to encourage young scientists to investigate the acceptance of popular beliefs that owe little or nothing to the rigours of scientific method. The award will be made to postgraduate students or post-doctoral researchers under 35 years of age in the physical, life sciences and related humanities area for a completed or planned body of work in these topics.

**The NSW Environment Protection Authority Eureka Prize for Environmental Education:**
**Value $10,000**
Applications close 11 July 1997.

This Prize sponsored by the NSW Environment Protection Authority, aims to encourage and reward research which contributes to the effective design of environmental education programs.

**The NewScientist/Reed Books Eureka Science Book Prize:**
**Value $10,000**

This Prize, sponsored by New Scientist and Reed Books Australia, is designed to encourage publishers and Australian authors to produce quality books which bring science and the results of scientific research to the general public.

**The Environment Australia Peter Hunt Eureka Prize for Environmental Journalism:**
**Value $10,000**

This Prize sponsored by Environment Australia, commemorates the outstanding work of the late Dr Peter Hunt of the ABC's Science Unit. The prize is awarded for a particular work, or for overall performance in the field of environmental journalism. Special emphasis is given to work that informs and influences public opinion and attitudes, and that recognises and promotes the principles of ecologically sustainable development.

**The Department of Industry, Science and Tourism Michael Daley Eureka Prizes:**
**Promotion of Science:**
**Value $7,000**
Applications close 11 July 1997.

This Prize is awarded for making science and the results of scientific research known and understood by a broader public, or for raising public awareness of the excitement of scientific discovery and its contribution to solving many of the problems facing society. The prize is open to people working within science, editors and news organisations but not individual journalists.

**Science, Technology and Engineering Print Journalism:**
**Value $7,000**
OF INTEREST

Science, Technology and Engineering
Television Journalism:
Value $7,000

Science, Technology and Engineering
Radio Journalism:
Value $7,000

These three Prizes are awarded to Australian journalists and communicators whose work in the relevant media area is assessed as having most effectively communicated scientific, technological and/or engineering issues to the public. Judging criteria include newsworthiness, scientific accuracy, creativity and entertainment value.

Hamamatsu Photonics Acquires Rights to Develop Australian Squeezed Light Devices

The well known Japanese company Hamamatsu Photonics KK has acquired the sole rights to develop a class of novel photon coupled 'quiet light' optoelectronic devices patented by Professor Paul Edwards [paule@ise.canberra.edu.au] and Dr William Cheung of the School of Electronic Engineering and Applied Physics in the Faculty of Information Sciences and Engineering at the University of Canberra.

The devices utilise amplitude squeezed light in which the photon number fluctuations are suppressed below normal random Poissonian (shot noise) levels. They have applications in the many circuits and systems for which performance is ultimately limited by quantum noise.

The University of Canberra quantum electronics group has been working with Dr Peter Lynam, School of Physics, Australian Defence Force Academy, and with colleagues in the Solid State Division of Hamamatsu Photonics with a three year grant from DEETYA under its Targeted Institutional Links (TIL) program.

The group was the first in Australia to demonstrate the generation of amplitude squeezed light and also the first to generate quantum-correlated multiple light beams using high quantum efficiency light-emitting diodes and laser diodes. The new class of "low noise photon coupled circuits" utilises quantum noise-suppressed light together with electronic and photonic feedback to realise low noise amplifiers, oscillators and optical logic devices.

An open loop version of the new class of amplifiers was listed by the Optical Society of America in Optics and Photonics News as one of the "major advances in quantum optics in 1993". The sub-shot noise amplifier concept arose out of fundamental studies of quantum-correlated light phenomena at the University of Canberra.

International patents have been filed under the agreement with Hamamatsu Photonics, which includes royalty payments to the inventors. The company undertakes to support further joint research projects with the Australian group.

The University of Canberra quantum electronics group is presently working with the ANU Department of Electronic Materials Engineering, Hamamatsu Photonics and Stanford University to develop low noise laser diodes specifically for squeezed light applications.

Old Energy for New

The Federal Government's 1997 budget abolished the Energy Research and Development Corporation (ERDC) and halved funding for energy efficiency programs. The federal government provided direct support for a wide range of research activities ranging from human health to chickens. But sustainable energy and energy efficiency research has been eliminated.

This short sighted decision is in stark contrast to the strong support given by the government to Australia's fossil fuel lobby. In recent months Australia has hosted President Clinton, Prime Minister Hashimoto and Chancellor Kohl. On each occasion Mr Howard made a special plea on behalf of the fossil fuel lobby that Australia be exempted from greenhouse gas reduction measures, to be decided upon at a major international conference in Kyoto, Japan in December this year.

Non-government organisations such as Greenpeace and the International Solar Energy Society will vigorously point out the hypocrisy of the government's budget cuts to sustainable energy programs at Kyoto. This will seriously undermine the Australian government's position. The American, Japanese and German delegations will notice the lack of credibility of the Australian position.

Australian solar energy and energy efficiency companies are growing rapidly, and providing labour intensive jobs. Australian solar water heater and solar cell companies have recently landed major contracts in Asia and are expanding production to cope with demand. Australian research groups lead the world in photovoltaics, solar heat, solar thermal electricity and energy efficiency products, and are well placed to assist Australian companies to take advantage of growing markets. Our competitors overseas, who enjoy government assistance, will rejoice at the news that the Australian government has kicked the bottom out of this vigorous, labour intensive and environmentally sound industry.

The Australian government already had a very low per capita investment in solar energy and energy efficiency. Funding should be increased to $1 per citizen per year ($20 million per year) in order to take advantage of the huge market for such products that will open as greenhouse gas reduction targets are made compulsory. This funding could be made through a more focused version of ERDC, to be called the Sustainable Energy Research and Development Corporation.

Andrew Blakers
Andrew.Blakers@anu.edu.au
http://www.anu.edu.au/eng/
Prof Scott was a dean for four of those five years (including two at UNSW), he was pleased that the selection committee considered his research output sufficient for this prestigious and competitive award. "I tried very hard to keep up my research while Dean," he said. "I published forty papers in four years as dean, including two in Nature and a 571-page book. I don't think that's normal for Deans at UNSW, and it is probably one reason I'm no longer a Dean here. We talk a lot about leading by example, but very few Deans actually do it. Mostly we Deans are bureaucrats." In Germany Scott will do experiments and device-modeling of thin-film memories which are non-volatile; they don't erase or 'forget' if the power is interrupted. They are more than a thousand times faster to erase and rewrite than are other non-volatile devices, such as EPROMs (electrically erasable programmable read-only memories).

