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AIPC 2002

AIP CONGRESS: REPORTS AND ROUNDUP

NEUTRINO OSCILLATIONS AND THE EARLY UNIVERSE

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*COVER: Artist's impression of the proposed new Synchrotron building in Melbourne.*

**Contributions should be sent to**
- A/Prof Chris Hamer, Editor
  - Physics, University of Newcastle, Callaghan NSW 2308
  - Tel (02) 4921 5451 fax (02) 4921 6907
  - phcslk@cc.newcastle.edu.au

**Design, Artwork & Printing**
- Scott Williams - Manager
  - Cronulla Printing Co. Pty. Ltd.
  - 16 Cronulla Plaza, Cronulla 2220
  - NSW Australia
  - Phone 02 9523 5954 Fax 02 9523 9637
  - physicist@cronullaprint.com.au

**Advertising Enquiries**
- Mrs Leigh Wallbank
  - PO Box 70, Oyster Bay 2225
  - NSW Australia
  - Phone: 02 9528 4362 Fax: 02 9523 9637

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PRESIDENT’S COLUMN

I am pleased with the response to my call for profiles of people who are out in the workforce. I have some great responses which have appeared, or will appear, in the Physicist and on the web. Please send in more as we would like the broadest range of careers and contacts.

I have now travelled to most state branches (sorry ACT - still not made it there) and I have tried to convey my view of where the AIP is today and where it is going. It is also interesting to see how members view the institute. In too many cases it is viewed as a body set up to serve, not one that members engage with.

It is to our detriment that members don’t realise how much the institute owes to a band of active and able volunteers. I am not putting the Executive on the back here (although they deserve it), I am referring to a bigger group of people who are less visible but make the institute what it is.

I will try to ‘catch’ them all but I am going to miss some and let me apologise in advance if I do. First there is the Physicist editor, who devotes an enormous amount of time to chasing articles, advertising, editing, refereeing, interacting with the executive (chasing the president for his column) and the publishers. There are also the assistant editors in each branch who offer a valuable service.

There are the branch committees which always have a nucleus of hard working people who are responsible for the activities which most readily engage the membership.

There are many others as well who appear over the horizon from time to time. The AIP has representatives on a number of national committees and boards for which Physics plays an important role. We have John Prescott, Peter Bouwknegt and a band of volunteers in SA as well as people in each state who monitor the advertised job situation, photocopy and post (by mail and on the web) job advertisements. John’s articles have been a great resource whenever I have had the opportunity to discuss employment with students, members of parliament, the public etc. Without these valuable data we would find it extremely difficult to argue anything about employment prospects.

Then there is the survey conducted by Phil Jennings and John de Lauter in WA on trends in university student numbers which is also a ‘weather vane’ to where physics is going. On the policy area, Tim Davis has run this well for years and has now handed over to Scott Butcher. The education ‘portfolio’ has been well taken care of by Dan O’Keefe, while the Women in Physics group has had a number of very active coordinators over the years and is currently headed by Suzanne Hogg. In fact there are a wide range of specialist groups that thrive through the active involvement of many volunteers.

I cannot overlook the people who agree to participate in judging panels for the prizes offered by the Institute.

Now there are many other people that I have forgotten I know but the purpose of this list is not intended to be exhaustive but to show who we rely on to keep the Institute on track and active. Apart from taking this opportunity to thank them all, I am focussing on their efforts to encourage more members to offer to share the load. The more people involved the lighter the load for each activity - and each one is incredibly valuable - and each one affects each and every member either directly or indirectly.

Thank you all and I appreciate the time and effort that you offer the Institute - we could not do what we do without you. You ensure that we continue to “punch above our weight”. I like that phrase which I think originated from the IOP but has become so much a part of the vocabulary that I even heard the Prime Minister use it in relation to Australian Science recently.

In closing, could I take this opportunity to thank the members of the Queensland Branch Committee who organised a hectic and fruitful visit to Brisbane in September. This meeting provided an excellent opportunity to meet a wide range of members to discuss current developments and concerns.

John O’Connor
John.OConnor@newcastle.edu.au
AIP Congress
This is a special issue of 'The Physicist', devoted largely to reports of the AIP Congress in July. We carry reports from the convenors of the various parallel sessions at the Congress, along with thanks to all the sponsors and exhibitors who took part. There are also some brief impressions from one or two of the speakers and participants at the Congress. Our two main articles are from winners of AIP Medals, namely Dr. Nicole Bell who won the Bragg Medal for 2001, and Professor Bob Delbourgo from Hobart who won the Massey Medal. This is the first year that the Alan Walsh Medal for Service to Industry has been awarded, and its inauguration fitted well with the theme of the Congress, "Physics and Industry Working Together". An article from the winners will appear in a later issue.

APESMA Survey
Enclosed with this issue there should be a survey form from APESMA, the Association of Professional Engineers, Scientists and Managers. This Remuneration Survey of Physicists is officially sanctioned by the AIP. It will provide up-to-date information about jobs in physics and their remuneration levels, which could be very useful in attracting new students into the field. For this reason, we urge you all to retrieve the survey from the round filing cabinet where it may inadvertently have found itself, and spend a few minutes to fill it out and return it.

Good News and Bad News
News on the environment in the past couple of months has been mixed. The good news is that the hole in the ozone layer seems to be shrinking. Scientists at the joint CSIRO-Bureau of Meteorology station at Cape Grim in Tasmania have found that the levels of ozone-eating chlorine in the atmosphere have finally begun to fall. They peaked at about 2.15 parts per billion in 2000, and have since begun a significant decline. The international ban on chlorofluorocarbons has had the desired effect, and the hole in the ozone layer should be repaired by about the year 2050.

The bad news is that the Johannesburg Conference on Sustainable Development achieved almost nothing. The United States and Australia again refused to ratify the Kyoto Treaty on greenhouse gases, although China, Canada and Russia have all finally agreed to sign, and sufficient nations have now ratified the Treaty to allow it to come into force.

Australia's position on Kyoto means patently absurd. "Kyoto will not solve the problem", says Environment Minister David Kemp; but Australia will probably meet its Kyoto targets anyway. Nobody claims that Kyoto will solve the problem entirely, but at least it is a first step in the right direction. If that isn't the answer, why doesn't Dr. Kemp tell us what is? And if we are going to meet the targets anyway, why don't we sign the Treaty? It would give us some valuable trading credits. The whole episode is a sorry blot on the government's record.

Managing Risk
It is good to see that at last some sort of backlash is occurring against the absurd level of payouts awarded in public liability cases, and the consequent astronomical increase in insurance premiums. In one recent case in Sydney, a man dived into the sea, hit a sandbank and injured his neck, and then successfully sued the local council for millions of dollars.

The result is that many community events are being cancelled because the organizers cannot afford the insurance. Doctors are leaving the profession in droves. Activities such as horse-riding may become commercially unviable. Cliffs all around the country are being faced with ugly wire fencing in case somebody hurts themselves off. Team sports such as rugby will soon find themselves under threat, because serious injuries occasionally occur in them.

The situation has to be rectified. It is neither possible nor desirable to shield people from all risk in their daily lives. We have to allow sports and recreations to continue, even if they do involve some risk, or we will be reduced to a vegetable existence, like caterpillars in a cocoon. For those unlucky enough to suffer a serious injury, the 'safety-net' principle applies: they should be eligible for a no-fault compensation scheme at the public expense, at some modest level set by a Tribunal, but certainly not at the million-dollar levels seen recently.

Premier Bob Carr has recently set the ball rolling in New South Wales. Levels of compensation should be 'capped', and decided according to some standard scale. A no-fault scheme should be introduced, and damages should only be awarded if serious wilful negligence can be proved. People should be allowed to undertake activities "at their own risk", and waive the right to claim public liability.

There are ramifications in the science arena as well. Health and safety regulations are now so restrictive that soon it will be impossible to carry out chemistry experiments in an undergraduate laboratory, and all the chemists will have to become theoreticians. In physics, the use of radioactive isotopes or NMR machines will become verboten. It is time the professional societies stood up and drew the line, to limit and roll back these onerous regulations.

Chris Hamer
Chamer@unsw.edu.au
**Malcolm McIntosh Prize**

Marcela Bilek, Professor of Applied Physics at the University of Sydney, has won the Malcolm McIntosh Prize for the Physical Scientist of the year aged under 35. Prof. Bilek is the first woman appointed Professor at Sydney, and worked at the Comenius Research Centre in Melbourne and in Cambridge previously. She works at creating super-tough designer materials for industry using plasma arcs and beams, magnetic fields and high energy electrical pulses.

**The Pawsey Medal**

The Pawsey Medal for 2002 has been awarded to Dr. Sergey Vladimirov, an ARC Senior Research Fellow in the School of Physics at the University of Sydney. He has helped pioneer Australian studies of complex plasmas - a rapidly growing area of research involving laboratory and industrial plasmas, astrophysics and space physics. His main contribution is in the theory of the collective behaviour of charged particles in a plasma when it is in a non-equilibrium state.

[Australian Academy of Science Newsletter]

**ReITERation**

The US is set to rejoin the International Thermonuclear Experimental Reactor (ITER) project, from which it withdrew in 1998. The project is intended to test the feasibility of generating electric power using magnetic fusion. A new reactor design has been produced which at $5 billion is only about half the cost of the original design. A meeting in Austin, Texas, of 45 leading plasma fusion researchers who make up a panel of the Department of Energy’s Fusion Energy Sciences Advisory Committee (FESAC) recommended that the US should start negotiations to rejoin ITER.


**New Director at Stromlo**

Professor Penny D. Sackett has been appointed as the new Director of the Research School of Astronomy and Astrophysics (RSAA) at the ANU. Professor Sackett was born in Nebraska, served as a Program Officer at the National Science Foundation, and was a research member of the Institute of Advanced Study in Princeton. For the last seven years she has been at the Kapteyn Astronomical Institute in the Netherlands. Her interests include the structure and content of galaxies and the search for extra-solar planets.

[Julian Lee, ‘ANU Reporter’, 30 August]

**Michelson-Morley revisited?**

Prof. Reg Cahill and Kirsty Kitto of the School of Chemistry, Physics and Earth Sciences at Flinders University have made the startling claim that the old Michelson-Morley experiments have been misinterpreted all these years. They argue that the experiments reveal that there is an absolute frame of reference, after all, and that the Earth is moving relative to it with approximately the velocity measured by the COBE satellite observations.


**Speed of Light Slows?**

A team of three researchers in Sydney, Professor Paul Davies of Macquarie University and Tamara Davis and Charley Lineweaver of the University of New South Wales, have claimed that the speed of light must have slowed since the Big Bang. In a letter published in Nature, they start from the result of Webb et al., that the value of the fine-structure constant has changed slightly over the last 6 billion years. They use arguments involving black holes to show that the electric charge cannot have changed, so the culprit must be c, the velocity of light.

Paul Davies has recently been given the Michael Faraday Award by the Royal Society in London. The award is given to the scientist who has done most to further public communication of science, engineering or technology in Britain.

**Hunting for Diamonds**

A team at BHP-Billiton, headed by Edwin van Leeuwen, has constructed an aircraft-mounted gravity gradiometer system so sensitive that it can detect diamond mines hidden under the earth. It is based on a system developed for Trident submarines in the US Navy, built from three spinning discs at right angles to each other, carrying pairs of accelerometers, and mounted on an inertially stabilized platform fitted with hydraulic dampers. Very sophisticated software is capable of removing the aircraft’s movements from the signal. The sensitivity is around one part per million, and the system can detect the gravitational pull of a two-year-old toddler from a few metres away. The aim is to detect diamond-bearing kimberlite pipes beneath the earth, from an aeroplane flying overhead - and apparently the new system is easily capable of it.

[Rachel Nowak, ‘New Scientist’, 21 Sept.]

**New President for the Academy**

Dr. Jim Peacock, Chief of the CSIRO Division of Plant Industry, succeeded Prof. Brian Anderson as President of the Academy of Science on 2 May.

**One Step Backwards**

A claim that element 118 had been created at the Lawrence Berkeley Laboratory by firing a beam of krypton ions at a lead target has now been withdrawn. The laboratory director admitted that the claim resulted from fabricated research data and scientific misconduct by one individual. Victor Ninov has been fired by the laboratory, and has responded by filing a grievance case against the lab. Suspicions about the results were aroused when physicists at the GSI heavy-ion accelerator in Darmstadt, Germany, were unable to reproduce the results.


The Physicist Volume 39, Number 5, September/October 137
NEUTRINO OSCILLATIONS AND THE EARLY UNIVERSE
- THE QUANTUM MECHANICS OF OPEN SYSTEMS

NICOLE BELL
Fermi National Accelerator Laboratory

INTRODUCTION

In 1930, in a desperate attempt to allow for the conservation of energy in beta decay, Wolfgang Pauli postulated the existence of a new particle: the neutrino. Little, however, could Pauli have imagined the scale of the endeavour that would eventually be devoted to uncovering the properties of these elusive particles, or that they would be studied in connection with topics as diverse as early universe cosmology and fundamental quantum mechanics.

Non-zero neutrino masses allow oscillations of neutrinos from one flavour to another. These oscillations, while a simple quantum mechanical phenomenon, have many quite fascinating consequences.

More than 70 years since they were first postulated, and 48 years since they were first detected in 1956, there is still a lot we do not know about neutrinos. For a long time, the goal of neutrino physics was to determine whether neutrinos do in fact have mass, and how the flavour states $\nu_e$, $\nu_\mu$, and $\nu_\tau$ are related to the states of definite mass $\nu_1$, $\nu_2$, and $\nu_3$. However, the field has undergone a revolution in recent years, due to beautiful experimental results for atmospheric neutrinos from the SuperKamiokande experiment in Japan, and for solar neutrinos from the Sudbury Neutrino Observatory (SNO) in Canada. The SNO experiment has recently obtained direct evidence that mu and tau neutrinos are coming from the Sun. Since the nuclear reactions that power the Sun can produce only electron neutrinos, this provides compelling evidence that neutrinos are transformed from one flavour to another.

DECOHERENCE

This leads us to the topic of decoherence. When we are dealing with an open quantum system, it is not sufficient to restrict our attention to pure states - it is necessary to consider mixed states, which are states for which there is less than complete coherence between superposed components. Interactions between a system and its environment typically lead to decoherence. Thus the study of neutrino oscillations in the early universe becomes a study of partially decoherent oscillations, which is quite different to the fully coherent oscillations of solar or atmospheric neutrinos.

Let's consider oscillations between two neutrino flavours. There are two limiting cases that are of interest: Neutrinos of the two flavours may have different scattering amplitudes (let's call these sensing collisions), or they may have the same scattering amplitude (blind collisions.) Sensing collisions can tell the difference between one neutrino flavour and the other. Technically, when a sensing collision takes place, the flavour degree of freedom of the neutrino becomes entangled with environmental degrees of freedom. For a blind collision, no such entanglement occurs. It is useful to picture sensing collisions as ones which collapse the neutrino wavefunction into either one flavour or the other. While no such collapse actually takes place, it is accurate to interpret such collisions as measurements.

An example of the sensing case is that of active-sterile neutrino oscillations. The active neutrinos scatter with particles in the medium, while the sterile neutrinos do not. On the other hand, the blind interaction would apply, for example, to the interaction of mu and tau neutrinos with an environment of electrons. In both the sensing and flavour blind cases, collisions typically lead to decoherence.

in the medium (on the other hand, the density of the sun or the earth is completely negligible so far as the cross section for neutrino collisions is concerned). What is perhaps surprising, is that some of the issues that must be considered when describing neutrino evolution in such an environment are directly analogous to those that arise when studying quantum information.
Fascinating dynamics is encountered when the rate of the collisions is much faster than the frequency of oscillations. If the collisions are of the sensing variety, they cannot completely inhibit oscillations and freeze the neutrino in its initial flavour state. This is known as the Quantum Zeno effect — it is a watched pot never boils type of effect.

On the other hand, if the collisions are blind to the neutrino flavour, they do not interrupt the oscillations in this manner. Rather, the effect of collisions is now simply to transfer the neutrino from one energy state to another. This makes a difference, because the oscillation frequency of the neutrinos depends upon energy. If the rate of these transitions is very rapid, the neutrino effectively experiences an oscillation frequency that is averaged over energies - the result being that all the neutrinos oscillate at the same frequency, despite having a spread of energies. This synchronisation of frequencies is a phenomenon known as motional narrowing in the field of NMR.

In both the Quantum Zeno and motional narrowing limits, it is possible to avoid decoherence despite the fact that the system is interacting rapidly with its environment.

**IMPLICATIONS FOR THE EARLY UNIVERSE**

While the quantum mechanics of open systems is a fascinating subject in its own right, in the neutrino context there are some intriguing early universe applications. The first of these is the generation of large lepton number asymmetries via neutrino oscillations. The period of interest is that when the universe had an MeV scale temperature, a time when the universe was less than a minute old. In this epoch, the universe was full of a primordial soup of particles — photons, electrons, positrons and neutrinos (plus a tiny number of baryons that would eventually become all the visible matter we see today).

If there had happened to be equal numbers of each neutrino flavour, oscillations would be of no consequence as they just interchange the flavours. However, we have no direct knowledge as to whether or not the numbers of the various flavours are equal. There could be quite large asymmetries between the numbers of neutrinos and antineutrinos, and these asymmetries may be different for each of the neutrino flavours.

We know that the baryon asymmetry, i.e., the difference between the numbers of baryons and antibaryons (normalised to the number of photons) has a value of about $10^{-9}$. If one had to guess the value of the lepton asymmetry, it might seem natural to choose a number of about the same size. But we have no direct way of telling if that guess is right. If a large lepton number asymmetry existed, it would have to reside in neutrinos (rather than in charged leptons) due to constraints on charge neutrality of the universe. An asymmetry residing in neutrinos, however, could be many orders of magnitude larger than the baryon asymmetry, as we have never directly detected the relic neutrino sea, let alone measured its properties. The information we do have about the relic neutrinos comes from our knowledge of Big Bang nucleosynthesis. Today, the relic neutrinos have a temperature of about 2K (that's an average energy of about $10^4$ eV) so the prospects of directly detecting them are quite slim.

Interestingly, oscillations between active and sterile neutrinos can actually generate large lepton number asymmetries. These asymmetries are produced via a positive feedback effect which operates when the neutrino oscillations are partially decohered through collisional interactions with their environment.

What about oscillations between active neutrino species? BBN sets limits on the neutrino asymmetries of $L_\nu < 0.03$ and $L_\nu < \text{few}$, the limit on the electron-flavour neutrino is more stringent than that for the other flavours, since electron-flavour neutrinos and antineutrinos directly take part in the processes that interchange neutrons and protons just before nucleosynthesis.

Our knowledge of the neutrino mixing matrix has dramatically increased in the last few years, and in particular, we now know the mixing angle between the electron and the mu and tau flavours is large. (It is fair to say that this came as quite a surprise. The prevailing theoretical prejudice had been that neutrino mixing angles should be small, in analogy with the quark sector.) A consequence of this large-angle mixing is that relic neutrino asymmetries become equilibrated across the three flavours and hence the stringent constraints on the electron-flavour neutrino can be translated to a constraint on all three flavours. This eliminates scenarios known as degenerate nucleosynthesis, and allows us to set the best limit on the lepton number of the universe.

**CONCLUSION**

There is a lot that we still do not know about neutrinos. We don't even know their absolute masses - oscillation effects only provide information about mass differences. Tritium beta-decay experiments may provide the answer to this question, as may cosmology (it might be possible to weigh neutrinos with galaxy surveys.)

Neutrino physics is a very active field of research, with many current and proposed experiments expected to produce interesting results in the near future. It is a fascinating field of study, especially when we consider the rich interplay between particle physics, quantum mechanics and cosmology.

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i See, for example, L. Stodolsky, Phys. Rept. 320, 51 (1999); L. Stodolsky, cond-mat/9702307.


Management Chair’s Report

Hello and Welcome to this Special Edition of the Physicist dedicated to the Congress. A collection of articles summarises the different aspects of the Congress. I hope you enjoy reading these articles and remembering the various aspects of the congress.

Congress Vision

In my previous report I outlined the Vision I brought to this Congress, that being a desire to change the perception the public and perhaps we ourselves have of physics as a discipline. In order to forward my vision I introduced a number of innovations to the Congress. In order that these visions might be evaluated I defined my goals in terms of measurable outcomes. These are listed below together with the achievements.

