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Cronulla Printing Co. Pty. Ltd.
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Published 6 times a year, on behalf of the Australian Institute of Physics by Cronulla Printing Co. Pty. Ltd.
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PRESIDENT’S COLUMN

Many of you by now will have heard that the AIP Congress in Sydney was a great success. Congratulations should go to Pal Fekete and David Neilson for their efforts in this respect. They had some tough challenges, not the least of which was the number of competing conferences in this region at the time.

As a consequence of a call from the state branches, endorsed by the AIP Council earlier this year, I have a program of visits this year to the various state branches. Last month I visited Victoria and Tasmania, next month it will be SA and WA. Sometime in September I will be visiting Queensland. The purpose is to provide an opportunity for the members to meet with the president and discuss issues of concern to them. Arising out of my last visit, I would ask members to assist in a project to aid the employment prospects of our graduates. I have been informed that some graduates are finding it difficult to ‘break into’ non-traditional areas so I am asking for your help in one of two ways.

The first way would be that if you have made it into a non-traditional area and are willing to be a contact to provide assistance or advice, please let me know and we will make a link on our employment page. Also I am looking for profiles of our members to act as examples to new graduates. Could you provide about 1/4 - 1/2 of a page of text about your studies and your subsequent career? A passport photo of you as well would be great. This would also be placed on the web page to provide role models for students and new graduates.

I would like to put in a plug for an IOP initiative. They have developed Physics.org which is the searchable database providing an easy way to find the best physics on the internet. The popular physics.org web site has been developed by the British Institute of Physics to use natural language search technology to match the question, age and knowledge of an individual to carefully selected sites. By registering users can store their age and knowledge profile as well as rate and comment on the links visited. This feedback can be used to highlight the most useful resources by sorting search results by relevance (default), user ranking or the number of times visited through physics.org.

Just as I seem to be ‘hitting the straps’ as president, I am reminded that my term is nearing an end (only 6 months to go!). It has been a lot of work, responsibility and communication but I have really enjoyed it. I raise it now because it will mean that soon the Secretary will be calling for nominations for a new executive. I tried to determine what would be the best strategy when I took over this position. Should I make an absolute hash of it so that lots of members would say “I could do better than that” and take up the cudgel? Should I instead try to do an above average job (trying all the time to look as if I am doing it easy) so that lots of members would say “piece of cake, I can do that”? I guess I didn’t try either but I will leave it to you to judge what strategy I did adopt!

Please give serious consideration to nominating for the executive. The AIP needs to remain strong to get through the tough times.

John O’Connor
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EDITORIAL

The AIP Congress

The AIP Congress in July was an enjoyable affair, with an excellent set of plenary lectures, and plenty of interesting work on show. Our thanks must go to the joint chairmen, Pal Fekete and David Neilson, the organizing committee and organizers of the parallel sessions for all the hard work they put into the conference. It was certainly pleasant to be able to look out over the sparkling waters of Darling Harbour at lunch and tea breaks. The attendance was respectable, in spite of earlier fears, and it seems the Congress should approach the financial break-even point, which is all we can ask.

The Industry Forum was a new feature of the Congress, and I found the session most interesting. The case studies ranged from proven success stories such as the Cochlear hearing implant, presented by Jim Patrick, and Redfern Photonics (Mark Sceats), through emergent technologies such as the Ambri medical diagnostic kit showcased by Bruce Cornell, on to heroic failures such as Acton Semiconductors, outlined by Jim Williams. The last refers to an attempt to commercialize some of the ANU’s novel semiconductor laser technology, which went through all the stages of setting up a company, only to be caught in the ‘tech wreck’ when all the potential investors pulled out. No doubt Jim Williams and his crew will try again when the commercial climate improves.

Technology standards continue to rise in the presentation of talks and posters. Most of the speakers nowadays use Powerpoint, even in the contributed talks in parallel sessions, and most of the posters were fancy laminated jobs. These certainly add a professional gloss and glamour to the presentations. Only a few old fogies such as your correspondent, mostly theorists, have not caught up with the new ways: but I was pleased to note Bob Delbourgo stubbornly sticking to hand-written transparencies in his talk in the parallel NUPP session. I don’t think Powerpoint featured heavily in his Massey Medal speech either!

Apart from Chairman’s Reports by Pal Fekete and David Neilson, we have not included any material from the Congress in this issue. The next issue will be devoted largely to highlights, reports and articles from the Congress, along with thanks to sponsors and exhibitors.