Together with two engineers, Prof Scott founded a spin-off corporation in the USA in 1986, six years before moving to Australia, to make computer memories and related devices from inventions at the University of Colorado, where he had been Professor of Physics for more than twenty years. Today the company, Symetrix Corp, licenses its technology to 14 large multinational corporations, including Siemens, NEC, Motorola, Matsushita, and others. Matsushita alone makes 5 million chips per month with this technology for use in digital telephones.

Prof Scott recently spent January and February as the Sony Corporation Visiting Chair of Science in Yokohama, an appointment reserved for only two or three scientists per year. While there he signed a contract between Sony and UNSW that, beginning Sept 1, will bring Sony scientists and engineers to UNSW for the initial phase of joint work, funded by Sony, to further develop this technology for use in such products as the Sony Walkman stereo systems and digital cameras. The first Sony scientist to arrive will be Mr Koji Watanabe, Assistant Manager of the Sony Memory Project in Yokohama, who has an MS in physics from Nagoya University. Koji speaks excellent English and is an avid SCUBA diver, so his adjustment to Australia should be quick and easy.

Scott has been issued three US patents in the last 18 months on the combination of his films with high-temperature superconductors to fabricate phased-array radars and other microwave devices of interest to the military and telecommunication industry. He hopes this will interest AWA and other Australian corporations in similar UNSW-industry collaborations.

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The Lecture Series will take place over 2 to 3 weeks in the period between May and August, with a lecture being given in Canberra and each of the six Australian State capital cities. The lecture will be of interest to a non-specialist physics audience, and will excite an enthusiastic response in students at senior secondary level and above. There will also be opportunities for the lecturer to visit universities and other scientific centres throughout Australia to engage in discussion and give research colloquia where appropriate. Air travel to and within Australia, and living expenses will be provided. Nominations (including self-nominations) should be received by 15 August 1997, and must include a 300-500 word citation, with references to key publications if possible.

Short-listed nominees will be asked to confirm their availability, and to provide a curriculum vitae including a summary of their contributions to physics and suggestions for a lecture topic.

Nominations, preferably by email, should be addressed to:
Moira Welch, Honorary Secretary, AIP
e-mail: M.Welch@uws.edu.au
PO Box 283, Richmond, NSW, 2753 Australia.

Further information may be obtained from:
Dr Judith Pollard, Department of Physics and Mathematical Physics, University of Adelaide, Adelaide, 5005, Australia
Tel: (61) (8) 8303 5316
Fax: (61) (8) 8303 4380
e-mail:jpollard@physics.adelaide.edu.au
TRENDS IN PHYSICS ENROLMENTS IN NEW ZEALAND SECONDARY SCHOOLS

ROBERT MACLAGAN

De Laeter and Dekkers [1] have recently published the latest in a series of papers in which they have surveyed the enrolments in Physics in Australian secondary schools. They have published similar surveys for Chemistry [2,3]. In response to their survey, I have presented similar data for Chemistry enrolments in New Zealand secondary schools [4,5]. In this article I wish to present the trends in Physics enrolments in New Zealand secondary schools. I will first discuss the general enrolment trends for the last two years of secondary schooling in New Zealand, before proceeding to discuss enrolments in Physics in detail, focussing on a comparison with other science subjects, especially Chemistry, the trends observed for enrolments by females, and the retention in Physics classes from Form 6 to Form 7.

Retention Rates

In Figure 1 the total 7th form enrolments and total Physics 7th form enrolments are plotted for the period 1975-1995. Form 3 Retention data for 1975, 1980, 1985, 1990 and 1995 are given in Table 1. In 1975 the retention rate* from Form 3 (the first year of New Zealand high schools) to Form 7 was only 12.9% (15.4% for males and 10.3% for females). It has steadily increased until it peaked at 53.9% with the 1993 7th form class. In 1995 the numbers in the 7th form represent 44.4% of the 1991 3rd form males and 52.3% of the 3rd form females. 3rd form enrolments peaked in 1976, but 7th form enrolments did not peak until 1993. 3rd form enrolments are currently

![Graph 1: Total 7th Form enrolments and Total Physics 7th Form enrolments 1975-95](1)

![Graph 2: 7th Form enrolments by Gender 1975-95](2)

Dr R G A R Maclagan is in Chemistry at the University of Canterbury, New Zealand. email R.mclagan@chem.canterbury.ac.nz

98 Australian & New Zealand Physicist Volume 34, Number 5/6, May/June 1997
about 25% smaller than the peak enrolment. In Australia the retention rate from Year 8 to Year 12 was 72.0% in 1995. The increase in the retention rate in New Zealand was not due to any change in the minimum school leaving age. While the number of students studying Physics in the 7th form has steadily increased, there has not been the dramatic increase that the 7th form enrolments had from about 1986.

The 7th form enrolments by gender are shown in Figure 2. In 1975 there were 54% more males than females in New Zealand 7th forms. In 1995 there were 14% more females than males. The number of females in Form 7 has increased 350.8% in the period 1975-95, while the number of males has increased 157.9%, less than half the increase in female numbers. Since 1989 there have been more females than males in the 7th form. In Australia, De Laeter and Dekkers found that females outnumbered males in Year 12 from 1976. There have been more females than males in Form 6 for the whole of the period surveyed with a corresponding higher retention rate. The retention rate to the 6th form has increased from 47.0% in 1975 to 84.1% in 1995. As can be seen from Figure 3, the retention rate from Form 6 to Form 7 remained essentially constant in the period 1975-1985, but has doubled in the period 1986-95.

In 1975 the retention rate from Form 6 to Form 7 for all students was 29.0%. In 1995 it was 59.4% slightly down from 62.1% in 1994.

In Table 1 are given the enrolments for each gender in Physics, and the total number of each gender for Forms 6 and 7 and the parent Form 3 class, for the years 1975, 1980, 1985, 1990, and 1995. For Form 7 the total enrolments are also given. I have also included the percentage of each gender in Forms 6 and 7 studying Physics, and, for sake of comparison, the corresponding numbers for Biology, Chemistry, and Mathematics. For the 7th form the numbers given are for the paper including calculus (Mathematics or Mathematics with Calculus). In 1987 the 7th form Mathematics papers were changed from Mathematics and Applied Mathematics to Mathematics with Calculus and Mathematics with Statistics. The percentages of 7th formers studying biology, Chemistry, Mathematics and Physics are shown in Figure 4.