Industry Tour

The industry tour on Friday was excellent. Some 23 delegates including myself visited Bishop Austrans, Hitachi, CSIRO and Cochlear. Bishop Austrans showed everyone their development of an alternative transport system for Sydney. They have a government grant, plus their own financing, to take it to the next stage. Hitachi showed us the role they play in data storage, which was certainly impressive. The needs of large organisations, especially banks, to have access to their data instantly is phenomenal! CSIRO showed some of their industrial work including squids and material coating, such as drill tips, to strengthen them. It was fascinating to tour Cochlear and discover what goes on at the worker’s level. Quite a different perspective to see the reality of the manufacturing process of bionic ear implants compared to the science which most of us are probably more familiar with. For me the highlight of the industry tour was Bishop Austrans. What impressed me was that the company is essentially all scientists and engineers: pretty much a reflection that they are still in the development stage. If everyone wants a job doing science in industry I would give them a look.

Thanks

I would like to thank the people on the two committees who put in so much time and effort to bring together a fantastic event. Without their efforts the Congress would not have been the success that it was. David Neilson as Program Chair did a fantastic job to balance the needs of an excellent program with continually changing pressures from management. The restriction to four days, the introduction of an industry forum, a Welcome reception during the Congress (previously held the night before), a number of sessions dedicated to medals and prizes, the delicate balance of keynote and plenary speakers and my desire to highlight talks that would impact on the media. All of these created new pressures for David to deal with and he managed them well. Thank you for working with me. Thank you also to the other members of the Program committee, some of you I dealt with directly and it was great to see the efforts you put in, sometimes against trying times.

On the management committee I would like to acknowledge John Love (Deputy Chair) who joined us when ACOFT joined the Congress. Ken Doolan (Industry Representative) with his small team of helpers put together the Industry Forum and Industry tour and impactted on the theme that pervaded the congress. Mahesh Maheswaran (Treasurer) kept an eye on our budget. Graeme Melville (Website Manager) did a great job managing the website and responding, often on the 11th hour, to changes that needed to be made. David Thornclaff (Exhibition and Sponsorship) and his small team chased sponsors and exhibitors around Australia and were responsible for our success in improving our funding from industry. NB as Chair I successfully attracted the two largest sponsors CSIRO and the IOP Moira Welch (Congress Liaison Officer) was there at the start when we chose the Principal Conference Organising (PCO) company to support our congress and gave feedback on AIP issues. Peter May (Congress Advisor) runs conferences for the Institute of Engineers Australia. His experience proved invaluable. Kate Wilson (Publicity Officer) put in an extraordinary effort and produced excellent results in her management of the media for the Congress. I would like to extend a special thanks to Kate. She was often my right-hand person when I needed someone to mull over ideas with.
I would like to thank the people at ACTS (PCO), in particular Anne Davey whom I had so much to deal with, Alyson Aresten and Liz Sheridan. They provided the support and often advice to make this congress a success. Thank you to our sponsors and exhibitors. A special section of this edition is dedicated to their acknowledgement. I would also like to thank the student helpers who assisted in the smooth running of the Congress. They are Shosanna Cole, Iwan Cornelius, Tom Hanna, Peter Hooper, Katja Lytikainen, Hong C. Nguyen, Alex van Brisch, Robert Ward. Finally I would like to thank the delegates who came. You are what makes the Congress after all. Thank you for being there.

For those of you who are interested Congress photos may be found on the web at www.aip.org.au/aipc2002/photos.html.

AIP Congress Evaluation

The paragraphs below summarise the short and long response feedback from the Congress. 124 evaluation forms were handed in and 70 people took the time to write long responses. This is very good statistics given that this was administered Thursday morning after a number of delegates had already left. In particular the written responses were very pleasing. Typically for an evaluation I expect only about 10% of the delegates to provide written response. Having 70 responses is phenomenal!

Delegates thought the theme was appropriate for a Physics Congress and that it added to the quality of the Congress. The Industry Forum was interesting and useful with many delegates saying they would like to see something like this at future congresses.

The Darling Harbour venue was a very good choice for our congress with many people preferring this to a university. Indeed a number of people told me personally to make sure we do not hold the next few congresses at a university. I am left with the comment by Mark Seccot when he spoke of the Australia Technology Park. There was no longer a need to spend 20 minutes convincing industry that we are not like a normal university. I believe Darling Harbour added a level of professionalism to the congress that we could not gain if we staged the congress at a university.

Everyone thought the Congress was well organised and a success. A number of delegates hoped for a shorter day but I am afraid this is unlikely in a city as expensive as Sydney. Some suggested that we break for dinner and then come back for talks in the evening. The dinner on the ferry was very popular. The biggest negative for the Congress was the delegate fee, which generated a number of comments from members. Unfortunately you get what you pay for. If you want to come to Sydney then you have to be prepared to pay for it. The location of the congress at Darling Harbour did not have a significant impact on the fees. One thing I think we could do better next time is make the fees more attractive for the students. I suggest that instead of fees of $600 and $400 for members and students respectively that we choose fees of $700 and $300 in the future.

The service provided by the Conference Organising company (ACTS) was efficient and helpful with most people happy with their dealings with them.

A number of people were not aware of a media presence at the Congress, which I find surprising as we kept delegates out of lunch for about 10 minutes on one of the days due to a television interview. Delegates did think that a media presence at a congress was important and that the congress provided a good opportunity to showcase physics in the media. A separate report by Kate Wilson highlights the impact we had on the media. I am very encouraged by what we achieved at this congress and as Communications Officer of the AIP I hope to develop this over the next few years.

People were satisfied with the selection of the Keynote and Plenary speakers and the topics they covered. Most people were happy with the length of the talks though some preferred them longer and suggested 45 minutes. There was also a need identified for more female speakers amongst the Plenary speakers.

The program was well received and delegates thought that the Minister of Science, the Hon. Peter McGauran, was a suitable person to officially open the Congress. Some people identified the need to broaden the participation in the congress and it was asked where are the Astronomers? Maybe next time guys?? We haven’t seen you since 1988!

The audio-visual support was good and the quality of talks high. A number of talks did not finish on time and most of our delegates indicated that it was very important that they did. Something to watch out for in future congresses, especially if you are one of the speakers that goes over time!

The lunch on Monday and Tuesday was well received but members found it a little less so on Wednesday. Note that the lunches on the last two days of the congress were not sponsored. This highlights the need to actively seek sponsors for all aspects of the Congress. Everyone in our community can help with sponsorship.

The feedback from the exhibitors was positive. Most thought that being away from a university was better. They were all pleased to see the Welcome reception held in the exhibition hall and said it gave them a great opportunity to mingle with people in a social setting. Lunch and morning/afternoon tea in the exhibition area was also a plus. The venue was excellent and the lighting was good. There were differing opinions about the fees for exhibition booths but overall most were happy to be there and talking to us. Delegates expressed a desire for more at the exhibition. We need help from you to identify and approach the people from industry that you would like to see at the exhibition.

The submission of abstracts on the web did not appear to cause many problems. Some people thought that it was important to be able to submit abstracts in Latex but it did not appear to be a very important aspect of the congress. Given the expense of receiving abstracts in Latex and processing them (only universities have the ability to deal with Latex) I will be recommending to the next committee to leave out Latex support. Delegates did believe that figures and references were important in an abstract. The poster competition was well received with a number of delegates suggesting we also have a competition for the best talk(s).

The refereed proceedings were well received with most delegates indicating that they should be made available at future congresses. Some thought will need to be given to the page limit.

Some of the comments I received in the long responses I believe summarise the findings above:

- Pal has done an excellent job. One of the best Congresses I have been to.
- I enjoyed the Congress. Learnt some interesting/cool stuff going on outside my field of research. Good job!
- Well done.
- A sense of excitement (buzz) about the conference.
- Outstanding organisation both before and during the Congress, and very friendly, helpful organisers, both AIP based and ACTS.
- Media attention — amazing for a Physics meeting and hope it might be a sign of good things to come in public interest.
Report from the Program Committee

For this Congress the Program Committee made a concerted attempt to respond to evolving needs of our Physics community. As a matter of course the traditional role was retained and we reported and celebrated highlights of recent academic achievements. However at the same time we addressed the important interface between academia and industry. The Congress theme was Physics and Industry Working Together, and this underlined the fact that the dynamism and creativity of physics extends well beyond academic confines.

The Congress venue was the splendid Sydney Convention & Exhibition Centre at Darling Harbour. It was a superb venue and it functioned very well. It was interesting to observe just how much a difference such a venue makes in attracting commercial exhibitors and in attracting the interest of the media. The media were actually eager to be there and this led to a relatively high level of coverage. The functional and compact layout of the Convention Centre drew together the delegates from the different streams in a single pleasant area. This actively encouraged many lively discussions and interactions spanning the diverse disciplines. At the same time the area was the setting for the two Posters Sessions and for the commercial exhibits.

A successful innovation at this Congress was the Industry Forum. The presentations from five physicists and senior representatives of leading technology-based Australian companies focused on the practical problems of commercialising good ideas. The speakers were:

Bruce Cornell (Senior Vice President, Ambri Ltd), Critical Care Diagnostics - Ambri Ltd,
Franco D Alessandro (Research Physicist, ERICO Lightning Technologies), The Dynoshere - increasing the efficiency of lightning protection - ERICO Lightning,
Jim Patrick (Senior Vice President, Cochlear Ltd), The Cochlear Story,
David Robinson (Managing Director of Bishop Technology Ltd), Engineering Innovators in Automotive Steering and Transport Technology - Bishop Technology Group, and
Jim Williams (Director, Acton Semiconductors), Semiconductor Optoelectronic devices at ANU: From Cutting Edge Research to Commercial Opportunity.

The Convener of the Forum, John Lowke (C.S.I.R.O.), clearly set out in his introduction the reasons each presenter had been invited to speak. This brought the diverse presentations together within a coherent structure. The talks were frank and surprisingly candid, and the overall outcome was practical and informative. There were two Lectures for the General Public at the Congress.

Karl Krasznaički, Dr Karl from the ABC, gave a highly entertaining presentation Great Moments in Science □ - The Four Forces and Murphy’s Law. This was received with tremendous enthusiasm by his large audience.

Harrison Schmitt, the last astronaut and only scientist to walk on the Moon on the Apollo 17 expedition (a full thirty years ago) gave a provocative lecture titled Fusion: The Space Connection. In his futuristic talk he speculated on commercial mining of Helium-3 from the surface of the moon to provide an abundant source of clean energy for the Earth.

There were ten major interest groups. Each group nominated a speaker for a Plenary talk. The Plenary talks were half-hour presentations. This expanded the time available for the specialist parallel sessions, but the restriction to half an hour proved controversial, with both enthusiasts and detractors. The majority of the Plenary speakers gave more specialised Invited Talks within their parallel stream.

Another innovation at the Congress were the one-hour Keynote talks. The Keynote talks were selected by the Program Committee from the Plenary talks on the basis of a perceived wide appeal to the general educated public, and the associated possibility of interest from the media. The Keynote talks lived up to their high expectations and broke much new ground.

Mark Scats, CEO of the Australian Photonics CRC employing 200 staff and which has spun off eight companies, gave the ACOFT talk Photonics - Physics and Industry - Today and Tomorrow.

Richard Maughan (Pennsylvania), who played a major role in establishing the first neutron therapy accelerator facility at the Karmanos Cancer Institute and who is now working on a proton therapy program at the University of Pennsylvania, gave the Medical Physics talk Hadron Therapy on recent very exciting developments in Radiation Oncology.

Sheila Tobias (Arizona), who is working on professionalising the science master's degree to attract more management students to science, gave the Physics Education Group talk on a vital challenge to academic physicists of Who will Study Physics. Her presentation was especially provocative and thought provoking. She looked into a future with Physics Departments teaching a Physics Professional Degree, a degree that would carry the perception of a much broader use within the emerging new society than is the case now with our traditional academic Physics degree.

Finally, Bertram Batlogg (ETH Zurich) was to have given the CMP Keynote talk, Organic Molecular Crystals: New Perspectives for Science and Technology. However because of recent controversy he decided at the last moment that it would be inappropriate to address a major scientific meeting. Instead, Alex Hamilton (University of N.S.W.) and Ross McKenzie (University of Queensland) were prevailed upon at short notice to review polymer electronics. Together they gave an exciting overview of this rapidly developing new field.

The Plenary talks were as follows:

Boris Kasyer (Fermilab), formerly the National Science Foundation Program Director for Particle Physics and a foremost phenomenologist in the area of neutrino physics, gave the AINSE/NUPP talk, Antiparticle symmetry violation and our existence.

Philip Burke CBE, FRS (Queen’s University of Belfast) the father of computational collision theory, gave the AMPOC talk, Atomic Collisions: Applications, Advances and Challenges.

Gerhard Rempe (Max-Planck Institute for Quantum Optics), Director of the MPI Quantum Dynamics Division that focuses on experiments with ultra-cold atoms and their quantum behaviour, gave the AOS talk, Taming Individual Atoms and Photons.

Barry Barish (Caltech), Director of the Laser Interferometer Gravitational-Wave Observatory (LIGO) Laboratory, gave the ASRG talk, LIGO and the Search for Gravitational Wave.

There were three additional Plenary talks.

Brian Schmidt (Australian National University), who has carried out...
groundbreaking research in the detection and measurement of supernovae at very high redshift, a source of key evidence that we live in an accelerating universe, spoke on *Measuring the Universe with Supernovae*.

Alan Jones, Chief Executive and Managing Director of the Institute of Physics Events, gave a talk *Physics - the Agony and the Ecstasy*, and Sir Peter Williams, President of the Institute of Physics (U.K.) spoke on *Physics and Engineering - Breaking Down The Barriers*.

There were two Poster Sessions, each Session displaying its Posters for two full days. The total number of Posters was 180, somewhat down from previous Congresses. This was partly thanks to the expanded time allotted for Parallel Sessions, but also because fewer students attended. It was very encouraging that the standard of the Poster presentations was so extremely high. Quality presentations from the students were recognised by the award of substantial cash prizes to the best Student Posters. Congratulations to the first-place Student winners, Tim Dean (Australian Defence Force Academy) and Carlin Yassin (University of N.S.W.).

The Massey Medal for contributions to physics by an Australian physicist was awarded this year to Bob Delbourgo (University of Tasmania) who covered all dimensions in his lecture. The Bragg Medal for the most outstanding PhD thesis in physics went to Nicole Bell (formerly University of Melbourne, now at FERMILAB) who spoke on the significance of neutrino oscillations in the early universe. A new award this year was the Alan Walsh Medal for Service to Industry. This was awarded jointly to Ian Bassett and John Haywood (Australian Photonics CRC) for their work on optical fibre sensors.

The AIP Congress must cover many very different sides of Physics and it is quite a challenge to ensure that it remains a coordinated meeting, one in which participants benefit from the diverse Programs of the different Interest Streams. At the same time, the organisers for the specialised fields need to have the greatest of flexibility so they can organise their individual programs to make them vigorous and of a very high international standard. In the end the standards of both the oral presentations and the posters turned out to be extremely high, making the Congress an enjoyable and stimulating event.

The complex Congress Program was organised by the Program Committee, key members of which were the Program Coordinators. There was one Program Coordinator for each of the ten specialist Interest Streams. Each Program Coordinator formed an independent sub-committee that held complete responsibility towards its Interest Group. The Program Committee was spread out nationally, making it impractical to organise face-to-face meetings. Communication was by constant circulation of email and by phone hook-ups. In hindsight, a few face-to-face meetings would have greatly assisted in the Program planning.

The Program Coordinators did a really incredible job for this Congress. There were some very testing circumstances, such as when a sizeable fraction of the abstracts, apparently correctly submitted electronically, disappeared into the ether. The Coordinators dealt with each of the challenges with exemplary professionalism, patience, perseverance and with hardly a murmur of complaint.

I want to sincerely and publicly thank the full Program Committee for their professionalism, dedication and for a job very well done. Special thanks also to George Hatzidimitris who developed the fine looking Program page for the web (www.phys.unsw.edu.au/AIP2002) at very short notice. The full Program Committee consisted of the AINSE/NUPP Coordinators - Dennis Mather (AINSE) and Stuart Tovey (University of Melbourne), the AMPQC Coordinator - Igor Bray (Murdoch University), the ACOPT Coordinator - John Canning (Sydney University), the AOS Coordinator - Chris Chantler (University of Melbourne), the ASGREG Coordinator - John Steele (University of N.S.W.), the CMP Coordinator - Michelle Simmons (University of N.S.W.), the Industrial Physics Coordinator - Ken Doolan (University of Western Sydney), the Industry Forum Coordinator - John Lovce (C.S.I.R.O.), the Medical Physics Coordinator - Anatoly Rozenfeld (University of Wollongong), the Physics Education Group and the Women in Physics Coordinator - Manjula Sharma (University of Sydney), and in addition, Bruce King (University of Newcastle), John Love (Australian National University), Julian Lover (Murdoch University), Keith Nugent (University of Melbourne) and Peter Metcalfe (University of Wollongong).

Finally I would like to thank all the participants at the Congress for creating such a successful, informative and enjoyable meeting.

David Neilson
Program Chair, July 2002

Dr Karl Kruszelnicki and Pat Pokete at the Public Lecture on Tuesday evening.

Publicity Officers Report

The aim of the public relations campaign was to increase public awareness of physics in Australia, and the role that physics plays in the development of technology. In particular the aims were to promote the AIP congress to the popular media, thus reaching as broad an audience as possible.

The public perception of physics is something which the AIP needs to work hard to change. Most Australians have very little awareness of the role physics has played in creating the world that we live in now and the technologies that we use everyday and often take for granted. They perceive it as that really hard subject at school that all the nerdy kids did, not as something that is relevant to them, or as something that is worth being funded. By promoting physics via special events such as the congress we hope to change this perception.

The publicity campaign can be divided into two parts — promotion of the congress to physicists prior to the congress to encourage them to attend, and promotion of the congress to the media during the and immediately before the congress to raise public awareness of the physics in Australia.

Prior to the congress an article was placed in the *Physicist* each month outlining the highlights at the congress such as keynote speakers and public talks. Articles were also sent to a range of other publications, such as the STANSW newsletter and *Campus Review*. There was no budget for advertising for the congress, so articles were placed with sponsorship in kind in publications which normally charge for such notices, for example *Optics Spectrum*.

Unfortunately registrations were still down on previous years, probably owing to several factors including the increased cost due to holding the congress in Sydney, and competition with other conferences running in the same week.

The second phase was getting generating media interest in the congress. A month prior to the congress media kits were produced and sent to science writers and reporters at newspapers, radio and television stations. In the few weeks prior to the congress a series of timed media releases and diary notes were sent to newspapers, radio and television stations, notifying them of highlights at the congress. In addition, the PR group for the Synchrotron Project (the Victorian Government public relations) were involved with promoting the synchrotron talks at the congress. During the congress a series of today's highlights at AIP Congress2002 were faxed to relevant media.
The media campaign was a great success. My mobile phone hardly stopped ringing from the day before the congress until the closing. The most media interest was generated, not surprisingly, by the astronaut, Harrison Schmitt. The ABC’s 7:30 Report came down to the congress and Kerry O’Brien interviewed Schmitt in the congress exhibition area. While this resulted in great publicity for physics, and the congress, a few people did have to wait nearly 5 minutes to get into the area to get their coffee at afternoon tea time, and my apologies to those who were disgruntled by this. Channel 10 also came down and filmed a short interview with Schmitt, followed by a walk through the exhibition area, showing large numbers of physicists drinking coffee around some of the exhibition booths, notably Agilent and Innovations group, while the voice over described the congress as the largest meeting of physicists in Australia. This aired on the 10 late news, which is national - the early news is largely local, particularly in Sydney.

On the Monday prior to the congress, while still at the Astrobiology Conference on Hamilton Island, Dr Schmitt was interviewed over the phone by John Laws. The interview was set up by myself (with some help from a friend in PR), and hence the interview gave his reason for being here as the AIP congress, and focused on physics and science in general, rather than astrobiology.