Jobs in Physics

A new feature appears in this issue, the Graduate Profile, which we hope will appear occasionally in subsequent issues. The idea was raised at the AIP Council meeting, as a way of showcasing some of our young graduates, and showing that in fact there are good jobs available in physics. Hopefully we may begin to attract some more incoming students into the discipline. I would be grateful if members could send in further profiles for publication.

One area where there are dozens of jobs going begging is medical physics. We carry a piece by Natalka Suchowska from the Royal Prince Alfred Hospital in Sydney discussing the problem. Rumour has it that medical physicists are leaving Australia in droves for North America, where they are being offered starting salaries up to US$120,000! This is certainly one area we should be advertising strongly to new students.

Finally, in this issue we also present a somewhat speculative article by Neville Fletcher on quantum mechanics. We take no responsibility for the views expressed, but we hope that readers may enjoy reading the article, and we might even generate some correspondence on these issues.

Chris Hamer
C.Hamer@unsw.edu.au
NOMINATIONS FOR POSITIONS ON THE AIP EXECUTIVE

Nominations are invited for the following positions on the National Executive of the AIP.

Vice President
Honorary Treasurer
Honorary Registrar
Honorary Secretary

Those elected will take office in February 2003, after the AIP Council meeting. Members are urged to take advantage of this opportunity to be involved in the election of the new officers of the AIP.

All positions are held for two years. The Honorary Treasurer, Honorary Registrar and Honorary Secretary may seek renomination at the end of their two year term of office. The Vice President, after serving for two years, takes office as President for two years.

Nominations of AIP members for these positions, proposed and seconded by AIP members, must be in writing and must include the consent of the person being nominated.

All nominations should reach the Honorary Secretary by September 30th 2002, either by email (m.welch@uws.edu.au) or by normal mail addressed to the Honorary Secretary at the address below.

Moira Welch, Honorary Secretary
Australian Institute of Physics
Phone: 02 4578 4328
Mailing Address: PO Box 283 Richmond NSW 2753

LETTERS

A.L. Franklin, Scientific Instrument makers to Australia

Recently I wrote an article on the late Arthur Franklin (AIP) and his company A.L.Franklin Pty Ltd (Keentok, M, 'A.L.Franklin Pty Ltd: Scientific instrument makers to Australia', The Physicist, vol 38, pp 161-163, 2001). There is a typographical error in the text of my article: the reference 'Keentok (2000)' should be 'Keentok (2002).

I am happy to report that this major paper (Keentok, 2002) has been accepted and published by the Historical Records of Australian Science (HRAS). The full reference is HRAS 2002, vol 14, pp13-46 (entitled 'A.L.Franklin Pty Ltd, Scientific Instrument Makers'). This paper includes some references on the history of scientific instrument making in Sydney. I might add that this issue of HRAS has a second paper on scientific instrument making by the late Prof Bert Bolton (FAIP) and Nicola Williams.

It is unfortunate that there are so few members left who remember Arthur Franklin, as this has made writing scientific history so much harder. The article has resulted in one email response from Bruce Hamon who remembered Arthur at AIP meetings but had had no other contact with him. However Bruce was able to give me some details of his involvement in scientific instrument design and manufacture while working in CSIRO NML and CSIRO Marine Science. Some of Bruce Hamon's work at NML is documented in the book by JFH Wright, "Measurement in Australia: A History of Australia's National Standards Laboratory". At this time, Bruce Hamon had contact with and correspondence with the late Prof Bert Bolton (also mentioned above). Bruce's work on CTD recorders and oceanography at CSIRO Marine Science is mentioned in the book "CSIRO at Sea: 50 Years of Marine Science" V Mawson, DJ Tranter and AF Pearce (eds). CSIRO Marine Labs, Hobart, 1988.

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AROUND THE TRAPS

The Melbourne Microprobe

A new generation nuclear microprobe system has been developed by a group at the Microanalytical Research Centre at the University of Melbourne, directed by David Jamieson. The nuclear microprobe is a high energy ion beam microscope, which has applications in many fields including medicine, geology, biology and the development of advanced materials. About 60 systems are in use worldwide. The new system offers higher spatial resolution (less than 1 micrometer) with increased current density (greater than 100 pA/micrometer) of the probing ion beam, together with much improved detectors. It uses special magnetic lenses to focus the beam, which have been designed in collaboration with Dr Chris Ryan of the CSIRO: the CSIRO/MARC quantum lens system. A first version of the system is operational at the CSIRO, Sydney, and has produced spectacular results in geological research and meteorite exploration. Another system, worth nearly $5.0 million, is being installed at the Dutch Institute for Nuclear and High Energy Physics in Amsterdam. A third system with several more innovations is under construction in Melbourne.