With the increased retention rate, there appears to be a small continual increase in the number of students studying Physics. This is illustrated in Figure 5. However the number of students studying Physics have not kept pace with the increased numbers of students.

The enrolments in Physics and Chemistry for both genders from 1975 to 1995 are shown in Figure 5. In 1975 56.4% of males in the 7th form studied Physics. Physics was the third subject offered at the same level in each of the years 1975, 1980, 1985, 1990, and 1995.
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TRENDS IN PHYSICS ENROLMENTS IN NEW ZEALAND SECONDARY SCHOOLS
most popular subject for males. In 1995 the percentage of males studying Physics had dropped to 38.1%. This is better than Chemistry where the percentage has dropped from 55.7% in 1975 to 30.4% in 1995. In 1995 Physics was the fourth most popular subject for males (after English and the two Mathematics courses), but for females it was the 13th most popular subject behind Accounting. Chemistry has dropped to 7th place for both males and females, from 4th for males and 6th for females. In 1975 Physics was the 7th most popular subject for females, just ahead of French. In 1975 only 26.5% of females in the 7th form studied Physics compared to 36.1% for Chemistry. The greater popularity of Chemistry over Physics among females has meant that until 1989, and since 1994, more students in the 7th form have been studying Chemistry than Physics. From 1986 onwards the numbers of males studying Physics in the 7th form has increased significantly more than Chemistry leading to the overall greater popularity of Physics. As Figure 5 shows, the number of females studying Physics has steadily increased, but not as greatly as the case for Chemistry where the trend is towards equal numbers of males and females studying Chemistry in the 7th form. In 1995 there are still twice as many males as females studying Physics in the 7th form. Action needs to be taken to rectify this imbalance if professions such as engineering are not to remain male dominated. The opposite situation exists for Biology where there are 50% more females than males studying Biology in the 7th form in 1995. Until 1979 more males than females studied Biology in the 7th form. As more females stayed on at school (the percentage retention has nearly quadrupled in the period 1975-1995) they tended to choose to study Biology rather than Physics or Chemistry. The percentage of females studying Mathematics with Calculus is also significantly less than for males. 32% more males than females were studying Mathematics with Calculus. This is an improvement on the situation in 1975 where there were more than twice as many males as females studying the old Pure Mathematics course.

For most of the period being examined here the retention of students in Physics classes in going from Form 6 to Form 7 was less than for Chemistry. This is illustrated in Figure 3. The retention rates do not differ greatly between males and females. When the retention from Form 6 to Form 7 increased significantly after 1985, the gap between Physics and Chemistry did not seem to change, but there has been a narrowing in the last few years. The greater number of students studying Physics in Form 6, particularly males, may be due to the need for Physics in many skilled trade courses. These students may not sit the Bursary examination. If the number of females studying Physics is to increase, the similar retention rate for males and females from Form 6 to Form 7 suggests that a focus of attention must be to attract more females to study Physics in Form 6.

Conclusions

The statistics presented here for New Zealand secondary schools show very similar trends to those presented by De Laeter and Dekkers for Australia [1]. Form 7 enrolments have peaked mainly due to a reduction in Form 3 enrolments. The increase in Form 7 enrolments that occurred after 1986 is particularly due to greater retention for females. The retention rate to Year 12 in Australia in 1995 was 72.0% compared with the 59.4% retention rate to Form 7 in New Zealand. In several areas the changes that occurred in New Zealand occurred several years earlier in Australia. For example, the increase in Form 7 numbers in Australia started in 1982. The total number of students studying Physics in Form 7 has not yet peaked, though the number of males has possibly levelled off or started to decline. While the number of females studying Chemistry in Form 7 has approached the number of males, the number of females studying Physics in Form 7 needs to at least double to approach that situation. There is some comfort in the fact that more males study Physics than Chemistry. As in Australia there has been a decline in proportion of students studying science - Biology Chemistry or Physics. In 1975 the “average” student studied 1.49 science subjects, but in 1995 only 0.86 science subjects were studied. By contrast for History and Geography combined there has been an increase from 0.69 to 0.97. For Mathematics there has been a smaller decline, from 0.96 to 0.87. Of some concern is the apparent lower retention rate from Form 6 to Form 7 for Physics compared to Chemistry. In my earlier study of Chemistry enrolments [3], I noted that about only one third of Form 7 Chemistry students would not study Chemistry at University. With the increase in the number of students staying into the 7th form, the fraction for whom Form 7 Chemistry is their terminal course in Chemistry must have increased. I suspect that the percentage for Physics is even greater.

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5 RGAR Maclagan, Chemistry in New Zealand (1992) 19 ANZ

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The Comet of the Century

Inhabitants of the Northern hemisphere were the lucky ones. For them, Comet Hale-Bopp put on a splendid show and might well top the charts as the best comet of the twentieth century. For those of us in the Austral regions of the globe it came into view when it was well past its best. Even so, its advent has sparked renewed public interest in those misty-tailed vagrants of the solar system, with refreshed demand for a good, readable book on the subject.

Sky and Telescope contributing editor Fred Schaaf has, in fast time, written a recommendable book titled Comet of the Century: From Halley to Hale-Bopp which, with a wealth of fact and anecdote, describes the latest scientific findings about comets, traces their history and even goes so far as to offer advice on how to immortalise yourself by discovering one. It delves into matters left aside by the world's top cometary expert, Donald Yeomans, whose scholarly volume Comets - A Chronological History of Observation, Science, Myth and Folklore is now six years old, though scarcely showing its age. The two books complement each other very well and together with Australian David Seargent's Comets - Vagabonds of Space comprise a most comprehensive trio on my bookshelf.

Schaaf's book, with its two sections of plates - one in color, the other black and white - is quite superb if you don't mind his often flowery prose, and can forgive his bias towards the obverse hemisphere. And, of course, being American he frequently slips into the use of imperial units. However the informative tables at the back avoid them. I like the inside cover sky charts clearly tracing the paths of comets Hyakutake and Hale-Bopp. Speaking of charts, Schaaf's are most extensive, showing the paths of many historical comets among the constellations and his orbital renditions show more clearly than those of Yeomans their positions above or below the ecliptic plane.

Schaaf and Yeomans both give interesting accounts of the discoveries of comets, including those made by satellite instruments. Yeomans has many photographs of discoverers: Schaaf has none. Both books show many historical pictures, drawings and woodcuts, yet I was surprised how little overlap exists between their selections.