This was a very successful interview, which resulted in John Laws interviewing another one of our speakers — Richard Maughan. This interview was done over the phone and broadcast live, from the AIP congress administration room. The topic was hadron therapy, and the interview generated a large number of phone calls to the radio station. The John Laws program has an audience of nearly 2 million — 10% of the Australian population, and virtually all of voting age. To have an audience this size listening to physics being promoted as an important part of medicine and a valuable thing for society to invest in is extremely valuable.

Since then there has been a follow up interview with Michael Jackson, the head of radio-ontology at the Royal Prince Alfred Hospital.

Advertising on the John Laws show, which is syndicated across Australia, costs over $2K per minute. Companies will spend over $60k to get the equivalent air time in advertising to the air time that we got, and people will listen to the interviews when they switch off during the adds.

Apart from astronauts and medical physics, the synchrotron session also generated media interest. Business Sunday (channel nine) filmed Sir Peter Williams talk at the congress, and interviewed Sir Peter, Richard Garret and Keith Nugent after the session. On the following Sunday morning, Business Sunday had a lengthy report on the synchrotron, some of which was filmed at the congress, the remainder at the synchrotron site in Melbourne.

The Australian Financial Review also interviewed Sir Peter Williams at the congress, and published an article on the Australian Synchrotron project.

Sir Peter was also interviewed by ABC radio s Robyn Williams, with the interview to air sometime in August.

Physics education also attracted interest. Robyn Williams interviewed Sheila Tobias, again with the interview to air some time in August/September. Prior to her arrival, Sheila Tobias was interviewed over the phone by a reporter from the Adelaide Advertiser. After her arrival, she was interviewed by the Sydney Morning Herald education reporter, and an article appeared on page 3 (apart from the front page, this is the best page to be on even better than page 2, because of the

Media Coverage
This is a summary of the media attendance and coverage of the congress. Note that in all these articles/interviews etc, the congress was mentioned in the introduction at least, and usually during the article as well. All interviews were done over the phone or at the congress venue, and filming by Channels 9, 10 and the ABC was done at the congress venue. Apart from the Newcastle Times article and the Business Sunday segment, all media interactions were handled and coverage organized by Kate Wilson and Chris Stewart (CPR). Newcastle times article on John O Connor, Business Sunday contact set up by Victorian Government PR department.

<table>
<thead>
<tr>
<th>MEDIA</th>
<th>COVERAGE</th>
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<tbody>
<tr>
<td>John Laws show</td>
<td>Schmitt interview with Laws on Monday, Schmitt interview replaced Friday in highlights of the week, Richard Maughan on Thursday, Follow up interview Monday 21st with Michael Jackson.</td>
</tr>
<tr>
<td>2M (National, audience 2M)</td>
<td></td>
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<tr>
<td>SMH (Sydney broadsheet)</td>
<td>Article in Thursday's SMH page 3 with large photo.</td>
</tr>
<tr>
<td>7:30 report – Kerry O'Brien (National)</td>
<td>Excellent interview with Kerry OBrien, filmed in exhibition area in front of agilent stand, aired Wednesday 7:30 report, have tape.</td>
</tr>
<tr>
<td>Robyn Williams, ABC radio (National)</td>
<td>Interviewed Sheila Tobias, Sir Peter Williams and Alan Jones on Thursday afternoon, to air on Science Show or in Conversation in a few weeks.</td>
</tr>
<tr>
<td>Adelaide Advertiser (Adelaide broadsheet)</td>
<td>Interview by phone to US with Sheila Tobias, article written and published in advertiser Thursday prior to congress, have copy.</td>
</tr>
<tr>
<td>Australasian Science (National)</td>
<td>Phone interview with Sheila Tobias, other info from Chris Hamer and PEG community sent, article in preparation.</td>
</tr>
<tr>
<td>Business Sunday (Channel 9)</td>
<td>Film Sir Peter's talk at 8:30 am, Interview with Sir Peter – 10:30 am, followed by interview with Keith Nugent and Richard Garret–11am. Aired extensive article on Sunday, but used only footage of Sir Peter Williams, not Keith or Richard.</td>
</tr>
<tr>
<td>AAP (Australian Associated Press - feeder for Australian newspapers, the Australian version of Reuters)</td>
<td>Attended press conference for Schmitt, and interviewed Sir Peter Williams by phone - have not seen outcome, did not have enough media monitoring.</td>
</tr>
<tr>
<td>2SM radio (Local Sydney station)</td>
<td>Short Interview with Schmitt on Wednesday - aired live. (Young audience.)</td>
</tr>
<tr>
<td>Australian (National broadsheet)</td>
<td>Faxed talk, article on Sheila Tobias and physics education appeared Tues Australian, page 3, have copy.</td>
</tr>
<tr>
<td>Financial Review (National, influential business paper)</td>
<td>Interview by phone with Sir Peter Williams, article on synchrotron published following Monday (?), have copy.</td>
</tr>
<tr>
<td>Channel 10 late news (National – note that earlier run is local, particularly in Sydney)</td>
<td>Short interview with Schmitt, walk-through of exhibition with commentary by Frank Collett on the congress, nice vision of agilent stand and innovations group AFM.</td>
</tr>
<tr>
<td>ABC Radio National (National)</td>
<td>Short piece on Schmitt, - 6:30 pm Wednesday evening, with grabs from press conference.</td>
</tr>
<tr>
<td>The Age (Melbourne broadsheet)</td>
<td>Phone interview with Sir Peter Williams - have not seen article, but don't have easy access to age.</td>
</tr>
<tr>
<td>Newcastle Times (Newcastle local paper)</td>
<td>Article on John O'Connor and colleagues receiving prize from IOP for promoting physics to the public in Newcastle.</td>
</tr>
</tbody>
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way the paper folds). Sheila’s talk was also reported on in the *Australian*, on the Tuesday of the congress, in the general section, which has wider, if less specialized, readership than the Higher Education supplement. *Australian Science* also interviewed Sheila Tobias, and are preparing an article on the state of physics education in Australia, to which end I have been supplying them with information on innovations in Australian physics education. This is a quarterly, so it will be out later in the year.

This is not a complete list of the media reports which resulted from the congress publicity plan — other newspaper articles and radio reports have been published and broadcast.

The most important result is that the Australian media are now aware of the AIP and the AIP congress in particular as a source of information and interesting stories. The AIP congress is now on the radar of the Australian popular media. The groundwork is well underway, and hopefully with continued effort the AIP will be the people contacted when the media wants to know something about science policy, science education, or even physics itself.

*Kate Wilson*

**Reports from Parallel Sessions**

**AOS/AIP/ACOFT2002:**

A great opportunity for a wide range of interests, and a non-zero interaction coefficient of science with industry and media

The latest conference of the Australian Optical Society was collocated with the 15th National Congress of the Australian Institute of Physics and the Australian Conference on Optical Fibres and Technology at Darling Harbour from Monday 8th to Thursday 11th July, 2002.

The collocation with the AIP and ACOFT (separately) is something we have done before. However, the use of this opportunity as a direct link with the public, media, industry and political groups was a significant experiment for our Society and the Institute. Significant numbers of us are members of these other groupings, and it was an opportunity to see the larger Physics community. Attendance by non-Physics-based members was improved over the last AIP collocated Congress. While our policy for submissions and selection procedures was unchanged, there was an increased bureaucratization of submission and registration, with an increased burden on us financially. The financial burden of Sydney and Darling Harbour was perhaps shown in the smaller numbers in several streams, especially student numbers; and in the absence of some streams usually represented in the AIP Congress. However, final overall numbers held up well. Key highlights of this conference from the point of view of the organizers are:

1. The AOS Conference alone was the largest stream in the collocated Congress in terms of submissions and presentations: 105 or so abstracts (see point 4 below), and a good number of talks on the usual wide range of topics represented by our membership. This of course does not take into account the large fraction of our membership that submitted papers to the ACOFT collocated conference stream, and of course members that concentrated on attending any of several related streams.

2. AOS stand-alone conferences have usually had peer-reviewed abstracts in the conference proceedings, corresponding to the assignment of an ISBN number etc. Historically the AIP Congress has avoided this, so it was a significant development to review paper submissions for the CD-ROM proceedings of the Congress (ACOFT is dealt with separately on this issue) and the response has been very welcome. The readers will judge the success of this initiative when they see the final product in a few months. For AOS, it is natural that several of the talks and abstracts were either review in nature, or were in the process of a major submission elsewhere, so that there were 23 submissions for the CD-ROM proceedings. I view that as a broad cross-section of our membership and welcome further developments in the future.

3. Our cognate societies OSA and SPIE were represented both in person (with our guest Mike Morris, incoming president of OSA) and in kind. Both OSA and SPIE contributed student prizes for the best student talk and best student poster in the AOS stream. This represents a development over the last collocation, in that each prize was worth US$1250, in part towards attendance and presentation at an SPIE or OSA sponsored conference by the student. A great success was the excellent standard of our student presentations collectively. Indicative of this was the short-listing of our awardee as a winner of one of the student poster awards of the Congress. Of which more below.

4. A particular effort of the organizers of AOS this time has been in joint sessions with other streams. We have benefited by this overlap and interaction, and I think the conference itself has been better for it. One joint session with ACOFT is a natural statement of our interest in fibre optic technology and related developments in optics. Our first session was a joint AOS/AINSE/NUPP/AMPOQC sessions in honour of Geoff Opat who contributed so much to each grouping and sadly passed away recently as has been detailed in the last issue of AOS News. Another joint AOS/ASGCRE/Artoz session was dedicated to Prof. Hanbury-Brown (on Interferometry) after he also passed away. These two remarkable individuals were life members of our society (or we don’t have that many, so both were significant losses for ourselves as well as Australia). At this point my fatigue set in, as there was no reason why joint sessions with Condensed Matter Physics, the other large stream at the Congress, could not be arranged at this or some future joint Congress.

I must thank the other members of the AOS Technical Program Committee: Keith Nugent, Barry Sanders, Murray Hamilton, and Ken Baldwin. In a personal or scientific sense, while we had fewer invited international speakers than is usual for an AOS Conference, these were substantially boosted by invited national speakers, and particularly by the joint sessions with other streams, and the plenaries of the Congress itself. The public lectures by such distinguished speakers were very entertaining, and our plenary Prof. Gerhard Rempe gave an exciting overview of many fascinating and demanding experiments and their results. I was caught up by behind-the-scenes work, but found highlights in plenaries by Profs Boris Kayser (AINSE/NUPP), Philip Burke (AMPOQC), Barry Barish (ASGCRE), and Brian Schmidt (AG). The IOP plenaries and the Bragg and Massey medal talks were also well done and entertaining.

Within the AOS Conference stream, Mike Morris gave a lecture at the usual high standard from our cognate societies with his talk on fabrication and development of diffractive optics. Savely Karshenboim gave an impressive overview of some of the key areas of current and future research and theoretical limitations in Quantum Optics, and Ken Gratton gave an excellent talk on optical communications.

I think the audience was particularly moved by the joint session in honour of Geoff Opat, chaired by David Neilson, with presentations by Keith Nugent, Tony Klein, Stuart Tovey and Peter Hannaford. I found all speakers in the joint sessions to be balanced, timely and clear in their excellent presentations. In my very limited experience of other streams, I found several talks in the AMPOQC stream to be inspiring.

Hence, I think the collocation was successful, particularly in enabling students to see a wide range of possible futures and areas of research. I was saddened by the absence of ‘Solar, Terrestrial and Space Physics’, and ‘Antarctic research’ two streams I particularly enjoyed at Adelaide, and the relative absence of Astro. Because of the collocation, there was little overlap with Medical Optics and the MP stream, but I hope members were able to take the opportunities presented. In a stand-alone conference we have more opportunities to invite such related groups and to have them integrated with the AOS program a little more smoothly. Another measure of success was the excellent industrial presentation and sponsorship. Links between industry and research are crucial for
Australia and are sometimes neglected; this Congress highlighted them. We can only look forward to future conferences with this relationship strengthened further. Many of the sponsors are usual sponsors of the AOS conferences. Interactions with the media with the two public speakers and the synchrotron presentations, especially from the IOP, were particular highlights in the coordination of the Congress. Pal Fekele and David Neilson deserve special mention in this context.

There were only two parallel AOS sessions in the last session of the conference. This was an advantage for the coordination of academics and students; this last session had excellent student talks, while several senior academics had unfortunately already left.

At the last AOS/AIP Congress in Adelaide, we had some 74 speakers, with some 106 posters distributed in two sessions (i.e. 180 total abstracts, compared to this year 105+). Although I mention this as a warning, part of this was dictated by the fees, by other major international conferences like IQEC, ICAP and SPIE within two weeks of the Congress, by the recent staging of our other conference ACOLS, and by the collocation with ACOFT, where of course many of our submissions were sent. Perhaps the website submission procedure could have contributed something to this, and hence I would commend improvements in these areas in future conferences.

There were too many good sessions to mention individually. Amongst the students, the quality of oral talks was again very high, and I might particularly cite Matthew Arnison (U. Sydney), Michael Brenner (U. Queensland), Nathan Langford (U. Queensland) and Martin de Jonge (U. Melbourne) amongst many others.

One of my highlights of the conference was the difficulty judging the AOS/OASA/SPIE student poster and oral prizes (and the AIP student poster prizes) with so many clear and insightful presentations. The winner of the AOS/OASA/SPIE student poster prize was Brian Orr's student Florian Englisch (Macquarie); and the winner of the AOS/OASA/SPIE student oral prize was Martin de Jonge (U. Melbourne).

My congratulations to the winners.

Chris.  Chantler

19th ANISE/NUP Conference

This conference of the Nuclear and Particle Physics group, sponsored by the Australian Institute of Nuclear Science and Engineering, was held in conjunction with the 15th AIP Congress.

The plenary speaker associated with this stream of the Congress, Dr Boris Kayser of Fermilab, talked on "CP violation and our existence", a topic of immense interest. He did a superb job, especially as he was only allotted 25 minutes.

The 34 talks and 13 posters illustrated the diversity of the NUP community. The topics covered ranged from nuclear physics to high-energy physics. Both sessions were about equally divided between experimental and theoretical presentations.

The number of participants in this stream was significantly down when compared to recent congresses. As a consequence most authors submitting papers were offered an oral presentation, the universally preferred option. The quality of all the presentations, oral and poster, was impressive.

Our invited plenary speaker (Boris Kayser) gave us an inspiring 40-minute talk on his current main research activity, neutrino physics. It was an exposition of great clarity and enthusiasm. Some highlights covered were:

- The recent results from the SNO detector in Canada have provided the final evidence that solar neutrinos really do oscillate, and that the long-observed deficit was not caused (for example) by a low production rate of neutrinos in the Sun.
- The implications of the contested result from the LSND experiment at Los Alamos, which will soon be confirmed or refuted by MiniBoone at Fermilab. If confirmed then nature needs an extra, sterile type of neutrino, sometimes called the "neutrino". If refuted then we can explain all data with the three known species.
- A description of key experiments coming on-line in the near future, for example KamLand and Borexino.

His talk was supplemented by many fine talks by other speakers. A list of the longer talks will give an idea of the diversity of this stream:

- David Krofcheck (Auckland), "Studies of highly compressed nuclear matter using Au+Au collisions at Brookhaven".
- Brian Robson (ANU), "A new classification of the fundamental particles".
- George Dracoulis (ANU), "Isomers as a probe of triple shape existence in neutron deficient Pb nuclei".
- Kevin Varvell (Sydney), "Final results from the NOMAD Experiment at CERN".
- Glenn Moloney (Melbourne), "Recent results on charge-parity symmetry violation from the BELLE Experiment".
- Stuart Tovey (Melbourne), "The future of experimental HEP in Australia".

Traditionally a prize is awarded for the best talk by a student. On this occasion the panel was unable to decide between two exceptional talks and, as their subject matter was very different, it was decided to award two prizes. The winners were Rachel But (ANU) with "Exotic fission fragment angular distributions" and Ross Young (Adelaide) with "Chiral physics in lattice QCD".

Finally as the Chairman of this stream, I would like to thank Dr Dennis Mather and Mrs Irene Parker of ANISE for their extremely efficient help in all aspects of organising this meeting.

Stuart Tovey

AMPOC

The pervasive nature of Atomic, Molecular and Quantum Chemistry research into many areas of physics was evidenced by the breadth of topics covered in the sessions. As an illustration, a number of examples from the oral and poster presentations are summarised below. Professor Philip Burke provided the keynote address in his talk titled "Atomic Collisions: Applications, Advances and Challenges". In his presentation he provided a historical account of developments in the field from the genesis of quantum collision theory to the present day. The impact of recent developments in both theoretical and experimental techniques on our understanding of collision processes were discussed and the ramifications of latest advances described. Tuesday afternoon marked the beginning of the contributed papers to the oral sessions. Talks were presented demonstrating how detailed calculations and experiments on atomic systems, including those on highly charged ions, can provide answers to fundamental questions in particle physics and QED. Theoretical and experimental studies into the possible variation
of fundamental physical constants were also described with more sensitive tests proposed for future investigations.

A number of presentation covered topics in electron-impact ionization. These ranged from prototype studies to probe the many-body dynamics of systems of interacting particles, experiments designed to sensitively probe bound state electron correlation effects in molecules and the application of experiment and theory to probe the composition of the earth's atmosphere. Of significant technological interest were presentations describing investigations into the electronic properties and the future potential of molecular diodes incorporating organic semiconductors and studies into the optical properties of conjugated polymers.

Impressive recent advances in the production of highly energy tunable and energy resolved positron beams and their applications to scattering experiments were also covered in the poster session, opening up a wealth of new experimental possibilities. This work was complemented by theoretical advances in positron research presented in a separate poster, where the stability of a range of positronium atoms and ions were calculated and the interaction of positrons with atoms investigated.

In summary, the meeting provided an excellent forum to explore commonalities and differences between the aims, techniques and approaches to studying a diverse range of physical phenomena. Whilst the numbers of participants were down on previous years, those who attended contributed enthusiastically to the sessions and the meeting demonstrated the high level and diversity of activity in Atomic and Molecular Physics research in Australia.

Julian Lower
Igor Bray

ASGRG

The Relativity stream's plenary speaker was Prof Barry Barish of Caltech, director of the Laser Interferometric Gravitational Observatory. In his plenary he outlined the basic operation of LIGO and progress at its two sites in Louisiana and Washington states. Engineering runs are almost complete, and they expect to make the first serious scientific measurements early in 2003. In his later longer talk, to the ASGRG parallel session he gave further detail on progress and their future plans.

Our parallel sessions were split into three separate types: theoretical (Monday sessions), gravitational wave detection (Thursday sessions) and the joint session with the AOP stream commemorating the late Robert Hanbury Brown (Wednesday).

The theoretical talks covered a range of topics including rotating cosmic strings, general and higher dimensional singularities and two talks on the theory and evidence for variation in the fine structure constant.

The gravitational wave talks fell into two types: overviews and specific problems. Barry Barish, David McClelland and Sue Scott gave overviews of current projects and an outline of the case for siting an observatory in Australia. The more specific talks were also of two general types. Benedict Cusak and Antony Searle (ANU) discussed two problems associated with global correlation of data and removing spectral lines caused by other environmental disturbances (such as power lines). Malcolm Gray, Chris Hollit (both Adelaide) and Ju Li (UWA) reported on progress in various aspects of noise reduction for these extremely sensitive instruments.

John Steele

CONDENSED MATTER PHYSICS

The condensed matter program of the Australian Institute of Physics had an unusual theme this year – in an attempt to break down the interdisciplinary barriers chemists, polymer engineers, electrical engineers and biophysicists all grasped the steps of the convention centre in Darling Harbour together. The location was superb with bright sunny days in Darling Harbour and an excellent meeting area in which to mix between sessions.

Over 100 abstracts were submitted to the condensed matter stream of the Congress demonstrating the strength of the CMP community. It soon became obvious that we were going to have to increase our initial allocation of 7.5 hours for the CMP sessions to having 15 hours – not an easy task with only a couple of months to go. This number of abstracts is particularly impressive given that in 2002 there will have been 3 major condensed matter conferences Wagga, COMMAD and the Congress. The central theme to the Congress was Physics in Industry Day so we took the initiative to invite some of our industrial collaborators to support special focussed sessions including Polymers, Nanotechnology, Advances in Silicon and Electronic devices. We were very fortunate to gain sponsorship from Dupont, Talbot Street, Scientific Technology and Prodigital and we would like to take this opportunity to thank these sponsors for their support of the physics community.