Comet of the Century is published in New York by Copernicus, an American imprint of Springer-Verlag. It should be available off the shelf in Australia at DA Books of Melbourne. With 384 pages in hardcovers it ought to be at a price which relates to the DM48 quoted on the review invoice.

To assist ordering, quote its ISBN 0-387-94793-0.

Colin Keay
Reviews Editor

Reviews

Fragile Objects

Pierre-Gilles de Gennes
& Jacques Badoz
Springer-Verlag, New York 1996
xvi + 190pp., DM39.80 (hardcover)
ISBN 0-387-94774-4

Subtitled "Soft Matter, Hard Science and the Thrill of Discovery", this book is based on popular lectures given by Nobel Laureate Pierre-Gilles de Gennes (Physics, 1991). To his great credit, the lectures were given in a large number of French High Schools but I do not recall the source material from lectures that he gave here in Australia when touring a few years ago.

Part I of the book deals with 'soft matter': colloids, such as latex, Indian ink, paint, etc., as well as liquid crystals, bubbles and foams. The reasons for their interesting properties are explained in simple language, with entertaining analogies and clever sketches. Part II, a collection of essays on research, is laced with witty but profound philosophical observations.

Part III, on Education, deals with the French schooling system and bemoans its shortcomings - for example the overwhelming emphasis on mathematics. In view of the rising tide of mathematical illiteracy which is engulfing our high schools, I read this part with considerable amusement! The book is a pleasure to read, in spite of (or is it because of?) its French didactic style and quite informative, at an elementary level, about a subject matter which is assuming increasing importance in modern materials science.

AG Klein
School of Physics
University of Melbourne

The Origin of the Concept of Nuclear Forces

Laurie Brown & Helmut Rechenberg
IOP Publishing, Bristol 1996
xii + 392pp., UK£49.50 (hardback)

This scholarly book reviews the origin of the Yukawa theory, in which the forces between nucleons are explained by the exchange of scalar mesons, which today we call pions. The main body of the text covers the period from 1932 (when the neutron was discovered) until 1952, when the discovery of the neutral pion established the existence of an isospin triplet of scalar mesons. It is well researched and abounds with references and historically interesting photographs. As might be expected from a serious study it cannot be classed as light reading.

However, with the many anecdotes and historical insights which the book contains, I found it hard to put down.

The book provides several examples of how very good physicists could stumble towards what today we consider to be an obvious, simple model. For example, after the discovery of the neutron, Heisenberg quickly built a model in which nuclei are composed of protons and neutrons. However, he insisted in regarding the electron and proton as elementary particles and the neutron as an electron-proton composite. The fact that the latter hypothesis violated his own Uncertainty Principle didn't seem to trouble him!

The parallel development of Meson Theory during the war in the West and the East (taken here to be the Soviet Union, Germany and Japan) receive separate chapters. It is interesting to
follow how physicists presumably unable to communicate converged on the same 'truth'.

The search for pions was complicated by Anderson's discovery, in the cosmic rays in the mid-1930s, of a particle with about the right mass and lifetime. In fact he had found the muon, which is a lepton or 'heavy electron', and thus immune to the strong nuclear force.

That puzzle was largely resolved by the key experiments of Rossi and Rasetti, carried out under trying circumstances in Rome under American bombardment. There is a very nice chapter on that episode.

The main part of the text finishes with the discovery of the charged pions by Powell et al in Bristol, who also observed pions decaying into muons, and with the discovery of the neutral pion a few years later at Berkeley.

There is an introduction, or 'prehistory', which discusses the period before 1932 when nuclei were considered as collections of protons and neutrons. That model suffered many problems, in particular with the spin/statistics connection. And there is a substantial epilogue covering the period after 1952 when it became clear from accelerator experiments that the nucleons and pions were composite not elementary, and that it was established that the nuclear force cannot be explained by pion exchange alone.

The book terminates with a brief discussion on the force that we regard today as being the fundamental strong force. That of course is QCD in which coloured gluons, exchanged between quarks and antiquarks, provide the force that binds quarks into nucleons, pions and other mesons. Altogether, a good read.

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University of Melbourne

Longitude
Dava Sobel
Fourth Estate, Sydney, 1996
(first published in the USA by Walker Publishing Company, Inc. in 1995)
viii + 184 pp., AS14.95 (paperback)
ISBN 1-85702-502-4

For some years the columns of this magazine have told its readers what they know already: that physics in Australia and New Zealand (and elsewhere) is in trouble. The source of that malaise is manifold, but certainly one of the reasons is the poor presentation of the subject to undergraduates. The staff in too many departments believe that a measure of their success is the excellence of their top graduates: how many Rhodes scholars, how many firsts, how many going on to Cambridge or Harvard for PhD study? In fact, such students would excel no matter what the standard of the teaching, because to a large extent they teach themselves: the best students are on a par no matter where you go.

A proper measure of the efficacy of a department would be what happens with the more mediocre material: how many ordinary or low honours degree graduates are enabled to find useful jobs in industry, how many inspired physics teachers are produced? Indeed, how many students taking only first-year physics walk away with some appreciation of the value of physics as an educational discipline, whether they understand the equations or not?

A couple of years back Paul Davies rather eloquently pointed out that the members of the Australian government appear to believe that learning about a subject is the same thing as learning the subject itself, and that is palpable nonsense. But that is not to say that there is no place for learning about physics in a university setting: an education in the liberal arts (meaning the arts, the natural sciences, the social sciences, and the humanities) is the exclusive territory of many tertiary colleges in the United States, and the graduates are extremely well-regarded in industry, higher education, and government. As another example, in many large US universities there are hundreds - even thousands - of students taking Anthropology 101, but similar numbers taking Astronomy 101; and astronomy is just physics in disguise.

With this in mind I'd suggest that the discipline of physics could save itself by making Physics 101 a general non-continuing course, part of a liberal arts degree. But give it an attractive name, and package it up. For the students, give them more physics, or engineering, or other science and technology subjects, call their course Physics 177; they're numerate (if not numerous) enough to handle the notion.

The problem next faced is two-fold. The first is to find the necessary staff to teach the hundreds of students you'll attract into this liberal arts physics course; I can't help you with that. The second is in finding suitable textual material to work with: remember that for this course you'll be expecting the students to do extensive reading, rather than just spoon-feeding them in lectures.

The book which I have got around to mentioning at last would be an excellent basis for part of such a course. It is one of the publishing surprises of recent years, to be seen now in best-seller lists. The full title, preserving the capitalisation used on the cover, is:

"Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time."