There were many highlights of the Congress including a timely talk by Sir Peter Williams discussing the many industrial uses of synchrotron radiation, such as tracing the distribution of pollutants in a wetland; protein crystallography; analysing hair samples for trace elements to determine for example whether Beethoven died of lead poisoning; and many others. He noted that there are 43 established synchrotrons in the world today, with 12 under construction and 19 more in the planning stages, and his talk provided a good summary of potential applications for the new synchrotron in Australia (for more information see www.synchrotron.vic.gov.au).

Another highlight of the condensed matter program was the "Advances in Silicon" session, where we had 3 excellent speakers remind us that despite over 50 years of research into silicon semiconductor devices we are still able to discover and invent new ways of developing devices with novel and unexpected phenomena. Martin Green reported how UNSW researchers have increased the efficiency of silicon light-emitting diodes by more than an order of magnitude to above 1%. David Jamieson reported on new techniques for implanting single dopant ions in silicon and detecting them as they enter the crystal, paving the way for the fabrication of a silicon based quantum computer. Finally Jim Williams showed how to detect minute traces of metal contamination in silicon devices and the relevance of nanoscale contamination in processing impurities of metal contamination away from the active regions of the device. It was a very exciting session.

Despite the loss of our Keynote speaker, Bertram Battlog, we were able to benefit from superb exposé on organic devices from Ross McKenzie and Alex Hamilton, forming another highlight of the Congress. As to the stats - there were 19 invited talks (6 from overseas), 21 contributed talks and 62 posters providing a good mix of opportunities to chat with people about their work. With one of the strong recommendations from the organising committee to increase the number of female speakers CMP did well with 3 of the invited speakers being female and 2 of the contributed speakers (equating to ~12% of the speakers). The quality of the CMP poster competition was outstanding,
and whilst she didn’t win a prize Yvette Hancock’s poster was perhaps
the most innovative and certainly the most fun! Congratulations to her
for her attempts to make us all Hubbard model converts.

Finally I would like to give special thanks to the Condensed Matter
Committee for all their help:

Stephen Collocot         Cathy Foley
Michael Ford             Mukunda Das
David Jamieson          David Neilson
Michelle Simmons

John Haywood and Ian Bassett are awarded the Alan Walsh Medal for
Service to Industry by the AIP President, John O’Connor (R).

INDUSTRIAL PHYSICS STREAM

Congress 2002, with a significant bias to commercialisation of
physics in keeping with the theme of the conference, was a very
different Congress compared with all of the previous conferences of
the AIP. The Industrial Physics stream began with the poster session
on the Monday evening and continued from 11 am on the Tuesday with
four sessions, the Industry Forum, Walsh Medal Lecture & two
sessions of contributed papers.

Highlight of Congress was the two hour Industry Forum in which
commercial aspects associated with manufacture of high technology
products by six different Australian companies were presented. John
Lowke did an extremely good and well researched job as Master of
Ceremonies for the Forum by providing background information to
introduce and link each of the six speakers:

- Jim Williams discussed trials and tribulations in setting up
  ACTON Semiconductors to manufacture GaAs lasers,
- David Psaila (filling in for Simon Poole) described the
development of JDS Uniphase as a spin-off company from the
  Optic Fibre Technology Centre, set up to manufacture fibre optic
  Bragg gratings,
- Jim Patrick described the basic acoustics that led to the
development of the Cochlear implant in parallel with the world
  wide growth of Cochlear Ltd,
- David Robinson described the variable ratio automotive steering
  system and other innovations that have led the Bishop Group of
  Companies to hold some 350 patents world wide,
- Bruce Cornell discussed the inception and growth of AMBRI Ltd
  a company set up to develop and market a sophisticated rapid
  medical diagnosis system and which now holds 60 patents with 75
  pending,
- Lasty Franco D’Alessandro outlined the development of the
  patented Dynasphere (which should be called Dynaspheroid)
  lightning protection system by Tasmanian company ERICO
  Lightning Technologies and described the physics behind how it
  should theoretically work.

Many questions were raised by the speakers in connection with the
rough road to successful commercialisation of innovative products
but there was little time to discuss them during the forum. All
speakers emphasised that patents are only worthwhile if you are
prepared to, and have the resources to, defend them.

The inaugural Walsh medal presentation and lecture followed at 2pm.
The 2002 first ever Walsh medal was awarded jointly to Ian Bassett
and John Haywood for service to the optic fibre industry and
development of optic fibre devices and, in particular, for "the
development of an optical fibre current sensor" with commercial
application in the electric power industry. Ian Bassett gave an
historical overview of the creation of the Optic Fibre Technology
Centre at the University of Sydney and the interaction with the
Australian Government, ABB, Transgrid and Pacific Power that made
possible the development of the current sensor. John Haywood then
summarised the physics behind the development of the current probe
which depends on the Faraday effect which causes rotation of plane
polarised light by a magnetic field. Both speakers gave excellent
talks and clearly explained why their work was worthy of the award.

Following the Walsh medal were two sessions of contributed papers
which included one talk on Patent Law by Fraser Old, a Physics
graduate from UNSW who is a Patent Attorney. One half hour was
devoted to short 3-5 minute talks by Industrial Physics poster
presenters in which most of these poster presenters took the
opportunity to give short presentations.

The Industrial Physics posters were included in the Monday/Tuesday
grouping of posters. Significant, first prize of $500 for the student
competition in the Monday/Tuesday poster session was Tim Dean’s
poster in the Industrial Physics stream on "Monitoring agricultural
insect pests...using a low cost mobile X-band profiling radar".

Congress 2002 was well run and very successful in demonstrating the
links between Physics & Industry. In addition to those in the
Industrial Physics stream, there were many papers of direct industrial
relevance in the Fibre Optic Technology and Medical Physics streams
as well as some papers in the Australian Optical Society and
Condensed Matter Physics streams. The venue at Darling Harbour,
Plenary Lectures & the standard of posters, particularly those
presented by postgraduate students, were all excellent. Postgraduate
students attending Congress 2002 were not only exposed to a wide
array of excellent physics but also aspects of marketing, company law,
management of intellectual property and the wide world of business.

Following the Congress, on Friday 12th July, a small group of delegates
undertook a very interesting industrial site tour to Bishop Austrans,
Hitachi Australia, CSIRO Division of TIP and Cochlear Ltd.

Ken Doolan

Tim Dean (ADF2) is awarded a student poster prize by Cathy Foley.
Nine papers and eight posters were presented during the Physics Education Group (PEG) Conference at the 2002 Congress. Of these, two papers and two posters were given by students. The numbers at the PEG sessions averaged around 55. This is a positive indicator of the quality of the papers and the interest that the Congress participants have in the teaching and learning of physics. The papers and posters ranged from descriptions of work in progress to research investigations. There were sessions on Use of IT in Teaching, Teaching and Learning in Labs, Innovative Methods of Teaching, and Interface of High School and University Teaching. The latter was a common session with the Science Teachers Association of New South Wales. The importance of ‘supply teaching’ was demonstrated by teaching development initiatives associated with physiotherapy, engineering and sports mechanics courses.

The PEG keynote speaker, Sheila Tobias, was a resounding success, capturing the imagination of the audience with a talk in which she used no visual aids. Sheila Tobias provided an international perspective on recruitment and retention of students majoring in physics. Reasons for the decreasing enrolments were articulated as the necessity for self-reflection by the physics community. She finished off by describing successful programs where the skill base of students is emphasised and the study of physics includes short courses in areas such as business and law. Peter Logan presented an invited paper on his experiences and insights gained during twenty years of physics education research. The importance of getting to know students’ skills and backgrounds upon entry into university by administering existing diagnostic tests was emphasised. By simply having such tests, students are made to acknowledge the entry requirements and can be guided to relevant resources and learning centres. The tests provide data that informed decisions can be made regarding curricula and learning environment. Such evaluations provide opportunities for research based investigations of the student cohort.

The PEG dinner on Monday night was well attended by twenty-five people. The PEG General Meeting was held during lunch on Tuesday. David Mills (Monash University) takes over from Peter Logan (University of Technology, Sydney) as Convenor and David Low (Australian Defence Force Academy) takes over from Manjula Sharma (University of Sydney) as Secretary/Treasurer. The outgoing Convenor, Peter Logan, was thanked for his contribution to the PEG group since its inception four years ago. Peter has been instrumental in gaining approval for an AIP Award for Excellence in Physics Education and will carry on working during the process of establishing the award.

The publication of refereed proceedings was well received by the PEG community. The refereeing process was initiated prior to the Congress to improve the quality of papers by providing authors the opportunity to edit their papers.

Manjula Sharma

Women in Physics

The Women in Physics (WIP) group was allocated a parallel session of one and a half hours during the Congress. At least 70 people attended the session with a steady flow of people to and from other parallel sessions. Particularly pleasing was the number of male physicists and Heads of Department attending the sessions, with feedback indicating that more would have liked to attend except for the constraints of parallel sessions. This interest by the physics community in fostering the WIP group is very encouraging indeed.

The session was opened by Sheila Tobias presenting a talk titled "Confucius: One barrier down, next barrier higher". Sheila outlined the process of setting goals, prioritising tasks and implementation during her career, and those of her contemporaries. Specific examples were given and the importance of mentoring, networking and the need to be part of the leadership and decision making hierarchy was emphasised. This was followed by talks given by Giuseppina Dall’Armi-Stoks and Manjula Sharma reporting on the First International Union of Pure and Applied Physics International Conference on Women in Physics. Giuseppina discussed the resolutions and recommendations of the conference while Manjula presented results of three separate studies on women in physics. The last talk titled, "Women in research", was by Prof Helen Garnett, the Executive Director and Chief Executive Officer of ANSTO. Helen gave an insight into her own experiences as she made her way through education, academia and industrial research into the very competitive business of scientific research development. She commended such a positive approach to anyone, encouraging everyone to "look for the positives" in any challenge and particularly in planning career moves. She was keen on identifying and making the most of one's special talents - for example, in the case of women, this may well be utilising their good communication skills. A lively session of very relevant and practical questions from the floor concluded the session, which then led into a General Meeting for WIP members.

The WIP General Meeting was from 6.30 to 7.00 pm. The Office Bearers remain unchanged, apart from the inclusion of Marion Stevens-Kalceff as the Lecture Tour Coordinator, Robert Hollows of Tara Anglican Girls School as the secondary school representative and Anna Wilson as the ACT representative and the WIP Program Coordinator for the 2004 Congress. Marion Stevens-Kalceff reported on the 2002 and 2003 Lecture Tours. Due to the number of outstanding Australian nominees for the 2002 Lecture Tour, the decision to have Australian lecturers for both years has been approved by the AIP Council. The WIP lecturer for 2002 is A/Prof Lidia Morawska while that for 2003 is Prof Halina Rubinsztain-Dunlop.

The issue of lack of appropriate female representation in plenary/keynote/invited speakers was raised at the Adelaide Congress and again at the Sydney Congress. WIP recommends that each stream be asked to nominate three possible keynote speakers, of which at least one is female and one male, with a case made for each nominee according to well defined criteria, and that the AIP Congress Program Committee be expected to select plenary speakers from these nominations in a balanced and fair manner. To assist with this process a proposal to develop a list of possible women plenary invited speakers, each with a supporting case was discussed. The list can be maintained in the WIP web page and can play an additional crucial role of fostering networking. It was also proposed to develop a list of potential female colloquium speakers, with accompanying abstracts, to enable input into the wider process of equity and diversity amongst keynote speakers in general at AIP congresses.

A few new ideas were discussed informally during the Congress. Ideas for the Canberra Congress received wide spread support and we are hoping to get them approved and to trial them. The proposals are to have a WIP social/planning session on the Sunday prior to the Congress and to sponsor a Forum on Careers in Physics. The social/planning session on the Sunday afternoon should run together with a specified WIP session during the Congress. There was wide spread approval of the fact that WIP actually had a visible presence at the Sydney Congress with the WIP session, albeit a parallel one. The ideal scenario would be for WIP to have a non-clashing session within the Congress.

Manjula Sharma
Impressions of the Congress

SHEILA TOBIAS
keynote, Monday, July 8, 2002

What attracted me to the 15th Biennial Congress, apart from the honor of being invited as a keynote, was its title and scope: Physics and Industry Working Together. As I said in my keynote address, unless physicists and physicists respond both to students' needs and aspirations and to industry's concerns, the community may fail to attract support and vital perspicacity from either. The fact that the keynote talks were intended to be interesting and accessible to a general audience made me feel even more at home.

My address, entitled Who Will Study Physics and Why? was intended to challenge an audience who tend to think that the next generation will be identical to the last. In fact, young men and women today want careers that open doors, not limit them. And the academic career path, even the research-oriented career path, may not be right for all. Thus, the range of opportunities that we in the United States are developing for science and mathematics graduates - including but not limited to professional M.S. degrees in those fields - would be, I thought, of interest to Australians.

A high point for me - and the advantage always of overseas travel was quoting John Prescott in my keynote address, whose studies of the employment of physicists in Australia have long been in my library back in Tucson, Arizona, and having him stand up after the talk, introduce himself, and make a comment! He and I had a chance for a longer conversation in the hallways later at the lunch.

Despite the fun, and how impressed I was with the stellar organization of the Congress, my own impressions of the Congress were mixed. I was disappointed that there were no local Australian women selected as keynotes. The women physicists I met at a late afternoon meeting on Wednesday are, like their counterparts everywhere, outstanding but not nearly as visible as they should be in a field that wants to stay on the moving edge. I had met some of them six months earlier at an IUPAP meeting in Paris for women in physics. I am sorry there are not more of them in Australia and in leadership positions.

At the same time, I found a vibrant group of physics educators, working on the cutting edge of education research. I attended almost all of their sessions and was privileged to be able to address the PEG group (as they call themselves) twice during the conference. Also, while in Sydney, thanks to Manju Sharma's prior arrangements, I was able to interact with physicists and physics educators at the University of New South Wales, at UTS, and at the University of Sydney.

I was pleased to see many students at the sessions and in the hallways and at meetings. Particularly impressive for me - as for all who attended, particularly those in industry - were the poster sessions, which I saw as a rich tapestry of innovative research and a confirmation that physics and physicists will remain important for science and for industry for a very long time.

Tucson, Arizona, September 9, 2002

GRAEME MELVILLE

Whether one is viewing a TV set, a car or a luxury liner, one rarely sees what is really behind the exterior appearance. The inner workings often remain a mystery, and by and large they are taken for granted. Every now and again, however, we delve beneath the surface and face a whole range of new experiences.

This has certainly been the case with me in regard to the AIP Congress this year. As one of the Congress organizers and website managers I found a number of issues that needed to be solved quickly and were, to ensure the success of the Congress. From my perspective I found that the great team were so successful in planning the Congress that everything ran very smoothly during it. Nothing was left to chance. As website manager I found the hard work was virtually over once the Congress started. Although everyone associated with the Congress did a great job, Pat and David as the main organizers, need to be congratulated in particular.

I found the talks interesting, varied and informative. Catering was excellent and socially, I believe, people had a good time. The boat cruise in particular was great, although I did not see that much of Sydney Harbour because of the conversations. I also met many new people from a number of different areas of physics. I certainly think Darling Harbour was an excellent venue and worth the extra cost.

I am looking forward to the next Congress.

The PHYSICIST

EDITOR WANTED

The present editor of the Physicist, Chris Hamer, will retire at the end of 2002 after five years in the position. Expressions of interest are invited from those who might be interested in becoming the new editor. The position is a necessary and important one for the AIP, since the Physicist is the flagship publication of the Institute. It occupies 1-2 days per week on average, and carries an honorarium of $5000 per annum. Please direct enquiries and expressions of interest to A/Prof. John O Connor, President of the AIP, at john.oconnor@newcastle.edu.au
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The Physicist Volume 39, Number 5, September/October
The Minister for Innovation, John Brumby, and the Minister for Major Projects, Peter Batchelor, have announced that Mr Alan Jackson has been appointed Technical Director for the Australian Synchrotron project. Mr Jackson will take up his appointment in October as a key member of the Major Projects Victoria team responsible for building the Australian Synchrotron at Monash University. “We are delighted to announce Alan Jackson’s appointment to manage design, assembly and commissioning of the Australian synchrotron,” Mr Brumby said. “This major new facility is crucial to Australia’s and Victoria’s future success in the global innovation economy.”

Mr Batchelor said that Mr Jackson had been selected as the best candidate after an extensive international search. “Alan Jackson comes to us on secondment from the Lawrence Berkeley National Laboratory in the USA bringing a depth of knowledge and experience of design, assembly, commissioning and operation of similar facilities worldwide,” Mr Batchelor said. “He has played a key role in shaping the Advanced Light Source at Berkeley. He has 34 years experience in particle accelerator design, and has been a leader in designing and commissioning third generation light sources, like the Australian Synchrotron, in the USA, Europe and Asia. It is great that Victoria is able to attract a Technical Director of such high international standing and with such a wealth of experience in successful synchrotron development. We are grateful to the Lawrence Berkeley National Laboratory and the US Department of Energy for enabling him to join the Australian Synchrotron project. Alan Jackson joins a first class Major Projects Victoria team led by Garry Seaborne, instrumental in the ANZAC frigates and Lucas Heights reactor projects.”

Mr Jackson chaired the International Machine Advisory Committee for the Australian Synchrotron until his appointment as Technical Director, so he is intimately familiar with the concept design for the synchrotron machine and ideally placed to guide its detailed technical and operational development. His experience will also make him a key player in developing the beamlines that enable intense synchrotron light to be used for experiments.

The Ministers paid tribute to the work of Professor John Boldeman, seconded from the University of Queensland as foundation Technical Director during the initial phase of the project. “John Boldeman has driven the concept design of the Australian Synchrotron to ensure we will have a world class facility,” Mr Brumby said. “He has striven tirelessly to make scientific excellence the heart of our design, and we warmly thank him for his efforts and welcome his ongoing commitment to the project through membership of our international and national advisory committees.”

The Australian Synchrotron is scheduled to commence operation in 2007, creating 700 jobs and injecting $65 million per year into the Victorian economy.

New Zealand Representative for Synchrotron Committee

Associate Professor Jim Metson has been appointed the New Zealand representative on the National Scientific Advisory Committee for the Australian Synchrotron project. The appointment follows an invitation last May from Victorian Premier Steve Bracks to New Zealand Prime Minister Helen Clark for a New Zealander to join the Committee.

“We are delighted about this initiative and appreciative of the Victorian State Government’s invitation for New Zealand involvement in the Synchrotron project. Professor Metson is already familiar with the Synchrotron project. That, along with his expertise and extensive contacts in New Zealand’s research community makes him an ideal New Zealand representative”, said New Zealand Minister of Research Science and Technology, Pete Hodgson.

Mr Hodgson said the arrangement would help ensure New Zealand researchers were aware of opportunities to utilise the Australian Synchrotron. “New Zealand places strong importance on the development of its research and innovation links with Australia. Collaboration between New Zealand and Australian researchers in the Synchrotron and other projects will result in win-win outcomes”.

Victoria’s Minister for Innovation, John Brumby, warmly welcomed Professor Metson to the committee. “Appointing a New Zealand scientist of Professor Metson’s calibre indicates the enthusiasm of researchers and governments beyond Australia for this regionally important project,” Mr Brumby said. “This appointment demonstrates the importance of trans-Tasman science links, and with Professor Metson’s input we can design a facility that will meet the broader research needs of both Australia and New Zealand.”

A synchrotron is a large and complex machine that produces beams of very intense light. It can be used as a molecular
microscope to study the composition of matter. Synchrotrons are invaluable tools for groundbreaking research in biological and life sciences, mining and geoscience, and for manufacturing pharmaceuticals, new age materials and micromachines. The facility in Melbourne will cost an estimated AS$157 million and is expected to begin operation in 2007.

Biographical Note
James Metson is an Associate Professor with the University of Auckland Department of Chemistry, Acting Director of the University's Light Metals Research Centre and a past Director of the University's Research Centre for Surface and Materials Science. He gained his chemistry doctorate at Victoria University of Wellington and has a distinguished reputation in the development of surface analytical techniques and in the surface chemistry and smelting technologies for light metals, particularly aluminium.