It is the story of how John Harrison constructed clocks which kept sufficiently accurate time at sea such that the longitude of a ship could be determined by observing the hour angle of a star of known right ascension.

I was familiar with the story beforehand - it is not a coincidence that my eldest son is named Harrison - but it was a pleasure to see it so nicely set out in Dava Sobel's book. That is not to say that I have no misgivings about this tome, the writing being over the top in places, there being a few factual errors and misunderstandings on the author's part with regard to the physics and astronomy involved, and she tends to be so fervently pro-Harrison that she does other characters an injustice; but it is a fine introduction to this interesting story. The pleasure of the read is enhanced by its small pocketable format, and the design of the book which mimics that of a bygone era; Harrison was working in eighteenth century England.

Why is it physics? Almost all of the problems that Harrison had to surmount were problems of physics: obviously a pendulum clock would not keep time in a ship being tossed on the ocean, so Harrison invented a radically different chronometer. And what about the expansion and contraction of metals used in his timepiece? And friction? How does the viscosity of the oil change with temperature? These were all challenges which Harrison had to overcome, or obviate. Set that against a conversion between the interpolated error in longitude allowed and the largest possible slip in timekeeping in seconds per day resulting: a beautiful illustration of the calculation of uncertainties in an experiment.

Harrison's greatest frustration, however, was with the scientific establishment of the time, many of whose names would be recognized by physicists today. They were not partial to this 'mere mechanic', preferring possible techniques for solving the longitude problem which involved the lunar distance method, or perhaps reading the positions of the Galilean satellites on Jupiter like a clock. But the most dangerous waters are also the most cloud-covered ones, and if Harrison's clock worked, then one only needed to glimpse a bright star between the clouds to work out where one was. Whilst the
establishment clung to its favourites, thousands died in shipwrecks; but once Harrison's achievement was accepted, Britain began to rule the waves, and profits boomed.

This book would not make a whole course, naturally. But with the timekeeping problem solved, there was a greater requirement for accurate astronomical tables. So the next step in the course might encompass how Thomas Young (he of the modulus of elasticity, the slit, the theory of three-colour vision, and the deciphering of the Rosetta Stone) was hounded to death in the 1820's due to the many errors printed in the Nautical Almanac, of which he was Superintendent. After that, fill in the developments driven by physics over 150 years - radar, for example - until the 1980's when many bushwalkers take hand-held GPS receivers with them. Of course, they wouldn't work unless the chronometers on the satellites allowed for time-dilation as they orbit the Earth at seven or eight kilometres per second. It's all physics, folks.

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Spaceguard Australia
Adelaide

Supersymmetric Methods in Quantum and Statistical Physics
Georg Junker
Springer-Verlag, Berlin 1996
xiii + 172pp., DM58 (hardcover)
ISBN 3-540-61591-1

This is a serious book for scientists and students who wish to learn the basic methods of supersymmetry (SUSY). The first chapter provides a brief introduction and history of the concepts of symmetry and the motivation behind the development of SUSY, and subsequent chapters define and develop SUSY Quantum Mechanics as well as SUSY classical mechanics and SUSY statistical mechanics. Some applications of SUSY are treated including the Pauli and Dirac Hamiltonians and two- and three-dimensional electron gases. This book is suitable for the reader who has had a good working knowledge of nonrelativistic quantum mechanics and preferably some understanding of relativistic quantum theory.

Junker begins with a definition of SUSY quantum mechanics allowing for N self-adjoint supercharge operators but focusses the reader's attention on the N = 1 and N = 2 cases. It is interesting that the electron gyromagnetic factor g = 2 arises naturally in the construction of a SUSY Pauli Hamiltonian (N = 1) without needing to derive this factor from the relativistic Dirac Hamiltonian. The important Witten model (N = 2) is developed in detail, in its quantum as well as in its classical versions. The Witten model is also used to study classical stochastic dynamics by rewriting the one-dimensional Fokker-Planck equation as a SUSY Schrödinger equation with imaginary time.

For me the book has been an eye opener. I recall learning SUSY in the context of (yet to be observed) transformations between fermionic and bosonic states, but Junker develops SUSY in a much broader context and demonstrates the importance of using SUSY. I have been aware of the symmetries inherent in the quantum systems I study, but now I can investigate and exploit the supersymmetry of these systems as well!

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School of Mathematics, Physics
Computing and Electronics
Macquarie University

Quantum Theory of Real Materials
JR Chelikowsky & SG Louie (eds)
Kluwer Academic Publishers
Dordrecht 1996
vii + 549pp., US$195.00 (hardcover)

For at least 40 years, in studies of solid state physics understanding has been gained on the basis of quantum mechanics. In the last 20 years, however quantum mechanics, combined with computer power, has also got to the point where it is extremely useful for material science and novel materials. This book reflects the worldwide interest in basic and applied solid state physics, seen today as an area of research that spans quantum mechanics to material and computational sciences.

The book focuses on the electronic properties of materials and covers the following topics: Electronic Structure and Quantum Dynamics; Semiconductors, Insulators and Metals; Surfaces, Interfaces and Clusters; Materials under Pressure, Superconductivity; and Fullerens, Superhard Materials and Other Novel Materials. The character and style of this book is adequate to the high topics it covers. The text brings together the writing of a group of solid state physicists, experts in the field, and, a clear attempt is made to reveal the latest theoretical and computational results and provide markers and signposts for interesting new research possibilities. Although this is not a textbook, the specific are as discussed also include fundamentals. The main text is supplemented by an index giving guidance on some specific aspects. With its focus on new concepts, methods of calculation, and new systems, this volume should benefit solid state physicists, material scientists and postgraduate as well as graduate students. The book is dedicated by the editors (J Chelikowsky and S Louie) to Prof ML Cohen on his 60th birthday.

MW Raday
Physics Department
University of Newcastle

The MATHEMATICA Book
Third Edition
(Mathematica Version 3)
Stephen Wolfram
Cambridge University Press
Cambridge 1996
xvii + 1403 pp., $69.95 (paperback)
$95.00 (hardcover)
ISBN 0-521-58888-X (paperback)
ISBN 0-521-58889-8 (hardcover)

Mathematica is one of the best software products ever developed. It can perform symbolic computation, numerical computation, programming, graphical manipulation, and word processing within a single system. The Mathematica Book is a comprehensive description of Version 3 of this software. A review of Mathematica Version 2 appeared in this journal Vol 32 (1995), pp 201-202.

There have been two outstanding developments in computing over the past five years since Mathematica Version 2 first appeared. Firstly, desktop computers have become capable of solving significant problems in computational science. The speed of today's desktop Pentium Pro PC is between that of the early supercomputers, the Cray 1 and the Cray X-MP, which were largely responsible for the birth of computational science (see Physics Today, October 1996 p24). Secondly, the World Wide Web with browsers and search engines has emerged to enable networked computers to share databases and information across the globe almost instantaneously. Version 3 of Mathematica is alive to both of these developments.

The computing requirements for Mathematica Version 3 are substantially more demanding than Version 2. The allocation of about 100MB hard disk, 16MB RAM or more and a clock speed better than 100MHz are recommended. Most post 1995
personal computers could meet these requirements but they are too
demanding for most pre-1995 PCs.
System requirements for Mathematica,
which can run on all platforms, include,
Windows 95, Windows NT 3.51 or
better, Mac OS 7.1 or better, Sun OS 4.1.2
or better.
The new Mathematica book provides a
host of World Wide Web site addresses
and Version 3 of the Mathematica
software incorporates a cross-platform
word processing package for Interactive
documents which is well suited to
preparing documents on the Web.
The Mathematica book is extremely
well set out. It is packed with
thousands of examples and it is structured in
a manner that encourages learning first
via examples. Even the short sixteen
page tour at the front of the
Mathematica book contains sufficient
depth for newcomers to work out via
examples how to get started on modest
problems. For example, on page 18, the
single line of code
\begin{verbatim}
RandomWalk[n, d] := NestList[
{#1[[1]], 
1} Table[Random[Integer], {d}], 
Table[0, {d}], n]
\end{verbatim}
provides an \textit{n} step random walk on
a \textit{d}-dimensional hypercubic lattice
and the code
\begin{verbatim}
Show[Graphics3D[L.Kine
RandomWalk[1000, 3]],]
\end{verbatim}
clearly displays a plot of the output for
a 1000 step random walk on the cubic
lattice. Try replicating that in two lines
of code with Fortran 90!
There are more than two hundred and
fifty enhancements and new features in
Version 3. A few of these include:
numerical solutions of boundary value
ODEs and initial value PDEs, extended
symbolic integration, the ability to
expand trigonometric expressions into
sums or products of trigonometric
terms, additional functions such as
generalized hypergeometric functions
and Mathieu functions, full typesetting
capabilities for text and labels in plots,
automatic conversion from
Mathematica graphics to eps, gif etc.,
and Z transforms as an add-on package.
The most significant new advance in
Version 3 is in the area of interactive
documents called notebooks. The
notebooks provide a front end to the
Mathematica kernel and their structure
is the same on all computer systems.
They consist of cells containing text
and Mathematica code which can be
activated as the document is being read.
It is possible to run the front end
notebooks on one computer and to run the
Mathematica kernel on another
using Mathlink. The cells comprising
the notebooks are themselves
Mathematica expressions and they can
be manipulated using the symbolic
manipulation tools of Mathematica.
This makes it possible to program the
actions of the notebooks. For example it
is possible to set up ButtonBox objects
that perform actions whenever you
click on them.
Mathematica is the ideal software
package to use to exploit the power of
todays fast desktop computers. This
single software package in combination
with the hardware of a Pentium Pro PC
would enable you to explore significant
problems in computational physics on
your desktop from number crunching
to analysis and the preparation of
publication quality reports.
As an aside, the new Mathematica
Book is extremely bulky. Two smaller
books to cover the same material, one
as an introductory user guide and the
second as a reference manual, would
be a significant improvement. I can’t
imagine the softcover binding in the
new book surviving the level of use that
the book deserves. Although the
hardcover binding is about 30% more
expensive it still represents exceptional
value for money. You couldn’t
photocopy the pages for less.

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University of New South Wales

Random Walks and
Random Environments
Volume II: Random Environments

Barry D Hughes
xxx+526pp., A$160 (hardback)

Volume I of this work comprised a
coherent self-contained account of
random walks and related processes.
Random walkers are moving particles
which, at fixed time intervals, take
steps of a prescribed length in random
directions. In contrast Volume II deals
with random materials in the sense
that the “disorder” is frozen in space.
Diffusion processes are those in which
the randomness arises as a consequence
of erratic particle movement while
percolation processes are those arising
from randomness in the material
environment, through which the
particle moves, and the latter chapters of
Volume II deal with the combined effect.
Throughout Volume II the author
continues the high level of erudition and
precision which characterised
Volume I of this work. The present
volume contains seven chapters with
titles:
1. An introduction to
2. Bernoulli site percolation
3. Percolation thresholds
4. Critical exponents in percolation
5. Transport and conduction in random
environments
6. Random walk in a random
environment
7. The ant in a labyrinth

The first four chapters constitute a self-
contained introductory account to the
geometry of random environments, with
particular emphasis on the so-called
Bernoulli percolation models, due to
Broadbent and Hammersley. These
chapters may be read independently
of Volume I. However, the final three
chapters of Volume II relate to transport
in random environments and depend
significantly on Volume I.
Percolation processes were originally
identified by Broadbent and
Hammersley in 1957 from the
consideration of the design of gas
masks for use in coal mines. A
Bernoulli percolation model is simply
a random environment which has
spatial elements (bonds or sites of
lattices) either present with probability
\( p \) or absent with probability \( 1 - p \).
Now, after only 40 years, the mathematical
theory presented in Volume II, already
encompasses a huge range of varying
physical phenomena arising from
numerous areas of both theoretical
physics and continuum mechanics.
The author attributes much of the
success of the subject to four
mathematicians (Elliot W Montroll,
John M Hammersley, Harry Kesten and
Benoit Mandelbrot) who “had the
vision to predict that in succeeding
decades, random walks, self-avoiding
walks, and percolation theory would
be the source of such subtle and
delightful mathematics and such
fruitful applications”.

With the publication of Volume II, the
author has successfully illuminated
these major areas which are of critical
importance to mathematics and physics.
Both areas are characterized by
significant mathematical theory which
contains many beautiful results, wide
ranging physical applicability and a vast
scientific literature. Undoubtedly, the
painstaking careful exposition of these
important areas, will be of considerable
benefit to these involved in the
mathematical modelling of random
physical phenomena. Barry Hughes
must again be congratulated for his
masterful exposition and the final word
is perhaps best left to him:
“The two volumes of the present work
have been written with the perspective
that random walks, percolation and
\( \triangleright \)
Decoherence and the Appearance of a Classical World in Quantum Theory

If the quantum theory is universal, as the current theory would indicate, how is it that Newton invented Newtonian mechanics and not quantum mechanics? How is it that we apparently inhabit a world well described by classical concepts and for which a description in terms of the quantum theory would be an enormous extravagance if not conceit? The answer, at least in this book, is, environmental decoherence.