Site Works Signal Synchrotron on Track for 2007
Site preparation works at Monash University in Clayton signal that Australia's most significant scientific infrastructure project - the synchrotron - is on track for completion by early 2007. The Victorian Government will next month call for expressions of interest to construct the outer synchrotron building. The Australian Synchrotron is expected to generate $65 million a year to the Victorian economy and create over 700 jobs.

Innovation Minister, John Brumby, said site preparation works were the latest in a series of synchrotron developments, including:
- Appointing Alan Jackson as project technical director.
- Calling for expressions of interest to construct the outer synchrotron building;
- Successfully completing vibration and imminent finalisation of geo-technical tests at the site; and
- Commencing community consultations in the Monash area through the appointment of a Community Liaison Officer and the first community briefing held today.

Mr Brumby said the Government would shortly release details on the final design of the facility and it was possible that Victoria could end up with a much more powerful synchrotron than originally envisaged. Major construction works are due to get underway in the first half of next year.

"I'm pleased to be able to announce today that this project is on track to be completed in early 2007," Mr Brumby said. "The establishment of a national synchrotron development in Melbourne is the most significant science infrastructure investment in Australia for decades."

National Scientific Advisory Committee Chair, Professor Frank Larkins, said there was strong investment interest in the synchrotron from many sources, including universities, research institutions, national science bodies, other governments and industry, especially through industry associations.

"All of these groups are actively involved in collaborative processes to design, cost and fund beamlines that will meet their research needs," Professor Larkins said. He said that with the Bracks Government contributing $100 million towards the project, the National Scientific Advisory Committee was able to focus investment interest towards the development of the beamline facilities, scheduled for construction in 2005.

Monash University Vice Chancellor, Professor Peter Darvall, enthusiastically welcomed the next phase of the Australian Synchrotron project. "Monash University is delighted to be hosting this major addition to Australia's research infrastructure. It's great for Victoria and great for Monash. It will become the heart of a new centre of excellence for Australian R&D," Professor Darvall said.

Mr Brumby said the synchrotron project was part of the Bracks Government's commitment to cementing Victoria's position as the innovation capital of Australia. He said that at present around 1200 Australian scientists and researchers were forced to travel overseas to access synchrotron technology. "The synchrotron is a cutting edge tool in research and development, which will help our scientists to make major breakthroughs, including designing new drugs for the fight against cancer and other diseases," Mr Brumby said.

"It will also enable scientists to develop new breakthroughs in advanced manufacturing like the design of new-age textiles and automotive and aeronautical components, and will assist in improving metal and materials technologies."

Stefanie Pearce
Department of Innovation, Industry and Regional Development Department of Tourism, Sport and the Commonwealth Games Government of Victoria.
ACROSS
1. Maoist converted, given time, to follower of Boltzman. (7)
5. Trims trees. (7)
9. Conditions Schrödinger equation put back. (5)
10. 2. Unfashionable fellow inclined to be subject of well-known theorem. (3, 6, 2, 3, 10)
11. Came shuffling with toxic menu to sever from the church. (13)
13. Two year old’s toy. (4)
14. Prenatal acrobatics related to being mum or dad. (8)
17. Secret unravelled about binary digits known only to a few. (8)
18. Creature hiding in the odd furlong. (4)
21. Atomic signatures a cretin spells badly. (8, 5)
23. Former students gathering about one with hesitation cannot form heavy metal… (9)
24. … but they can form rubies and sapphires from bovine pelt, we hear. (5)
25. Unknown quantity missing from outside for ever. (7)
26. Stops believers consuming entropy. (7)

DOWN
2. see 10.
3. Collision a grim ending to agreement. (6)
4. Tribal symbols to stem dissent. (6)
5. Less than spectacular, it’s all done with mirrors. (8)
6. Needs real bundles of paper. (8)
7. Distinguishing marks appearing in solution to partial differential equation. (15)
8. Gooey spell cast over underground field of study. (10)
12. Dishevelled shy rep takes step into a world of many dimensions. (10)
15. Reportedly the kind of wave that injures Thorpie. (8)
16. How a linguist might describe M-theory? (8)
19. Bedlam riot said to be the cause. (6)
20. Jovian moon consumed by Ann’s charges. (6)
22. God causing canal to flow uphill. (4)
PRODUCT NEWS

Spec 10 Series: The Most Sensitive Spectroscopic CCD Detectors
Spec 10 is a series of high performance CCD systems built especially for spectroscopy by Roper Scientific (Princeton Instruments). These systems feature performance-optimized spectrometric CCDs, with a rectangular array format, and ultra-low noise electronics, to capture your data with superior accuracy and precision.

The Spec-10 systems can be configured with a wide range of detectors offering various chip formats, including front and back illuminated. Some of these formats have been developed exclusively by Roper Scientific in conjunction with the CCD device manufacturer. One such example is a new CCD detector that has been manufactured in such a way that the etalon effect (fringeing), a common problem in NIR spectroscopy, is significantly reduced.

New to the Spec 10 series is the new large format Spec 10:2K detector. Offering a 2048 x 512-pixel CCD device that measures 27.6mm x 6.9mm, it is ideal for high-resolution spectroscopy. The system can be run in either high-capacity mode to provide wide dynamic range (e.g. absorbance spectroscopy) or in high sensitivity mode for experiments with low light (e.g.Ramans and fluorescence spectroscopy).

Roper Scientific continues to lead the way in design of the detector control electronics, with the Spec 10 systems having the lowest read noise in the industry (3 electrons @50kHz). Also, the detector controller is offered with a dual speed digitiser.

For more information on the Spec 10:2K detector or other chip formats available, please contact Teresa Rosenzweig (teresa.rosenzweig@coherent.com.au) or Jim Weeks (jim.weeks@coherent.com.au).

Coherent Scientific Pty. Ltd
116 Sir Donald Bradman Dr., Hilton SA 5033
Phone: +61 8 8150 5200 or Fax: +61 8 8352 2020
Email: scientific@coherent.com.au
web: www.coherent.com.au

New 6 W, 532nm Millennia Laser Features Single Pump Diode Architecture
Spectra Physics has introduced a new addition to their popular Millennia diode-pumped, all solid state laser product line. The Millennia VI utilizes a single pump diode architecture, and offers 6 W of CW power at 532nm. It is available in both scientific and OEM configurations. The single pump diode architecture reduces the long term cost of ownership since the pump diode is the only consumable in an all solid state laser. Moreover, the ProLite series pump diodes used in the Millennia result in exceptional lifetime - typically over 10,000 hours at the rated power.

The new Millennia VI also provides the same reliability and unsurpassed performance as other Millennia series lasers. This compact, rugged laser delivers the best beam pointing stability (2 microradians/deg. C) currently available on the market, making it ideal for demanding applications in pumping ultrafast lasers as well as a variety of industrial tasks, such as semiconductor wafer inspection. All Millennia lasers now utilise an all solid state, rack-mountable power supply that features temperature cooling technology with a small overall footprint and high wall-plug efficiency.

For further information please contact:
Lastek Pty Ltd, 10 Reid St, Thebarton SA 5031
Tel: (08) 8443 8686, Fax: (08) 8443 8472
Toll Free: 1 800 88 2215
Email: sales@lastek.com.au www.lastek.com.au

New High Efficiency Temperature Controller
A new advanced temperature controller with Fuzzy Logic optimisation from Wavelength Electronics is now available from Wavelength Scientific.
The 3 Amp WTC3863 is a complete PMW thermoelectric temperature controller. It uses half bridge switching in the PWM mode to achieve maximum output efficiency at high current levels. The integrated power FETs convert to linear switch-free operation during low output currents to ensure ±0.01°C accuracy. A sophisticated PI plus fractional order control loop offers robust thermal stability over time and temperature.
The component will operate over the -10°C to +85°C range of case temperature, with output power delivering linearly above 50°C and it will operate with a control electronics power supply voltage (VDD) of 3.3 to 5 V.
The user need only add resistors to set current limits, gain values, and establish the sensor bias current and a pair of LC filters around the TEC load.

For more information on these and other Wavelength Electronics products please contact:
Michael Redolph, Wavelength Scientific Pty Ltd
Unit 7 The Watertower, 1 Marian Street
Redfern NSW 2016 Tel: +61 2 93190122
Fax +61 2 93181292 michael.warrener@wavelength.com.au
http://www.warrener.com.au

Tulaser’s ThinFilmStar is a highly sophisticated UV light source for Pulsed Laser Deposition (PLD)
Pulsed Laser Deposition (PLD) is an extremely versatile technique for depositing a wide range of thin films. Complex multilayer films can be created by simply interchanging targets during the deposition cycle with a multi-target manipulator. The outstanding advantage of this technique is the growth of multi-component films. Now, a user-friendly excimer laser is available to rapidly ablate and deposit metal oxides and other materials. The design ensures highly uniform and reproducible film properties for ferro-electrics, piezo-electrics, smart materials etc.
While the PLD for Ultra High Vacuum (UHV) systems in use increased their functionality Tulaser has been focusing on the laser source creating unique plasmas. Now Tulaser is proud to present a brand new approach towards noise investigations and applications in using excimer laser technique.
Tulaser’s ThinFilmStar is a technical quantum leap with a low divergence, small aperture area and an extremely fast rise-time leading to high peak power. These factors combined with high focalisation result in extreme high intensities and thus homogeneous ablation. Compared to conventional excimer lasers, which only tried to increase pulse energy, this UV light source achieves the same goal through decreased plasma shielding. The ThinFilmStar is the leading edge for this technology using less energy to obtain a homogeneous ablation profile.

This highly reliable and compact excimer laser means for our customers small capital investment compared to conventional lasers and because of the implement-
ed laser tube design low operating costs.

For further information please contact:
Lastek Pty Ltd, 10 Reid St, Thebarton SA 5031
Tel: (08) 8443 8686, Fax: (08) 8443 8472
Toll Free: 1 800 88 2215
Email: sales@lastek.com.au www.lastek.com.au

Ultra Long Range Piezo Tip/Tilt Platform
A new Piezo tip/tilt mirror platform that offers a scanning range of ±425 mrad (±1.3°) in two orthogonal axes has been released by Physik Instrumente (PI) of Germany.
The S-334 measures just 2.54 cm x 3.3 cm x 3.81 cm and has a resonant frequency of 1.0 kHz (including the mirror). With integrated strain gauge sensors it offers sub-micro-radial resolution and high linearity of the entire travel range.
For more information on these and other PI products please contact:
Bret Dohunany, Warsash Scientific Pty Ltd
Unit 7 The Watertower, 1 Marian Street
Redfern NSW 2016 Tel: +61 2 93190122
Fax +61 2 93181292 breti@warsash.com.au
http://www.warsash.com.au

Coherent’s New Hands-Free Ultrastable Laser System - Chameleon
Coherent has had great success in supplying reliable, high performance, diode pumped solid state (DPSS) and Ti:Sapphire-based ultrastable laser technologies to the scientific research community and can now provide these laser systems together in a single, fully integrated, automated and optimised system called the Chameleon. Unique features of the Chameleon include:
- Tuning from 720nm to 950nm in less than 30 seconds, fully optimised for each wavelength, hands-free.
- Automated dispersion compensation for uniform pulse duration across the tuning range.
- Integrated, compact air recirculator for effortless tuning through water absorption bands without the need for an external purge.
- Passive mode locking technique for design simplicity and ease of use.
Chameleon thus provides a new and compact ultrastable laser solution for researchers and multi-user facilities who want to maximise their time working on their experiments (rather than tweaking their laser) producing high performance laser output through an easy to use platform with low maintenance requirements.

Chameleon applications include:
- Time-resolved photoluminescence
- Non-linear spectroscopy
- Fluorescence upconversion
- Quantum optics
- Terahertz imaging

For more information please contact Gerri Stewart (gerri.stewart@coherent.com.au) or Teresa Rosenzweig (teresa.rosenzweig@coherent.com.au), Coherent Scientific Pty Ltd
116 Sir Donald Bradman Dr., Hilton SA 5033
Phone: +61 8 8150 5200 or Fax: +61 8 8352 2020
Email: scientific@coherent.com.au
web: www.coherent.com.au

The Physicist Volume 39, Number 5, September/October
Dr. SARAH PEARSON

I really enjoyed studying physics and have also found that it has given me the opportunity to follow a diverse, challenging, rewarding and international career. My physics background has made me very employable but in order to acquire the top jobs in which I have worked I also needed to show a strong ability to communicate and work in teams.

My career has spanned four countries around the world and has taken me into areas such as business and finance, communication of science through TV and teaching. I am currently a Physics lecturer at the University of New England and, in spite of the frustrations, it is the most rewarding and flexible job that I have had.

University Studies

University of Oxford – Doctorate of Philosophy in Particle Physics.

My thesis was entitled "The Track Trigger for the ZEUS Detector and its Implications for ep Physics at HERA". The main topic of research was the design of an algorithm to select data online from a high energy particle physics experiment, which was in the process of being constructed in Hamburg.

University of Liverpool - Bachelor of Science (First Class Honours in Physics).

Range of subjects studied in final year included:

- Statistical Physics and Thermodynamics
- Quantum Mechanics
- Physics of Nuclei
- Physics of Atoms
- Physics of Nuclear Energy
- Particle Physics
- Low Temperature Physics
- Astrophysics

Employment

I am currently a University lecturer in Physics at the University of New England.

Other jobs have included the following:

- Research Consultant – CSIRO Department of Exploration and Mining
- Scientific Researcher - "Beyond 2000" Television Programme
- Actuary – Towers Perrin
FOUR DIMENSIONS, MORE OR LESS?

ROBERT DELBOURGO
University of Tasmania

The talk will be focussed on the different facets of dimension in physics and how they have impacted on my own work on dimensional continuation for extracting quantum anomalies of current conservation laws in field theories, associated with particular symmetries. Finally a model of the physical world, based on equal numbers of bosonic and fermionic coordinates, will be described which has the property of being effectively zero-dimensional.

To begin, I'd like to express my sincere appreciation to the IOP and AIP for thinking me worthy of this singular honour. Over the years it has been my good fortune to collaborate with many congenial colleagues from various nations and I regard this award as much a tribute to their endeavours as to mine. When I look at the list of previous recipients, I simply cannot believe that the Institute has considered my work relevant enough to pick me as this year's medallist, particularly as my research seems to have moved away from Sir Harrie Massey's own interests in space and astrophysics and has no direct industrial applications that I am aware of. Yet it is probably true to say that, apart from Don Melrose's work, the contributions from the other Massey prize-winners are also a long way removed from his work.

Nevertheless, if one looks at the content of Massey's textbooks and papers, one cannot fail to recognize the kind of applied mathematician he was, aside from his wonderful physical intuition. As a matter of fact, a glance at his bibliography will show that, as well as his magnificent volume on Atomic Collision Theory written with Mott, he wrote another monumental tome with Kestleman on Ancillary Mathematics, based on lectures he delivered to Physics undergraduates at University College, London. So perhaps he might have enjoyed what I will be relating today and savoured a few of the tricks that I have applied to physical problems.

The citation for this year's medal covers wide ground and I've no intention to ramble over it. In choosing the topic of my talk today I thought it preferable to stick to a well-defined path. Therefore I have decided to steer clear of the subject of strong interactions between nuclei, or at a more elementary level between quarks, where I have done some research on their relativistic and dynamical symmetries. This is because Tony Thomas covered the material admirably two years ago, including chromodynamics. Instead I have chosen to pick out a thread that weaves its way strongly throughout my work and which is dear to my heart: it concerns dimensional continuation and the many insights one can gain by such exploration.

This quest seems to have frightened Pascal out of his mind, who declared in his Pensées that:

"[I feel] engulfed in the infinite immensity of spaces whereof I know nothing, and which know nothing of me. I am terrified ... The eternal silence of these infinite spaces alarms me."

Cayley, Hermite and Riemann had no such hang-ups and they blazed the trail to multi-dimensions. These days, enlargements of space-time carrying extra coordinate degrees of freedom terrify no-one and if anything the concept has become a bit too commonplace. Please accompany me as we wander through these extra (or fewer) dimensions to see what one can learn from such a promenade.

I shall try to keep the mathematics to a minimum but I can't avoid writing out the odd formula or equation in order to explain the general ideas. First of all, let's be clear what we mean by "dimension", for it has several connotations.

The many facets of dimension

Space-time dimensions

The man in the street is now familiar and perhaps comfortable with the notion that space-time consists of four dimensions with events and world-lines within such a continuum. However, as the advertisement urges us to "think outside the square you live in", it is perfectly conceivable to imagine a universe augmented by extra coordinates (normally added to space rather than to time), bearing in mind that these new coordinates may be difficult to access physically. In other words it is straightforward to build a framework where we have N - 1 space coordinates and one time coordinate and to extend all of our physical procedures into this higher-dimensional scenario. At this stage N is to be considered an integer. This then is the first interpretation of dimension, namely the number of degrees of freedom of the space-time manifold. If N is small, say N = 2, we can often solve our problems in closed form because the equations simplify considerably and special methods can be used, like complex variable theory. On the other hand, space-time enlargements can have distinct advantages. For consider the case of flatworms literally stuck to the surface of the earth. They would only be conscious of two spatial degrees of freedom and would have a hard time comprehending the nature of the 3-D solar system if they could even see it. But if they learnt their relativity theory they could well deduce that they lived on a constant curvature 2-D surface by surveying large triangles and checking on the sums of the interior angles - that is another story. They would however be hard-pressed to understand the appearance of rain: a sudden event conjured from another dimension. How much simpler it would be for them to look at the earth and analyse the solar system from a three-dimensional perspective, I think you will all agree! Might this not also apply to us poor 3-D limited creatures?

Dynamical dimensions

The idea of dimension also arises when enumerating the degrees of freedom of dynamical systems; these are characterized in phase space by the positions and velocities of the system's components: 3 + 3 per component. They can be very large when there are lots of components and are not readily visualized by the limitation of our brains. In fact for all macroscopic systems these dimensions are so colossal (~10^40)
that we take advantage of their enormity to apply statistical procedures with great effect. Right at the other extreme it may happen that the dynamics contains friction and produces an attractor, eventually causing the system to shed its many degrees of freedom and leaving an orbit that has far fewer degrees of freedom. The size of the final configuration might even be "fractal," signifying fractional dimension amongst other things.

To give you an idea how non-integral fractal dimensions may arise from constrained, damped systems, let us return to the flatworms and imagine that they like to live on the seashore, avoiding water in case they drown and not venturing inland in case the sun desiccates them. One would then be inclined to say that their coastal orbit is a curved 1-D line. As Richardson and Mandelbrot have emphasized, that conclusion is false, because the coastline is infinitely jagged in a self-similar way as one zooms in. A long flatworm, say 10 cm long, might take 100,000 crawls to circumnavigate the coastline of an island, but a baby flatworm 1 cm long takes more than 1,000,000 crawls to cover the same journey, which is quite astonishing. In order words, the coastline gets longer the closer we look at it. We surmise that the coastline is somehow longer than a smooth line and has a fractal dimension greater than unity, in a way that can be precisely defined. Likewise the fairy-floss outline of clouds on a photographic plate causes them to have a fractal dimension 1.35 much less than the expected value of two. The famous Lorenz butterfly attractor has fractal dimension of 2.06, indicating that the chaotic wings have a non-negligible thickness. I'll return to this second interpretation of dimension presently.

### Physical dimensions

Thirdly there is the notion of MLT dimension, whereby we characterize all physical quantities via dimensional analysis, e.g. [Force] = ML/T², etc. (Strictly, there is another dimension, Boltzmann's constant k, associated with the connection between entropy and information or between energy and temperature, but let's not worry about that here.) Techniques of dimensional analysis are very useful for providing relations between physical quantities, once we know the relevant parameters, e.g. \(T = \sqrt{\frac{E}{mg}}\), for the period of a simple pendulum, or \(F = \tau/\nu\) for Stokes' drag force. Two dimensionful quantities of great relevance in nature are the velocity of light \(c \sim LT^{-1}\) and Planck's constant \(\hbar \sim MLT^{-1}\), which set the scales of relativistic and quantum mechanics respectively. We have good reason to believe that they are constant, so taking them as unity (going to *natural units*), all physical quantities can be expressed dimensionally in terms of M, e.g. \([x] = M^{-1}\); and this is what we particle physicists regularly do. Incidentally, observe that all mathematical functions, like the exponential or trigonometric functions, contain dimensionless quantities as their arguments. Note too that dimensionless quantities in physics abound, like the fine structure constant \(\alpha = e^2/4\pi\epsilon_0\hbar\) or the ratio \(m_e/m_p\). These ratios cannot be found by dimensional analysis, but if we could predict them we would be touching the holy grail of physics, since every fundamental quantity would be fixed once and for all.