Decoherence refers to the loss of quantum coherence due to irreversible interactions between a quantum system and the external world. Decoherence corresponds to a loss of information about the relative phases of superposed states. It is the central concept for a description of the measurement process. It is also central to our understanding of the emergence of a classical world.

One of the most exciting concerns of physics today is the creation, control and preservation of quantum coherence. Most recently we have seen some significant breakthroughs in our understanding of these issues in the discussion of quantum computation. Computers that exploit the quantum feature of the superposition of distinct physical states appear to offer an enormous efficiency dividend for previously exponentially inefficient classical algorithms. We are now on the threshold of a technology of quantum coherence in which new quantum feedback and error correction schemes monitor massively entangled quantum superposition states and protect them from the ever present trend of decoherence. In such a technology, the

Copenhagen split between the quantum and classical realm becomes no longer a question for the philosophically inclined but an essential issue of experimental design.

The literature on the interpretation of the quantum theory is by now enormous and continues to grow. An outside observer could be forgiven for thinking that consensus seems to be a long time coming. Indeed for much of the last 70 years, the debate has lingered at length over a description of measurement (in terms of instantaneous projective measurements) that is of virtually no use at all in describing any real measurement that has ever been performed... until quite recently. Most measurements are not instantaneous and not arbitrarily accurate. This is not to say that there has been no progress in describing real measurement processes. Indeed there have been some very important results established by mathematicians and physicists who recognised that all measurements necessarily involve an irreversible process. The quantum theory of irreversibility has taken a little while to get straight, but is now essentially in place, through the work of Zeh, Ludwig, Kraus, Barchielli, Zurek and others. Most recently experiment has begun to outpace the theoretical breakthrough. It is now possible to hold a single atom, not an ensemble, in place for hours and interrogate its internal electronic state even as it undergoes fluorescence in the presence of a laser field. The theory developed to deal with such situations, covered variously the method of quantum trajectories or Monte-Carlo wave functions, enables us to talk consistently about the pure state of a continuously monitored isolated quantum source.

This book provides an ideal review of the current state of theoretical work on decoherence. Each chapter is the work of an individual author with considerable expertise in an aspect of the problem. All the various modern approaches are here, from the 'consensus' view of environmental decoherence, well described in the article by Joos (Chapter 3), to the more ambitious proposals such as decoherent histories (Kiefer, Chapter 4), and spontaneous collapse, (Stamatescu, Chapter 8). The failure of the decoherent histories program is particularly well represented by Kiefer. All the authors have taken considerable trouble to provide extensive references and a number of important technical details are contained in the appendices. In my opinion this book is required reading for anyone beginning research in the foundations of quantum mechanics, or the quantum theory of open systems. It provides a reasonably complete snapshot of the current state of the field. Many of the chapters are technically demanding, but the more philosophically inclined will find much here to stimulate, and possibly annoy.

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Book Notices

Spectral Theory of Guided Waves
AS Silbergleit & Yu I Kopylevich
IOP Publishing, Bristol 1996 ix + 310 pp, UK£100.00 (hardcover) ISBN 0-7503-0381-6

This book is a mathematical work describing waveguides in terms of spectral theory, eigenvalue equations and their associated matrices. The main difference from other books on the subject is that it is not directed towards applications, and this is a limitation for its use by physicists. On the other hand, pure mathematicians probably don't need such a book, anyway. For example, the introduction is quite abstract and treats waveguides as mathematical rather than physical objects. There are some mentions of physical quantities and waveguide terminology, e.g. in the chapter on elastic waveguides, but the book lacks a global physical interpretation of its results and should have a different title.

Becquerel's Legacy
A Century of Radioactivity
MC O'Riordan (ed)

The twenty papers delivered at a conference in London to commemorate the centenary of Becquerel's epochal discovery suffer from being mainly (seventy-five percent) British. And they are a mixed bag. "The Radioactive Earth" is an excellent summary as is "The History of Radiation Protection". It would do certain sections of the community a power of good to read and appreciate the paper on "Radiation Accidents". Among the poorer papers is "Radioactive Waste Disposal" because it deals entirely with the Nirex process with no mention whatever of competing methods, such as Australia's Synroc or the Swedish copper encapsulation technique. 

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If nothing else, through chapters like “Functional Brain Imaging”, this slim volume highlights the multitude of uses and benefits to humanity of Bécquerel’s greatly magnified contribution to our civilisation. It’s worth reading.

Introduction to Mathematical Logic
Alonzo Church
Princeton University Press
Princeton NJ 1996
ix + 578 pp., US$19.95 (paperback)
ISBN 0-691-02906-7

This volume in the Princeton Landmarks series is a reprint of the revised 1956 version of this notable title first published in 1944 in the Annals of Mathematics Studies. Quite a pedigree. Especially since the author has been a major pioneer of mathematical logic in this century, with a considerable influence on the development of computer science. Church died in 1995 and at this time, it is fitting that the release of this inexpensive reprint should make his masterly treatise available to everyone with an interest in the subject.

New Books

Energy and Entropy Generation
JS Shinier (ed)
Kluwer Academic Publishers
Dordrecht 1996
x + 246pp., US$177.00 (hardcover)
ISBN 0-7923-4128-7

Magnetism
A Supramolecular Function
O Kahn (ed)
Kluwer Academic Publishers,
Dordrecht 1996
xii + 660pp., US$290.00 (hardcover)
ISBN 0-7923-4153-8

Fluid Physics for Oceanographers and Physicists
SA Elder and J Williams
Butterworth-Heinemann, Oxford 1996
xiii + 395pp., A$65.00 (paperback)
ISBN 0-7506-2958-4

Metastable Liquids
Concepts and Principles
PG Debenendetti
Princeton University Press
Princeton NJ 1996
x + 411pp., US$69.50 (hardcover)
ISBN 0-691-08595-1

From Newton’s Sleep
J Vining
Princeton University Press
Princeton NJ 1996
xvi + 398pp., US$16.95 (paperback)

Unsolved Problems in Astrophysics
JN Bahcall and J Ostriker (eds)
Princeton University Press
Princeton NJ 1997
xiv + 377pp., US$24.95 (paperback)