### Scaling dimensions

Finally there is the notion of scaling dimension. This has to do with the space-time dependence of fields that we come across in physics and how they vary or stretch with \(x\). Specifically fields \(\phi\), such the electromagnetic field, occur in Hamilton's action integral. The action is fundamental to all of physics and it has the same dimensions as Planck's constant; specifically, it is the integral over all space-time of the Lagrangian density. One can regard it as something like the energy integrated over all space and time. It plays a truly basic role in classical mechanics and even more so in quantum mechanics. Now in natural units the action typically contains a kinetic term having the form \(\int \phi^2(x) dx\), where \(dx\) is shorthand for the \(N\)-fold \(dx_1 dx_2 \ldots dx_N\) over all space-time. By counting the powers of \(x\), you may observe that the resulting action is invariant under rescaling \(x \rightarrow \lambda x\), provided that the field has the scaling behaviour \(\phi(\lambda x) = \lambda^{-d/2} \phi(x)\). We say that \(\phi\) carries the canonical scale dimension \((N/2 - 1)\) and in this case it coincides with the dimensional analysis value \([\phi] = M^{N/2}\). But observe that if one were to add a mass term in the action such as \(\int m(x) dx^2\), then this term would be proportional to the mass \(m\), which would give a factor of \(x^4\) into the equation for scaling, and the theory would be back to classical physics.

A simple lesson in continuation: the factorial function

We are all familiar with the factorial function, \(N! = N(N-1) \ldots 1\) when \(N\) is integer, and its generalization to \(N\) fractional for non-integer \(N\), namely \(\Gamma(N+1) = \int_0^\infty x^N e^{-x} dx\). What can we learn from it? What can it illuminate?

1. \(\Gamma(N+1)\) obeys the same recurrence relation as \(N!\) factorial for non-integer \(N\), namely \(\Gamma(N+1) = N \Gamma(N)\); this may be established by integration by parts;
2. The integral for it is well defined for real positive \(N\) and particularly in the interval 0 ≤\(N\) ≤ 1. Indeed the case \(N = 0\) defines 0! for us;
3. Although the integral looks hard for \(N \approx 1\) at small \(x\), it can be continued to non-integer negative values by using its recurrence relation \((1)\); this procedure is called analytic continuation and in fact \(N\) can even be taken as complex;
4. If there are any problems with such continuations they will show up through the recurrences; thus the limit \(N \rightarrow 0\) of \(\Gamma(N) = \Gamma(N+1)/N\) throws up an infinity and this is quite proper: the function \(\Gamma(N)\) possesses singularities in the form of simple poles at non-integer values \(N\).

The message is this: don't be timid about continuing your answers from integers to non-integer values. If there are any (mathematical) obstacles to such continuation, they will reveal themselves in the expressions and one must find a way of circumventing or interpreting them.

This leads me directly to a nice trick that I found for deriving relations between physical variables which I'd like to recommend to you. As Much asserted,

"Every statement in physics has to state relations between observable quantities."

Dimensional analysis can be a useful guide if these variables have different powers of M L T but it is quite useless if the two variables are both dimensionless or possess identical dimensions. Suppose for instance that one comes across two quantities, call them \(A\) and \(B\), which one strongly suspects are connected. For the sake of argument assume one finds physically that they take on the values \(A = 9\) and \(B = 2\). One still has no idea how they are related; it might be: \(\alpha = 4B + 1\) or \(\beta = 1/2\), or any of an infinite number of possibilities.

But now entertain the possibility that the physical theory producing \(\alpha\) and \(\beta\) depends on a fixed parameter \(N\) which is readily continued to other values; \(N\) might be the number of interacting fields or the number of space-time dimensions or any other integer that one can easily extend mathematically. If one were able to work out the dependences, say \(\alpha = N(2N + 1)/4\) and \(\beta = N/2\), (where \(N\) takes the value 4 in the real world), then one could deduce the correct relation, \(\alpha = \beta(4B + 1)/2\) as in practice, for realistic calculations, the right hand
sides will likely turn out to be pretty complicated functions of $N$ and might be only worked out in some asymptotic limit as a power series in $N$, but the general idea still applies. Kenny and I used it effectively for relating the two Feynman constants describing the approach to chaos, where in that case $N$ referred to the cycle sequence number. Tonight I would like to explain to you how I have exploited variants of the above trick in my own research into quantum field theory (QFT).

**Dimensional continuation**

It is a small, almost trivial step to enlarge space-time from 4 to $N$ dimensions. All that happens is that coordinates, vectors, tensors and spinors acquire extra components and it is just as easy to write out one's favourite field theory for arbitrary $N$ as it is for $N=4$, but with two caveats:

1. There is a subtle distinction between even and odd $N$, in as much as spatial reflection or parity can change its meaning;

2. The Levi-Civita tensor $\varepsilon_{\mu \nu \lambda ...}$, which is completely antisymmetric in its indices, grows with $N$; what is more, it is needed to construct axial or "screw vectors" and this affects the definition of the "cross product" of two vectors.

But the rest of the exercise is straightforward: vector indices run though $N$ values, the electron field acquires $2^N$ components and all space-time integrations, whether over $x \in$ Fourier space over $p$, are over $N$-tuples. The standard texts teach us how to change from Cartesian to radial/polar coordinates: we simply meet more angles. The solid angle $\Omega_N$ is given by the volume element $d^N x = r^N \ dr \ \Omega_N = r^N \ dr \ \Omega_N$, where $\Omega_N = \Omega_N$.

Not only do Dirac spinors describe particles and antiparticles, but they contain extra spin components, connected with rotations in the bigger space. Therefore instead of $4 \times 4 = 16$ independent Dirac matrices, there are $2^{2N} \times 2^{2N}$ of them and their commutation rules become more hairy.

![Figure 1. Some typical Feynman graphs](image)

**Dimensional singularities**

So what use is all this? Well, it turns out that in quantum field theory we have to evaluate certain Feynman integrals associated with graphs illustrated in Figure 1 for the case of electron-proton scattering). Typical among these is the integral

$$\int \frac{d^N p}{(p^2 + k^2)^N} \sim \int \frac{d^N p}{(p^2 + k^2)^N} \sim \frac{N^{N/2}}{\Gamma(N/2)} \int (p^N + k^N) \sim \frac{N^{N/2}}{\Gamma(N/2)}$$

which is fine for non-integer $N$ but displays an infinity or "divergence" when $N = 4$, corresponding to a pole of the $\Gamma$ function. This problem is a standard bugbear of QFT that we have learnt to live with and cure by a "renormalization procedure". The key point is the first order singularity $-1/(N-4)$ in the answer which has to be treated correctly. (Notice that when $N < 4$ there is no need for any cure, so three dimensions are somehow "better".) The normal treatment is to subtract a renormalization term where $k^N$ is replaced by a mass scale $M$; this fixes its way into the redefinition of the physical constants, like the charge and the electron mass, provided the theory is of the "renormalizable" variety. Anyhow at the end of the day, as $N \rightarrow 4$, one is effectively left with the perfectly acceptable logarithmic difference

$$\frac{2}{N-4} \left( k^N N^N - (M^N N^{N-1}) \right) \sim \log \frac{k^2}{M^2}$$

This artifice was first devised by 't Hooft & Veltman and Bollini & Giambiagi for handling the infinite integrals of QFT in a gauge-invariant manner. Akevampong and I decided to go the whole hog and explore the continuation of the entire field theory to arbitrary dimensions, not just the integrals, and see where it led us. We struck gold before long.

**Quantum anomalies**

One of our guiding principles in physics is the idea that fundamental theories should be beautiful. Dirac was the main proponent of this view. In mathematical terms, beauty finds its expression in the symmetry of the action for the theory under a set of transformations. Sometimes the symmetry is hidden underneath and we may have to dig hard to uncover it. However the task is not impossible. As Einstein is reputed to have said at Princeton,

"God is slick, but he ain't mean".

Anyhow, if the perfect symmetry involves a continuous parameter, Noether taught us that we ought to expect a conserved current, at least classically. By her time-honoured methods one may derive the law conservation of energy-momentum and of the electromagnetic current. The latter law in particular follows from the invariance of the action under changes of phase of all the complex fields, $\psi(x) \rightarrow e^{i\alpha(x)} \psi(x)$. This is called a "gauge transformation" and, besides requiring the existence of an electromagnetic field, it leads strictly to the charge continuity equation, $\partial_\mu j_\mu = 0$ — all a direct consequence of nature's blindness to local phase changes of complex fields.

On the other hand, if the symmetry is imperfect, the right hand side of the continuity equation is no longer zero, though broken symmetries are on occasions hard to spot:

"Like the ski resort full of girls hunting for husbands and husbands hunting for girls, the situation is not as symmetrical as it might seem." — Mackay (in Harvest of a Quiet Eye)

This situation arises for chiral transformations of spinor fields $\psi(x) \rightarrow e^{i\alpha \sigma_3} \psi(x)$, when the spinors carry mass. The continuity equation takes the form $\partial_\mu j^\mu = 0$; where $j_\mu$ is the "axial" current. On setting $m = 0$ one's first instinct is to state that it will be otherwise. This is true classically but quantum mechanics says otherwise! The crucial point here is that the $j_\mu$ are to be interpreted as operators and to extract physical answers we must take their expectation values or "matrix elements". In 1969 Adler, Bell and Jackiw proved that the divergence of the vector elements $\langle V_{\mu\nu}(N) \rangle$ could not possibly vanish. The root of their argument was the observation that this process was tied to a new mass scale $\Lambda$ introduced in order to regularize an infinite integral; this adds to the right hand side. One ends up with a correction term $\partial_\mu j_\mu \sim e^{i\phi_{\mu\nu}} F_{\mu\nu} F^{\mu\nu} \sim E.B$ where the r.h.s. is called a "quantum anomaly" because it destroys the classical law. Anomalies represent a big worry in gauge models of electroweak interactions because it is vital to maintain the conservation law of the current at all costs; it therefore becomes essential to cancel off the coefficients multiplying the
quantum anomalies and this in turn places restrictions on the numbers and charges of fundamental particles. Our present standard model of particle physics is miraculously anomaly-free!

Now since dimensional continuation is a neat way of handling the problems of quantum field theories, we thought to ourselves: "Is there a milder way of comprehending quantum anomalies?" Indeed there is. In a nutshell, we should examine the symmetry of the action under the transformation in question for any dimension $N_k$ if it is invariant for all $N$, there can be no quantum anomaly. But if any part of the action specifically demands $N = 4$ exactly for the symmetry to hold then we can be sure that there will be a quantum anomaly. The point is that the divergence equation throws up the anomaly as a so-called "evanescent" term, which vanishes as $N \to 4$ and is effectively proportional to $(N - 4)$. When this evanescent factor multiplies the $1/(N - 4)$ pole coming from the divergent Feynman integral, one gets a finite quantum correction. It's as elegant as that and saves a heap of struggles with regularization masses, which bring in problems of their own!

For example, let me quickly sketch how one may extract the chiral quantum anomaly we were just mentioning in a little bit more detail. A rather tricky question which must first be answered is what we mean by an axial current for any $N$. (A vector current poses no difficulty, it is just the $N$-tuple $j_a$ and because the action is always gauge invariant under phase transformations of the complex fields, for any $N$, it follows that the vector current will remain conserved, come what may.) However, an axial vector or a pseudoscalar quantity is a "screwy" object. To cut a long story short, in $N$-dimensions, the axial vector should be reinterpreted as a triply antisymmetric tensor, $j_{a123\ldots}$, and its divergence should really be regarded as its "curl" $\partial_{[a123\ldots} A_{b]}$, antisymmetrized in the four indices. One then finds that a chiral transformation will alter the action for $N > 4$, producing an extra evanescent term $(2/3T) T_{a123\ldots} A^{a123\ldots}$, in the axial conservation law, whether fermions are massless or not. Now a quantity like $T$ cannot exist in 4-D because it has 5 antisymmetric indices. But $T$ exists perfectly well for large $N$ and we can carry out our computations as before. Hey presto, that's nothing but the chiral anomaly when we descend to $N = 4$. By this means we were readily able to derive the anomalous matrix elements $\langle V_{[a123\ldots} | \nabla^2 | V_{b]} \rangle$.

But one may likewise derive the gravitational matrix elements $\langle g_{[a123\ldots} | \nabla^2 | g_{b]} \rangle$ and the corresponding chiral anomaly, though this is not how I originally found it with Salam. To do this properly one must first extend quantized Einstein-Hilbert gravity into any dimension. During the course of this exercise, Ramon-Medrano and I discovered a lovely nugget, namely the symmetry property that any quantized gravitational theory must possess. It’s from the same ore that gave Becchi, Rouet, Stora and Tyutin their famous BRST symmetry for chromodynamics. Now gravity is another gauge theory associated with general covariance (choice of coordinate system) and the gravitational or stress-tensor current is always conserved, like the electromagnetic current, for any $N$. The problem with $\langle g_{[a123\ldots} | \nabla^2 | g_{b]} \rangle$ arises when taking the divergence of the axial leg, because of the evanescent term and it finally leads to the law $\partial_a \partial_a g_{a123\ldots} = -\frac{N}{16\pi G} R_{a123\ldots}$, where $R$ is the full Riemann curvature tensor; the anomalous gravitational contribution is nothing but the analogue of E.E.B for electromagnetism. This happens to be my most cited paper, not just for its general interest, but because it places strong restrictions on model building. Just as the electromagnetic contribution to the chiral anomaly must be cancelled, so must the gravitational contribution. Curiously this paper is the one that took me the least amount of effort or time to write up - just one week. I mention this because I've often found an inverse correlation between the popularity of some of my work with the time I've slaved to produce it - which is quite galling.

The same idea applies to scaling invariance and the conservation law of the scaling or "dilation" current. The addition of an interaction term to the action like $\frac{g}{l^4} \partial^\alpha \partial^\beta (\partial_\alpha \partial_\beta) \phi^2$ except at $N = 4$. (Another way of saying the same thing is that $g$ remains dimensionless only in 4-D.) An immediate consequence is that the divergence of the dilation current drops in an evanescent term equal to $g(N - 4)$ times a product of fields. Such terms are responsible for the quantum "scaling anomaly". Evidently the same rule can be applied to any other invariance law and its associated conservation equation. I really feel this is the best and simplest way of discovering the anomalous quantum corrections to classical results.

More physical dimensions

So far my attitude has been that a continuation in $N$ helps to introduce another parameter and allows us to obtain relations between physical quantities in the limit as $N \to 4$. Thus for me it's back to 4-D in the end. There are a few solitary voices who claim that coordinates themselves are dynamical variables having no meaning at miniscule scales, and that space-time degenerates into "space-time foam" because of gravitational field fluctuations associated with quantum mechanical uncertainty. This means that the arena in which physics is played becomes fuzzy. These voices advocate that space-time is truly a fractal concept and that we live in a universe which has fractal dimensions, where $N$ is almost but not quite equal to 4. The quantum infinities that I referred to previously would then be avoided altogether! Intriguing as this idea is, is somewhat vague and as far as I know; nothing quantitatively convincing has emerged from it.

At the other extreme, there are very many physicists who believe that higher integer dimensions really do exist, only they are hard to spot; like it was for the flatworms until they experienced rain. There is a lot of speculation about the nature of these extra space-time dimensions. One large school of thought believes that they are curled up into a small scale of the order of Planck's wavelength $10^{-35}$ m with the symmetries of the coordinates within these tiny scales being responsible for the observed particle spectrum via excitations of these tiny additional degrees of freedom. This is the rationale behind string theory and the favourite number of extra dimensions currently happens to be six or seven. More recently it has been suggested that, apart from gravity, the particles and the force fields between them are constrained to act in 4-D. Thus our world (with its action) is to be viewed as a surface or "brane" lying in the "bulk" dimensions, rather like a pancake in higher space. (See Figure 2 for picturing how our 4-D universe can be embedded in higher dimensions). It has even been suggested that the thickness of the pancake brings in a fundamental length scale $\lambda$ which may not be small at all, certainly not as small as

![Figure 2. Two views of the universe.](image-url)
the Planck length, and may lead to observable consequences. The relevant formula in this context is \( G_N \sim R^{-6} \alpha M_{P0}^{-2} \) where \( M_{P0} \) is the corresponding Planck scale in the bulk. Thus far nothing solid has emerged from these investigations; just a lower bound \( M_{P0} \leq 2 \text{ TeV} \) or so, in order to avoid conflict with experiment, namely the possibility of "missing energy" through gravitational radiation into the bulk.

In even more recent papers it has been proposed that the big bang model of the universe might be replaced by an "ekpyrotic" model where, at the instant of creation of the universe, the two 4-D pancakes embedded in 5-D collide, leading to a sudden catastrophic heating. This has lately become a subject of intense excitement and has captured the cosmological headlines, even while the nitty-gritty details are being explored. I must confess that I find all this activity somewhat speculative and difficult to test.

More is less: Negative dimensions

I would now like to offer you another intriguing idea, that one can reduce the number of degrees of freedom, not by diminishing N, but by adding extra, curious coordinates. And one may even reduce the effective dimensions to negative values! These coordinates may not be so curious after all. You know that the Pauli principle leads to Fermi-Dirac statistics, which stipulate that wavefunctions of identical fermions must be totally antisymmetric under interchange, i.e., \( \psi_\alpha(\mathbf{x})\psi_\beta(\mathbf{x}) = -\psi_\beta(\mathbf{x})\psi_\alpha(\mathbf{x}) \) for two electrons. Well it is possible to invent a set of n "Grassmann" coordinates \( \xi \) which have the same "anti-commutation" property, viz. \( \xi_a \xi_b = -\xi_b \xi_a \) and to attach them to our space-time \( x \) in the idea behind the theory of "supersymmetry" is that one may invoke rotations from \( x \) to \( \xi \), thereby turning from bosonic coordinates (and fields) into fermionic coordinates (and fields). Then impose supersymmetry by requiring the full action to be invariant under such extended rotations. In the standard approach, developed over the last 30 years, the (complex) \( \xi \) are associated with "spin" and there are at least two of them, in order to correspond to spin "up" and "down".

Before outlining their possible application to physics, I would like to point out some of their peculiar properties and one in particular. The addition of these fermionic degrees of freedom serves to decrease the number of dimensions! Let's see how. You will all be familiar with the standard Gaussian integral

\[
\int_{-\infty}^{\infty} \exp(-x^2) \, dx = \sqrt{\pi} / x.
\]

Nor will its N-dimensional generalization surprise you:

\[
\int_{-\infty}^{\infty} \exp(-x^2) \, dx = \sqrt{\pi} \, N / \sqrt{\det(S)},
\]

where \( S \) is necessarily a symmetric matrix. I want you to notice that the determinant on the right occurs in the denominator. Interestingly, as Berezin stated most clearly, it is feasible to define differentiation and integration rules for fermionic coordinates. Queer though they may be, they are perfectly consistent. One of the consequences is that the analogue of the Gaussian formula reads,

\[
\int_{-\infty}^{\infty} \exp(-\xi A \xi) \, d^n \xi = \sqrt{\det A},
\]

where \( A \) is necessarily antisymmetric and \( N \) is even. Here the determinant arises in the "numerator" and this is inverse to the bosonic case. The net effect is that one may view each fermionic real pair of coordinates (or each complex coordinate) as subtracting one degree of freedom. I don't know of an intuitive way of conveying this, except to say that it works out peculiarly well in various ways. The change of sign between bosons and fermions is apparent in:

- the F-D and B-E statistical distribution formulae, \( \exp(\alpha e^2 / \beta e) \pm 1 \);
- Fermion anticommutation \( \eta_i a_i = -\xi \eta_i \), versus Boson commutation

\[
x y = y x;
\]
- This is reflected in a fermionic loop carrying an opposite sign factor to a bosonic loop when evaluating quantum corrections; because one can get their infinities to cancel, this is one of the main reasons why many theorists have fallen in love with supersymmetry.
- the supertrace formula, \( \langle E \rangle = \sum_i (-1)^i (\mathcal{E}_i exp(-E_i / kT)) \), where \( E \) is the fermion number of the state over whose energy we are summing.

Anyhow, the net effect is that after attaching \( M \) of these complex anticommuting \( \xi_a \) to the usual four commuting space-time \( x \), one ends up with \( (4+M) \) effective degrees of freedom, and for sufficiently large \( M \) one can even finish up with a negative number!

Might the universe have zero total dimensions?

For the last several years I have been toying with a model of particle physics, which is different from conventional applications of supersymmetry. I find it fascinating because it has equal numbers of fermionic and bosonic coordinates, so one can regard it as a zero dimensions hypothesis. In some ways, it resembles the hypothesis that the total energy of the universe is zero, with positive kinetic energy cancelling negative potential energy. To outline the basic concept, let me set the scene by reminding you about the present zoo of fundamental particles. One can group the known menagerie of fermions into 3 species, consisting of one lepton and its neutrino plus an up-type and down-type quark, in colour triplets; see Figure 3. It is a completely mystery why nature offers things in ones, twos and threes and why there are no more than 3 species. String and brane theories do nothing to illuminate this mystery, so it would be useful to attempt to shed some light on this matter.

The spin 1/2 particles group into three species or "generations" (superscripts denote charges):

\[
\begin{align*}
\psi^ \alpha & \quad (u^{\alpha/3})_R, \quad (u^{\beta/3})_G, \quad (u^{\gamma/3})_B; \\
\psi^ \mu & \quad (d^{\alpha/3})_R, \quad (d^{\beta/3})_G, \quad (d^{\gamma/3})_B; \\
\psi^ \tau & \quad (e^{\alpha/3})_R, \quad (e^{\beta/3})_G, \quad (e^{\gamma/3})_B;
\end{align*}
\]

accompanied by force fields associated with gauge bosons,

\[
\begin{align*}
W^+ & \quad Z^0, \quad W^-, \quad \gamma, \quad 8 \text{ gluons}, \quad \text{graviton}\ g.
\end{align*}
\]

Figure 3. The particle zoo

Thirty years ago Pati and Salam originally suggested that leptons connotate a fourth colour. Taking a leaf out of their book, attach 4 complex (Lorentz scalar, not spinor) Grassmann coordinates \( \xi \) to our four spacetime \( x \). Ascribe \( \xi_0, \xi_1, \xi_2, \xi_3 \) the quantum numbers of three coloured \( d \)-type quarks and \( \xi_4 \) the quantum numbers of the charged lepton. (A similar vision model with a different charge assignment for \( \xi_0 \) was proposed in 1979 by Harari and Shupe, but it was never associated with intrinsic Grassmann coordinates.) Our fields are functions of bosonic \( x \) and fermionic \( \xi \). The nub of the argument is that \( x \) tells us where something is and \( \xi \) tells us what it is that's there.
Ignoring the space-time location $x$, and concentrating on the type-dependence, namely $\xi$, a field expansion like

$$\Psi(\xi) = \Psi + \gamma^a \xi_\alpha + \gamma^b \xi_\beta + \gamma^c \xi_\gamma + \gamma^d \xi_\delta + \gamma^e \xi_\epsilon + \gamma^f \xi_\zeta + \gamma^g \xi_\eta + \gamma^h \xi_\theta + \gamma^i \xi_\iota + \gamma^j \xi_\kappa + \gamma^l \xi_\lambda + \gamma^m \xi_\mu + \gamma^n \xi_\nu + \gamma^o \xi_\xi + \gamma^p \xi_\psi + \gamma^q \xi_\omega$$

automatically terminates and contains $16 = 1 + 4 + 6 + 4 + 1$ components, representing precisely one generation of particles. This strikes me as more than an accident. Taking this pointer, we should examine the dependence of $\Psi$ on the complex conjugates $\xi_\alpha^*$ too. Proceeding in this vein, one finds that the full $\Psi(\xi, \xi^*)$, with appropriate reflection symmetry (to reduce the number of terms in the expansion) on the $4 \times 4$ magic square, contains just three species of quarks and leptons plus two 15-fold multiplets only and is economical so far as counting of particles is concerned.

<table>
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<th>$\xi^\phi \xi_\xi$ power</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tr>
<td>0</td>
<td>$\psi_c$</td>
<td>$c^\dagger$,</td>
<td>$u$,</td>
<td>$c$</td>
<td>$\mu^*$, $s$</td>
</tr>
<tr>
<td>1</td>
<td>$c^\dagger$,</td>
<td>$c^\dagger$, $c$</td>
<td>$\tau^<em>$, $\tau^</em>$</td>
<td>$\tau^<em>$, $\tau^</em>$</td>
<td>$\mu^*$, $s$</td>
</tr>
<tr>
<td>2</td>
<td>$c^\dagger$, $c^\dagger$,</td>
<td>$\tau^<em>$, $\tau^</em>$</td>
<td>$\tau^*$,</td>
<td>$\tau^<em>$, $\tau^</em>$</td>
<td>$\mu^*$, $s$</td>
</tr>
<tr>
<td>3</td>
<td>$\mu^<em>$, $\mu^</em>$,</td>
<td>$\tau^<em>$, $\tau^</em>$</td>
<td>$\tau^*$,</td>
<td>$\tau^<em>$, $\tau^</em>$</td>
<td>$\mu^*$, $s$</td>
</tr>
<tr>
<td>4</td>
<td>$\nu^<em>$, $\nu^</em>$,</td>
<td>$\tau^<em>$, $\tau^</em>$</td>
<td>$\tau^*$,</td>
<td>$\tau^<em>$, $\tau^</em>$</td>
<td>$\mu^*$, $s$</td>
</tr>
</tbody>
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Despite the promising outlook, I must admit that I haven't yet succeeded in obtaining the correct mass matrices and mixing for these states, but I'm still working on this problem on and off. Also the connection with quaternions and octonions continues to tantalize me but obstinately eludes me. However I believe that if you have a promising idea that is different from the mainstream, it is important to stick to your guns and not be unduly deflected by the juggernaut of fashion. Be sure of your facts, lay your groundwork and the rest will take care of itself. This extract from Barrow's *Book of Nothing*, concerning a Canadian naval radio conversation, conveys my message:

"Navy Please divert your course 15° to North to avoid a collision.
Civilian Recommend you divert your course 15° to South to avoid collision.
Navy This is the captain of a US navy ship, I say again divert your course.
Civilian No I say again, divert your course.
Navy This is the aircraft carrier ENTERPRISE. We are a large warship of the US navy. Divert your course now.
Civilian This is a lighthouse. Your call."

In Australia, we should not complain too much about our geographical isolation from the main centres of scientific activity, even though the internet has done much to mitigate this disadvantage. For we have the advantage of being shielded to some extent from the current fads of research and therefore have the opportunity to think more deeply about basic ideas and perhaps be less influenced by popular paths which finish up as dead ends. Not that I'm suggesting that one should continue blithely, regardless of new trends and oblivious to significant developments. Of course one must still keep one's ears to the ground listening for important resonances that are likely to lead somewhere.

I hope that this talk has given you an inkling of my type of research. The visits has been through a special window, but you have probably glimpsed what sort of physics catches my eye. Hopefully I won't have to mumble an incoherent reply to the standard cocktail party question at the coming reception: "We know you are a theoretical physicist, but what exactly do you do?"

Thank you for your patience in sitting through this lecture after a full day's program. In closing let me leave you with a thought, due to Oliver Wendell-Holmes:

"A mind once stretched by a new idea never regains its original dimensions."

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CONFERENCE REPORT

The biannual International Congresses on Plasma Physics are the most international of the full-spectrum plasma physics conferences, having no permanent tie to any one regional physical society, but rather making different regional links as they move around the world. This year the conference, being located in the southern Asia-Pacific region, incorporated the 6th Asia Pacific Plasma Theory Conference, the 24th Australian Institute for Nuclear Science and Engineering (AINSE) Plasma Science and Technology Conference, and the 6th Japan-Anu-Australia Plasma Theory and Computation Workshop.

In an age of specialization, ICPP 2002 was a general conference in plasma physics. A theme of the conference was the unity of plasma physics, covering all aspects, from low-temperature plasmas to fusion plasmas, from industrial applications to astrophysics, and all three approaches to investigating physical phenomena: experiment, observation and theory.

The Congress was organized on behalf of the ICPP International Advisory Committee (IAC) by the Local Organizing Committee (LOC). The International Program Committee, co-chaired by Robert Dewar of ANU and Michael Tendler of the Royal Institute of Technology, Stockholm, met in Sydney in February 2002 to select the program of 49 invited Plenary and Review talks for the morning program. These were selected from nominations submitted by the IAC, the LOC, the Program Committee itself, and self-nominations in abstracts submitted. An innovation at ICPP 2002 was the interesting program of afternoon invited topical talks assembled by four autonomous specialist subcommittees chaired by Iver Cairns and Marcela Bilek of the University of Sydney, Sadrahuddin Benkaddi of University of Provence and Michael Tendler, Stockholm. The themes of the sessions were Space and Astrophysical Plasmas, Plasma Applications, Transport and Complexity in Magnetically Confined Plasmas, and Fusion Plasmas.

The conference, attended by 292 delegates, was opened by Professor Lawrence Cram of the Australian Research Council. Professor Cram also addressed a lunchtime forum of Australian plasma physicists on the first day of the Congress, at which the National Research Priorities debate was discussed.

It is also a tradition of the International Congresses on Plasma Physics to hold a forum on the last day, to reflect on where we are now and where we are going in plasma physics — what are the most important scientific, technological and political challenges over the two years to the next ICPP, and beyond. The forum in Sydney was chaired by Dr Jean Jacquinet, Head of the Research Unit of the Association Euratom-CEA, Controlled Fusion Research Department, Cadarache, France. Panelists selected broadly to represent the four strands of the afternoon sessions gave short presentations, followed by lively discussions involving the audience, including students.

The main sponsors were the International Union of Pure and Applied Physics (IUPAP), US$14,000, and the New South Wales Department of State and Regional Development, AUD 10,000. The IUPAP grant was predominantly used to encourage participation by delegates from the most underdeveloped countries (those classified Low-Income or Lower-Middle-Income by the World Bank). The Manly Rotary Club hosted a reception for delegates from developing countries on the Sunday prior to the opening of the Congress.

The Congress was underwritten by the Australian Institute of Physics, the Plasma Research Laboratory and Department of Theoretical Physics at the Research School of Physical Sciences and Engineering, ANU, and Professor Don Melrose’s consulting account at the School of Physics, University of Sydney. The profit will be used to fund the publication of a Proceedings in the American Institute of Physics’ Conference Proceedings series, with delegates receiving a CD ROM of the Proceedings.

In addition, IOP Publishing Limited has agreed to publish a cluster of papers from the morning Plenary and Review talks in an issue of Plasma Physics and Controlled Fusion, with web links to ICPP 2002 papers published in subsequent issues. The cluster issue will be made free on the web to ICPP 2002 participants for a period of time.

The venue, overlooking the surf beach at Manly, proved to be ideal for a conference of the size of ICPP 2002 and many delegates expressed their satisfaction with the organization of the Congress. Social and cultural highlights were the conference dinner at the Manly Pacific (with an after-dinner talk by Dr Karl Krauszhnicki) and an organ recital by well-known UK plasma physicist Professor Malcolm Haines in the Great Hall of Sydney University, and a public lecture by Academician Vladimir Fortov, Russia, reporting on fascinating micro-gravity dusty plasma experiments in the MIR space station and the International Space Station.

At a meeting of the IAC during the Congress, the venue for ICPP 2004 was chosen to be Nice, France.

The photo shows the participants in a musical soirée held during the Congress at the home of Emeritus Professor Heinrich Hora. Standing, from the left: Mrs Polly Haines (a distinguished mezzo-soprano), Professor Malcolm Haines (Imperial College, London), Professor Robert Dewar (ANU), Academician Xiantu He (Institute of Applied Physics & Computational Mathematics, Beijing), Academician Vladimir Fortov (Russian Academy of Science, Moscow), Professor Michael Tendler (Royal Institute of Technology, Stockholm), Academician Oleg Krotkin, (Lebedev Physical Institute, Moscow), Professor Heinrich Hora (UNSW). In front, from the left: Dr Frederick Osman (UWS, Penrith), Professor Weiyan Zhang (China Academy of Engineering Physics), Mrs Rena Osman and Mrs Rose Hora.

Frederick Osman, University of Western Sydney, Penrith
Robert Dewar, Australian National University, Congress Chair
Ian Falconer, University of Sydney, Congress Secretary
VICTORIAN BRANCH

At our June meeting, the annual TH Laby Medal for the outstanding physics honours student in Victoria in 2001 was presented to Scott Findlay of the University of Melbourne by the Federal President, John O'Connor. The title of Scott's Honours project was 'Retrieval of the structure of non-periodic objects using high-energy electrons' and it considered improved techniques for the interpretation of images formed using transmission electron microscopy.

The presentation was followed by an excellent talk by John Jenkin (La Trobe University) entitled 'The Compton Effect: Whose idea was it?' (or 'Don't go to the movies when a Nobel Prize beckons!'). Jenkin described his detective work into discovering the pivotal role that an Australian, Eric Jauncey, played in Arthur Compton's adoption of the quantum interpretation of x-ray scattering in 1922. Having rejected this model for over five years, Compton appeared to change his mind overnight. In fascinating detail, Jauncey's early life in Adelaide was described, along with his association with WH Bragg and the role that Bragg played in Jauncey's appreciation of quantum physics. After working in Leeds in the United Kingdom and undertaking several short-term positions in the United States, Jauncey was hired by Compton, then Professor of Physics at the Washington University in St Louis, Missouri. At Jauncey's funeral in 1947 Compton paid tribute in his eulogy, stating that 'Jauncey had brought quantum concepts to America'.

EPA. This included a description of the refurbishment of the building housing the centre which had once been a psychiatric hospital. Environmentally appropriate principles had underpinned all aspects of the rehabilitation. The EPA has several specialist units including the Centre for Air Quality Studies, Environmental Chemistry, Freshwater Science, Marine Science and Scientific Support. The Environmental Chemistry unit undertakes environmental forensics as well as applied research and training while the Air Quality unit performs modelling and forecasting, providing smog alerts where appropriate, and maintains an air monitoring network of 15 stations. The Freshwater and Marine Sciences divisions monitor water quality, undertake environmental research and community programs as well as providing beach reports.

After the presentation, members were taken on a tour of the building, which provided an excellent opportunity to view the instrumentation used for investigating and monitoring air and water quality as well as discussing the EPA's role with the guides.

Ann Roberts

TASMANIAN BRANCH

The third lecture in our winter lecture series was delivered by Dr Fred Watson on 13 August. A good-sized audience was enthralled by Fred's witty presentation on the topic "Astronomers Behaving Badly". Fred gave an historic perspective of the advance of astronomy from medieval times to the present highlighting the controversies between powerful and influential astronomers through the ages. He described with some delight the antics that these pillars, and some lesser know names, of astronomical history got up to and the less than gentlemanly things they said about each other and did to each other. It would certainly appear that the idea of a litigious society is not nearly as recent as we may think! All in all the talk was an enjoyable romp through astronomical history and the people involved in making it.

Fred Watson also presented enthusiastic and inspiring Youth Lectures with the title "Industrial-Strength Cosmology" in both Hobart and Launceston. Fred presented and demonstrated our well-substantiated industrial-strength knowledge of the development of the Universe and outlined current and possible future research in this field. He presented this, in his inimitable manner, as an audacious and amazing achievement for the residents of the surface of a small remnant of the Sun's formation to understand the origin of the Universe.

Cosmology gives us a remarkably cogent picture of the Universe's evolution. The Youth Lectures are a recent innovation for the Tasmanian Branch and bring an interesting student-level, Physics presentation to late year high school students during school-hours. One school acts as host and the surrounding schools are invited to attend. The Southern Youth Lecture was at Elizabeth College in Hobart and about 90 students from four schools enjoyed the presentation. Launceston College provided the venue for the presentation of the Northern Youth Lecture. Unfortunate timing meant that the Northern Youth Lecture corresponded to a study week, and only 20 students from two schools attended.

The 10th annual Tasmanian AIP Physics Quiz for Year 11/12 students was held at The Friends' School on Saturday 31st August. Twelve teams of up to four students per team from 5 colleges competed. This year's Quiz featured an introductory talk by Dr Stuart Conney, a recent theoretical physics graduate, who discussed his present modelling research on electro-cardiogram (ECG) interpretation. Teams collectively answer six rounds of ten questions to determine which school wins the perpetual AIP Quiz Shield for the next 12 months. Additional prizes are awarded for the members of the top three teams. Individual prizes of chocolates are awarded for 'Who, What, Where, When' questions between the rounds while the marking is done. An afternoon tea between rounds 3 and 4 provides an opportunity for the students to meet each other and members of the AIP. The 'Who am I?' questions this year featured Paul Dirac, whose 100th birthday was in August, and Leicester Maclay, the Tasmanian Professor of Physics (1895-1969) who was instrumental in establishing three core research fields in Tasmania: biophysics, optical astronomy and cosmic rays. A special prize provided by CSIRO Marine Laboratories in Hobart was given to Jon-Ho Chan for identifying Emmy Noether in a 'Who am I?' question. Answers to other 'What, When & Where' questions included the time of the last walk of man on the Moon, Bose-Einstein condensate and location of the Australian National Synchrotron facility.

The AIP Quiz is strongly supported by research institutes and industry in Tasmania enabling us to present prizes which include the Comalco medals, books, subscriptions to Sky & Space magazine, family passes to the Launceston Planetarium and books to all schools which enter. A subsidy is also offered.
for those travelling from the further reaches of the state to the Quiz. This year's sponsors were Comalco, CSIRO Marine Science, the School of Mathematics and Physics and the Faculty of Science and Engineering (University of Tasmania), Sky and Space Magazine, The Bureau of Meteorology, The Queen Victoria Museum and Art Gallery, Australian Antarctic Division and Monniken Technology.

This year's winners were a team from The Friends' School consisting of Guy Boyd, Alex McCormick, Wils Headberg and Karl Mathiesen. They each received gold medals, presented by Dr Andrew Forbes, Program Leader at the CSIRO Marine Research, Hobart. Tie-breakers and a count-back was necessary to separate three further teams tied for second. Elena Kelareva, Cameron Watchorn and Peter Landowski representing Elizabeth College received silver medals and Isuru Amarasekara, Jon Ho Chan, Alex Pologai and James Baker from The Hutchins School bronze medals. All the members of these teams also received book and other prizes. A further team from The Friends' School comprising James Bennett, Christopher Davies, Samuel Henry and Alastair Phillips came fourth but were also awarded individual book prizes for their efforts. We are particularly grateful to The Friends' School for providing this year's venue. Details of the 2002 AIP Quiz with all the questions and some photos can be found on the branch website at <http://www.phys.utas.edu.au/physics/AIP_TasBranch>

The 2002 Women in Physics lecturer, Lidia Moroswa, gave her presentation in Hobart on 28 August. Only a paragraph is included here as Lidia is lecturing nationally. Archimeyes' cry, "Eureka!" arose as he realised that a phenomenon of common experience could be understood and explained. Likewise, Newton's Laws relate to matters of common experience. By contrast, Einstein and other 20th century physicists explain things that are beyond our normal daily experience. In this age of applied physics, what are the frontiers where we may explain, "Eureka!"? Lidia Moroswa's frontier is aerosols. They come from volcanoes, vehicles, burning rubbish and reactions within the atmosphere. Most aerosol particles are less than 0.1 mm in diameter. How can they be measured? What are their effects? But is it enough just to do the science at the frontier to improve air pollution? Lidia quoted with affection her Polish countrywoman, Marie Curie, "You can't hope to build a better world without improving the individuals."