Edwin Hubble
Mariner of the Nebulae
GE Christianson
IOP Publishing, Bristol 1997
x + 420pp., UK£19.50 (hardcover)

The Early Universe with the VLT
J Bergeron (ed)
Springer-Verlag, Berlin 1997
xii + 435pp., DM48 (hardcover)
ISBN 3-540-62414-7

The Blue Laser Diode
S Nakamura and G Fasoff
Springer-Verlag, Berlin 1997
xvi + 343pp., DM98 (hardcover)
ISBN 3-540-61590-3

Neutron Dosimetry
Nuclear Technology Publishing,
Ashford, Kent 1997
xvi + 585pp., UK£97.00 (hardcover)
ISBN 1-870965-43-4

Comets and the Origin and Evolution of Life
PJ Thomas, CF Chyba
& C P McKay (eds)
Springer-Verlag, New York 1997
xiii + 296pp., DM49 (hardcover)
ISBN 0-387-94650-0

Insights of Genius
Imagery and Creativity in Science and Art
AI Miller
Copernicus (Springer-Verlag),
New York 1996
xii + 482pp., DM38 (hardcover)

Number by Colors
A Guide to Using Color to Understand Technical Data
B Fortner and TE Meyer
Springer-Verlag (TeLOS),
New York 1997
xxv + 349pp., DM72 (hardcover)

Conformal Field Theory
P DiFrancesco, P Mathieu
& D Senechal
Springer-Verlag, New York 1997
xvi + 890pp., DM138 (hardcover)
ISBN 0-387-94785-x

How Nature Works
The Science of Self-organised Criticality
P Bak
Copernicus (Springer-Verlag),
New York 1996
xiii + 212pp., DM44 (hardcover)
ISBN 0-387-94791-4

The Collected Works of E P Wigner
Part A: The Scientific Papers Vol IV
A S Wightman (ed)
Springer-Verlag, Berlin 1997
ISBN 3-540-56985-5

Dynamics of Multiphase Flows Across Interfaces
A Steinichen (ed)
Springer-Verlag, Berlin 1996
xii + 267pp., DM92 (hardcover)
ISBN 3-540-60848-6

Optical Properties of Semiconductor Quantum Dots
U Woggon
Springer-Verlag, Berlin 1997
viii + 251pp., DM218 (hardcover)
ISBN 3-540-60906-7

Light Scattering in Inhomogeneous Atmospheres
EG Yanovitskij
Springer-Verlag, Berlin 1997
xvi + 371pp., DM128 (hardcover)
ISBN 3-540-61362-5

The Stability of Matter
From Atoms to Stars
Second Edition
W Thirring (ed)
Springer-Verlag, Berlin 1997
xi + 675 pp., DM 98 (hardcover)
ISBN 3-540-61565-2

Semiconductor Optics
C F Klingshirn
Springer-Verlag, Berlin 1997
xvii + 490pp., DM69 (softcover)
ISBN 3-540-61687-x

From Quantum Mechanics to Technology
E Petru, J Przystawa
& K Rupcheck (eds)
Springer-Verlag, Berlin 1996
ix + 375pp., DM106 (hardcover)
ISBN 3-540-61792-2

Sensors Update (Vol 2)
H Baltes, W Gopel and J Hesse (eds)
VCH Publishers, Weinheim 1996
xi + 236pp., DM348 (hardcover)
ISBN 3-527-29432-5

Molecular Applications of Quantum Defect Theory
Ch Junge (ed)
IOP Publishing,
Bristol 1996
xi + 654pp., UK£95 (hardcover)
ISBN 0-7503-0162-7

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July 1 - 9  IAMAS/IAPSO Joint Scientific Assemblies
World Congress Centre, Melbourne, Victoria
Contact IAMAS/IAPSO Secretariat, Convention Network,
224 Rouse Street, Port Melbourne, Victoria, Australia 3207
Tel (+61) 3 9646 4122, fax (+61) 3 9646 7737,
email nscorlet@peg.apc.org

July 9 - 11 International Conference on Frontiers in Quantum Physics
Satellite Meeting of 12th International Congress of Mathematical Physics (ICMP'97)
Contact CS Lim, Physics Department, Faculty of Physical & Applied Sciences,
Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
Tel +60 3 829 2880/2907, fax +60 3 829 2880/825 6086,
email slim@pkrisc.cc.ukm.my, web page http://www.jssg.ukm.my/ik/qp97.htm

July 10 - 12 The Eighth National Physics Conference of the New Zealand Institute of Physics
Dunedin, New Zealand.
Conference theme: Physics in Education and Society.
Contact Craig J Rodger, Department of Physics, University of Otago,
PO Box 56, Dunedin. Tel +64 3 4479 7749, fax +64 3 4479 0964,
email nzip@physics.otago.ac.nz.

July 21 - 25 The Ninth International Conference on Recent Progress in Many-Body Theories
The University of New South Wales, Sydney, Australia
Contact Jill Walker, Secretary, MBIX Conference, School of Physics,
The University of New South Wales, Sydney 2052 Australia
Tel +61 2 9385 5649, fax +61 2 9385 6060, email mbix@newt.phys.unsw.edu.au,

July 27 - Aug 1 International Conference on Magnetism 1997, Melbourne
(incorporating the Symposium on Strongly Correlated Electron System)
Contact The Meeting Planners, 108 Church Street, Hawthorn Vic 3122 Australia
Tel +61 3 3 9819 3700, fax +61 3 9819 5978, email meeting@iacess.com.au

Sept 7 - 13 ICIS'97 - Seventh International Conference on Ion Sources, Taormina, Italy
Contact Dr Giovanni Ciocciola, INFN-LNS, Via S. Sofia 44, 95123 Catania, Italy
Tel/Fax 39 95 542 800, email ICIS97@LNS.infn.it
Web page: http://www.lns.infn.it/www/icis97/home_icis97.html

Sept 10 - 12 New Zealand Acoustical Society Conference
Contact NZ Acoustical Society PO Box 1181, Auckland, New Zealand
Fax +64 9 623 3248

Oct 12 - 16 The Second International Conference On Isotopes, 2ICI, Hyatt Regency, Sydney
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Tel 02 9437 4879, fax 02 9439 6561.

Oct 16 - 17 The Second Conference on Nuclear Science & Engineering in Australia ANA 97
Hyatt Regency, Sydney
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Nov 24 - 26 The Tenth AINSE Nuclear Techniques of Analysis (NTA) Meeting and
4th Vacuum Society of Australia (VSA) Congress
Australian National University, Canberra, Australia
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