The fourth and final lecture in the Tasmanian winter series on 17th September was one entitled "Twinkle, twinkle quasi-star. How I wonder what you are? - The search for the littlest quasar". Dr David Jauncey from the CSIRO Australia Telescope National Facility took us on an astronomical journey to try and reach ever finer spatial resolution when observing the cosmos. We all know that stars twinkle from atmospheric effects and planets don't. This is because the planets are not point like sources. What most people don't know is that, at radio wavelengths, quasars twinkle because of the varying interstellar medium, they scintillate. Considering the moon's surface as seen from the earth, one arc minute is equivalent to approximately 100 km, one arc second about 1 km, one milli-arc second about 1 m and one micro-arc second about 1 mm. This is the kind of angular resolution achievable with scintillation measurements of distant quasars and is what is required to understand what is going on within them. The earliest observations searching for quasar variability used the largest single dish radio-telescopes and variability was discovered on timescales of hours and longer. This variability is too fast to be due to intrinsic source variations. The extreme brightness of the sources necessary for them to be observed half way across the universe can not come from a region as small as a few light hours in size. Thus there must be another explanation for the variations. Measurement of the variations observed with telescopes in Australia and USA for a particular quasar showed a consistent 7 minute delay in the variations. This proved that the source must be relatively local. The local interstellar medium, consisting of very thin gas clouds of varying density, will generate a first Fresnel zone with an angular size that would correspond to this kind of variation. The angular size of the first Fresnel zone at a distance of 100 pc is 5 micro-arc second or 20,000 times the resolution of the Hubble Space Telescope. Using the orbital rotation of the earth the same effect can be seen in about half a dozen quasars. The future for this extremely high angular resolution technique is bright. It should be possible to map the nearby gas clouds and deconvolve their scintillation effects to look at the smallest quasars that exist to see how really bright and small they actually are.

Marc Duldig, Gary Burns and Ian Newman Chapple, have been using sonar imaging to map the bottom of Sydney Harbour. They have detected the wrecks of at least 10 large vessels and dozens of smaller ones, including the remains of the 'Currajong', a collier which sank when it collided with a large passenger steamer in 1910. ['Sydney Morning Herald']

### AROUND THE TRAPS

#### Breaking the Law

Dennis Evans of the ANU and coworkers at Griffith University in Queensland have shown that entropy can decrease in small systems over short times, violating the second law of thermodynamics (G. Wang et al., Phys. Rev. Letts. 89, 050601). They put about 100 beads of latex into a water-filled cell, and focused a laser on one of the beads, drawing it into the beam. They then caused the cell to oscillate back and forth, and tracked the position of the bead over time. Over short periods, they found that sometimes entropy was conserved rather than generated. They claim that this could have "important ramifications for nanotechnology and indeed for how life itself functions".

['Physics World', August 2002]

#### Primed for Take-off

A physicist at the University of Technology in Sydney, Suzanne Hogg, has discovered a nice little sideline in the film industry. She has been employed as a consultant to calculate trajectories for Evel Knievel-type stunts, where a car takes off from a ramp and soars over a building or other cars. Elementary mechanics is used to calculate the ramp angles and take-off speeds required to perform the feats. She has worked in movies such as Babe and Pig in the City, and TV shows such as Water Rats.

[Nic Svenson, 'Sydney Morning Herald', 18 Aug.]

#### Bottom of the Harbour

A team of scientists from the Defence Science and Technology Organization, led by Dr. Phil
Prompt Critical

Nuclear Swords and Ploughshares
When two American physicists, one an arms control expert, Richard Garwin, and the other a French Nobel laureate, Georges Charpak, get together on writing a book the result is bound to be interesting. Their joint effort, titled "Megawatts and Megatons", has earned wide praise and some good reviews for its comprehensive coverage of both civil nuclear electricity generation and modern nuclear weapons. As one might hope, they advocate reduction of the latter, and the expansion of the former.

The book is largely based on an earlier one in French by both authors, and in a few places its age shows. For example they make use of the UNSCEAR 1993 report and seem unaware of some contrary conclusions from the UNSCEAR 2000 report. This is particularly evident when they draw conclusions about the dangers of nuclear radiation by clinging to the discredited linear no-threshold (LNT) hypothesis relating radiation dose and adverse health effects, especially cancers. There is not a single mention of the radiation hormesis phenomenon for which evidence is mounting year by year. There are other mistakes and discords, but overall Garwin and Charpak have written a valuable contribution to the nuclear debate. Their arguments in favour of nuclear power generation are compelling, and refute specious anti-nuclear claims on issues such as safety and waste disposal. "Megawatts and Megatons" runs to 412 hardcover pages and is published by Alfred Knopf in New York. It may be obtained through Amazon.com for AU$8 and bears the ISBN 0-375-40394-9. Forgiving the shortcomings identified above, it is highly recommended for libraries and individuals interested in nuclear affairs.

Colin Keay
Reviews Editor

REVIEWS

Reviews

Measured Tones. The Interplay of Physics and Music (2nd ed)
Ian Johnston
IoP Publishing, Bristol 2002
xv + 406 pp., UK £4.99 (paperback)

The first edition of this book was a great read, and this edition is even better. The author looks at the physics and mathematics involved in music. But this is only a part of his story, told in what he calls 'interludes'. The main theme traces the history and flavour of European music and physics, and draws parallels between them. This novel and attractive plan makes it easy to read.

In this second edition, nearly all figures have been redrawn, which enhances the visual appeal of the book. There are also updates on electronic instruments and MIDI, on noise 'music' and on the use of pentatonic scales in different cultures, with emphasis on the harmonic ideas of simple ratios that, in Europe, are traced back to Pythagoras.

Here we have an improved version of a very good book. Anyone with an interest in both physics and music (but not necessarily any technical background in either) will enjoy reading it.

Joe Wolfe
School of Physics
University of New South Wales

Quantum Generations - A History of Physics in the Twentieth Century
Helge Kragh
Princeton University Press, Princeton 2002
xvi + 494 pp., US$18.95 (paperback)
ISBN 0-691-06552-3

With a small backward extension into the last decade of the nineteenth century, quantum physics is encompassed within the past one hundred years. This reviewer has been around for much of that time and has memories of more than half of it. For the physics that I was involved in, either as a practitioner or as a teacher, this book is impossible to fault and I suspect the same will be true for others.

It places the advance of physics squarely in its social context. It covers individual discoveries, like the quantum Hall effect, as well as major enterprises, like the Nobel Prizes. As well, it is full of less familiar vignettes that illuminate the rest. As an example: that Sutherland, an Australian, had proposed the existence of a "neutron" in much the same terms as Rutherford did, twenty years later. In a similar vein there are touches of whimsy: for example, what did Lenin think of the electron? I was constantly saying, "I didn't know that".

An unusual feature is the inclusion of many graphs and tables quantifying such matters as US military expenditure on R & D and much more. Did you know that the solid state electronics industry (transistors and integrated circuits) owed its rapid advance not to industry but to the military? The book is a tour de force for a single author, but this gives it the great advantage of coherence. It is patently scholarly and stylishly written. It encourages you to go on reading, either continuously or to dip in, a chapter at a time. Whether you are looking for background material for your field, for lecture materials, or just for your own satisfaction, the book cannot fail to leave you better informed. The index is not adequate; but it is a "good read".

John Prescott
Physics and Mathematical Physics
University of Adelaide

Experimental Techniques in Low Temperature Physics (4th ed)
G K White and P J Meeson
Clarendon Press, Oxford 2002
xii + 280 pp., £29.50 (paperback)
ISBN 0-19-851427-1

This is an excellent guide to experimental techniques in low temperature physics, written by very experienced researchers. The book is successfully packaged as a "lab handbook", which covers the most important basic areas for researchers new to the field. It is also an excellent reference book for the experienced researcher. Especially nice is the appendix on suppliers of cryogenic equipment, which gives the web address of all-important companies in categories of equipment. I am happy to say that this book is a "must" for any laboratory designing cryogenic experiments. It could also be useful as a reference text for an undergraduate or postgraduate course in experimental techniques. The book is well organised, starting with an easy to read historical and scientific perspective, followed by chapters on the engineering and physics describing the most important techniques and equipment relevant to the field. The best part is the effort and care put into many diagrams. The cliche "a picture speaks a thousand words" can be directly applied to this book. This enables concise explanations on how basic equipment works. Good hints and "rules of thumb" for the experimentalist are also included. When designing complicated experiments it is easy to overlook some basic design principles, which become obvious with hindsight. The authors successfully express their experience to the reader in a very understandable way, to help avoid these pitfalls. I say "well done!"

M E Tobar
School of Physics
University of Western Australia

Data Analysis with Excel - An Introduction For Physical Scientists
Les Kirkup
Cambridge University Press, Cambridge 2002
xvii + 446 pp., £38.00 (paperback)
ISBN 0-521-79737-3

This book is designed as a textbook for a
course in statistical data analysis for undergraduate physics students. As well as providing the formulae for the statistical techniques there are excellent instructions for obtaining the results in Excel. Although there are new quite a few books with Excel instructions, most provide a disc with extra functions to cope with Excel's inadequacies. This is annoying when you have a large lecture stream and a department reluctant to spend money on licences. Kirkup's book uses only raw Excel. There are plenty of introductory statistics textbooks. This one differs from the others in a few respects. First, all the examples are related to physics. Although it covers all the topics in most other introductory texts, it includes a few extra topics not normally covered in basic texts, such as the use of scientific notation and measuring random and systematic errors, including calibration, offset, gain, and loading errors. Unusual for basic texts, this one also discusses weighted regression and transformation of data so the linear regression is valid, with particular reference to the appropriate transformations for some of the common relationships in physics.

Overall I found the book excellent, with only two faults. First, in chapter 1, Kirkup incorrectly defines the population standard deviation, although he later gives the correct definition in Chapter 5. Second, in the last section of Chapter 8 dealing with ANOVA, the overall ANOVA test is explained, but there is no mention of multiple comparison tests. If you get a significant result from the ANOVA, you want to know which groups are different. Just doing the ANOVA overall test is incomplete.

S Middleton
Department of Statistics
University of New South Wales

Practical Applications of Internal Dosimetry
W E Bolch (ed)
Medical Physics Publishing, Madison WI 2002
viii + 468 pp., USS 60.00 (hardcover)
ISBN 1-930524-09-9

This book is about radionuclides which accidently or otherwise were inhaled, ingested or entered the body via the skin. The emphasis is on medical procedures rather than the physics of activity measurements, though the latter is given due. Serious students and practitioners of radiation protection will find the book required reading to update internal dosimetry and radiation protection procedures in particular when having to deal with long-lived actinides, commonly alpha emitters.

The ten chapters of the book were written by experienced scientists from US Universities and National Laboratories who are long-standing contributors to the US health Physics Society. The chapters are summaries of talks presented at the 2002 Summer School of the Society during June of this year. The introductory chapter explains the anatomical and physiological bases governing detection and treatment of inhaled or ingested radionuclides or absorbed via wounds or other injuries. Subsequent chapters deal in detail with internal dose assessment programs and procedures for the monitoring and control of internal exposure. Most chapters include tables of radionuclides obtained by fission monitoring on workers who had been subject to repetitive measurements carried out within current regulatory and legal requirements.

The last chapters deal with dose assessment in nuclear medicine and external beam radiation therapy, the latter being used to ensure that predetermined doses are homogeneously delivered while avoiding surrounding sensitive surfaces. For nuclear medicine, computer codes have been developed for patient specific dosimetry and treatment planning which, among others, can cope with 3D data as displayed in SPECT and PET images.

G C Lowenthal
School of Mechanical Engineering
University of New South Wales

The Quantum Hall Effect
D Yoshioka
Springer-Verlag, Berlin 2002
xii + 203pp., EUR59.95 (hardcover)
ISBN 3-540-43115-2

Quantum Hall effects belong to an emergent area of fundamental physics. The subject has an exciting history. It bagged two Nobel prizes, one for integer QHE to Klaus von Klitzing and the other for fractional QHE, shared by two experimentalists Daniel Tsui and Horst Stormer, and a theorist Robert Laughlin. In the past two decades research activities in this field have grown enormously. It has led to many important advances in understanding the nature of electronic excitations, transport and collective behaviour in 2D systems in strong magnetic fields.

In this monograph Daijiyo Yoshioka has done a marvellous job. In the first half of the book he gives an excellent pedagogic description of both integral and fractional QHES. He begins with a brief history and discusses the physics of 2D electron gas in a magnetic field. Two key points that localisation and electron correlations are responsible for integral and fractional QHE respectively, are clearly emphasised.

The remaining half gives a specialised account of recent activities in this field, namely: composite particles, chiral Luttinger liquids, even denominator states, edge states and higher Landau levels. It is pleasing to see a number of suggested problems and their solutions at the end.

This book would be a good reference for a post-graduate course in Condensed Matter Physics. Those interested enough to learn the subject from scratch, are recommended to buy personal copies.

Mukundan Das
RSPhysSE
Australia National University

Time in Quantum Mechanics
J G Muga, R Sala Mayato & L I Egusquiza (Eds.)
Springer-Verlag, Berlin 2002
vii + 419 pp., EUR 62.95 (hardcover)
ISBN 3-540-43294-9

I enjoyed reading this valuable addition to Springer's Lecture Notes in Physics series. Beginning with a clear introduction to the perplexing issue of the nature of time in quantum mechanics, the reader then undertakes a stimulating excursion through a sequence of chapters written by leading researchers. Theory and experiment are nicely balanced, and extensive lists of references accompany each chapter. Although (as the editors point out) this collection of works based on papers at a workshop is not the final word (another text on the subject is planned), this text is currently the final word as it presents a representative survey of current topics on this subject.

The book is interesting from several perspectives. The issue of time in quantum mechanics cuts to the heart of quantum theory, and despite decades of complacency by the majority of pragmatic practitioners of quantum mechanics, the questions about temporal coordinates for events, duration of events, quantisation of time, measurements of time and clocks, energy-time uncertainty relations and classical limits for time in quantum systems are important practical and philosophical considerations. The subject is also interesting historically because of the debate over lifetimes of decays, transition line widths and the controversy over sudden quantum jumps. Furthermore, the book is enlightening from a sociological perspective to see how "sides" of these controversies developed and later reconciled as unified approaches developed (eg, positive-operator valued measures). I recommend this text as an overview of a mature but as yet unresolved bugbear of quantum mechanics.

Barry C Sanders
Department of Physics
Macquarie University
OBITUARY

DR ANTHONY MYRON BREED

Anthony Breed grew up on his parents' farm near Cummins where he developed the innovative skills and independence of mind which are necessary attributes of the first-class experimental scientist that he became.

Sadly, Anthony died unexpectedly on September 5 at the very young age of 32, following a massive heart attack.

He gained a South Australian Institute of Technology medal in 1989 for outstanding achievement in his Bachelor of Applied Science degree. He chose to do research work in Applied Physics with Associate Professor Geoff Goodwin from 1989 to 1997, studying the ionized upper atmosphere (ionosphere). Initially he used radio signals from Navy Navigation Satellite System (NNSS) satellites to measure the day-to-night, seasonal and sunspot cycle variations in the electron content of the ionosphere. The measurements are important in forecasting conditions for long distance radio communication. Subsequently, Anthony was involved in making the first long-term measurements in the southern hemisphere of the total electron content of the ionosphere by using radio signals received from Global Positioning System (GPS) satellites. The measurements allow the ionospheric error to be eliminated so that the positions of GPS receivers can be found with the highest accuracy, as required in surveying and military applications. Anthony worked jointly with personnel from the University of South Australia, the Defence Science and Technology Organisation (DSTO) and La Trobe University.

Anthony gained a Master of Applied Science (1992) and a Doctor of Philosophy (1996) for very significant contributions in satellite studies of the upper atmosphere.

Anthony then joined the Australian Antarctic Division and satisfied his sense of adventure with several visits to the Antarctic, including two winters at Casey base. With the Division he was involved in a raft of polar ionospheric studies with his scientific colleagues including: ionospheric convection; nowcasting ionospheric conditions; sporadic E; polar patches; signatures of plasma drift; E region Bragg scatter; and several specific event studies utilising ground and satellite data. This research resulted in numerous scientific publications and conference presentations. Anthony had excellent technical skills with scientific instruments, in particular with the digisonde and TIGER SuperDARN radar, and had exceptional analytical, computer and complex programming expertise - he was a well rounded experimental scientist. Anthony used these skills during the relocation of the digisonde from Casey to Davis bases in Antarctica during the 2001-02 summer - a very demanding task - and was poised to make a significant contribution to understanding polar cusp region ionospheric processes.

Anthony designed several research campaigns with the digisonde to detect polar patches and his analyses resulted in a better understanding of the ionospheric motions involved in polar patches. Several new display techniques have shown variations in plasma drift velocity associated with patches possibly related to their formation mechanisms. Recently Anthony analysed digisonde data for some specific events, most notably "The Day the Solar Wind Almost Disappeared," a period in May 1999 when solar wind density decreased to unusually low levels. By combining DPS data with other satellite and ground-based data, the effects of this event on the polar cap were investigated. Initial findings show a large increase in the size of the magnetosphere associated with the drop in solar wind pressure, and a corresponding shrinking of the polar cap. This resulted in the DPS observing extended periods of auroral precipitation and cusp-like signatures in drift velocity.

A conference paper has been presented on this topic and a journal paper is in preparation. He extended his research interests by measuring the movement of polar patches of ionization in the upper atmosphere, using digital ionosonde radar soundings. Most recently Anthony was involved in the Tasman International Geospace Environment Radar (TIGER) project, whereby radar echoes are used to map the convective movements of the high latitude (auroral) ionosphere which is closely associated with space weather. TIGER is an important part of an international network of auroral radars.

Anthony had interests beyond his science. He was a popular and highly respected breeder of champion Alaskan Malamutes. This passion saw him spending many weekends touring around Tasmania showing his beloved dogs. He was also strongly involved in public and media promotion of these superb animals.

Anthony's self-reliance and tenacity were closely interwoven with his outstanding insight and technical ability. He is remembered as a gifted, brilliant applied physicist who has already made significant contributions to upper atmospheric research as evidenced by his several publications in recognised journals. Anthony was highly regarded by all who knew him as a kind, unassuming young man who was always unstintingly helpful to others. Sadly such a bright scientific light has been extinguished before he could further illuminate the field of ionospheric physics. He is sorely missed by his many friends and colleagues and our thoughts and sympathy are with his parents and family.

Geoff Goodwin, Ray Morris and Marc Dulkig

The Physicist Volume 39, Number 5, September/October 2002
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<td>November 29-30</td>
<td>ASB 2002: Australian Society for Biophysics 26th Annual Conference</td>
<td>University of Melbourne</td>
<td>Contact: A/Prof. Frances Separovic, Dept of Chemistry</td>
<td>Tel: (03) 8344 6464 Fax: (03) 9347 5180</td>
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<td>December 8-11</td>
<td>ASCILITE, Australasian Society for Computers In Learning in Tertiary Education Conference</td>
<td>Auckland, New Zealand</td>
<td>Contact: Mike Gal, University of New South Wales</td>
<td>Email: <a href="mailto:COMMAD@phys.unsw.edu.au">COMMAD@phys.unsw.edu.au</a></td>
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<td>December 11-13</td>
<td>COMMAD 2002, Conference on Optoelectronic and Microelectronic Materials and Devices</td>
<td>Sydney</td>
<td>Contact: Mike Gal, University of New South Wales</td>
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<td>February 4-7</td>
<td>Wagga, 27th Annual Condensed Matter and Materials Meeting</td>
<td>Charles Sturt University, Wagga</td>
<td>Contact: A/Prof. Trevor Finlayson, Monash University</td>
<td>Email: <a href="mailto:wagga@spme.monash.edu.au">wagga@spme.monash.edu.au</a></td>
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<td>February 9-13</td>
<td>AMN-1, Advanced Materials and Nanotechnology</td>
<td>Te Papa, Wellington, New Zealand</td>
<td>Contact: <a href="mailto:amn@conferences.co.nz">amn@conferences.co.nz</a></td>
<td><a href="http://www.macdiarmid.ac.nz">http://www.macdiarmid.ac.nz</a></td>
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<td>August 19 - 21</td>
<td>Workshop on Recent Advances in Absorbed Dose Standards</td>
<td>ARPANSA, Melbourne</td>
<td>Contact: Mr. Robert Huntley, ARPANSA, Lower Plenty Rd., Yallambie, VIC 3085, Ph: +61 3 9433 2224, FAX: +61 3 9432 1835</td>
<td>Email: <a href="mailto:robert.huntley@health.gov.au">robert.huntley@health.gov.au</a></td>
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