David Jamieson

ANU Space Thrust

Professor Rod Boswell and his Space Plasma and Plasma Processing Group at the ANU have found a way to make a "plasma thruster" for use in space exploration. The thruster is still only a benchtop laboratory experiment, but is simpler than any other thruster presently available. It can throw out ions 10 times faster than the rockets on Saturn 5 or the space shuttle, and thus requires only one tenth the amount of propellant and brings down the cost of the mission. The technology needs to be tested in space, and Prof Boswell has approached AUSPACE, the company building much of the Fedsat satellite for the Australian government, to collaborate on this process.

[Christopher John, 'ANU Reporter', 7 June]

Gravitational Wave Detector On-Line

The LIGO detector in Louisiana is now taking its first preliminary measurements. The Laser Interferometer Gravitational Observatory project (LIGO) involves two large L-shaped Michelson interferometer stations, one in Hanford, Washington, and the other in Louisiana, at a total cost of US$296 million. Prof Barry Barish, director of the LIGO project, reported on progress at the recent AIP Congress in Sydney. It will take years to ramp up the detectors to their full design sensitivity, a displacement of 10" m., or one thousand times smaller than the size of a nucleus. Noise from passing trucks and falling trees in the neighbourhood is shaping up as a major problem, and the formal start of data collection has been put back to the end of the year.

There are some doubts whether the observatory will ever see anything. Theories of gravity-wave production are "kind of crummy", according to Barish. In the years since LIGO was first proposed, estimates of the frequency and power of detectable events have actually decreased.

[Geoff Brumfield, 'Nature', 30 May]

Quiet, please

School students are being mobilized to help find the quietest place in the country. The aim is to find a site for the world's largest radio-telescope, the Square Kilometer Array. Australia is part of an international consortium bidding to host the telescope, which will cost around $1 billion, and a key factor is to find a site where the radiofrequency noise from mobile phones, mining equipment, etc. is minimal. Students from Narrabeen High School and others in South Australia and Western Australia are being armed with equipment to conduct the first national census of background radiofrequency noise.

[Daniel Lewis, 'Sydney Morning Herald', 22 June]

Inquiry at Bell Labs

An investigation into possible data fabrication at Bell Laboratories has been expanded to include three important papers on superconductivity published in Nature. Papers coauthored by Jan Hendrik Schön on the use of organic molecules in microelectronics came under suspicion in May, when it was noticed that the same graphs were appearing in different papers. The three extra papers added to the inquiry describe how two fullerenes (C60 and C70) and calcium copper oxide become superconducting when doped, and were brought to the panel's attention by researchers including Nobel prizewinner Philip Anderson from Princeton University. Many physicists have been busily engaged trying to duplicate the research.

The scandal has had repercussions elsewhere. The share price of Lucent Technologies, parent of Bell Labs, lost a third of its value in a week. The share price has gone from a peak of $63 in 2000 to about $1.60 recently.

[Geoff Brumfield, 'Nature', 4 July]

Reactor Rift

Building of the replacement nuclear research reactor at Lucas Heights in Sydney was temporarily stopped when a geological fault line was discovered running through the site. The fault line was discovered during excavations for the new reactor foundations. The director of the regulatory branch of ARPANSA, the Australian Radiation Protection and Nuclear Safety Agency, called the discovery "an inconvenience and a disappointment". A full report on the fault and its implications was expected to take two to four weeks.

Environment groups called for the immediate closure of the Lucas Heights reactor and a halt to construction on the replacement.

[Stephanie Peatling, 'Sydney Morning Herald', 22 June]

Mining the Moon

Harrison Schmitt, who landed on the Moon aboard Apollo 17 in 1972, gave a plenary lecture at the AIP Congress in which he speculated on the possibility of mining the Moon for helium-3. The isotope is rare on Earth, but is found in abundance on the Moon, and could be used as a fuel for nuclear fusion reactors. A helium-3 - helium-3 reaction would produce little or no radioactive waste, unlike the more usual deuterium-tritium reaction. Dr. Schmitt proposed a somewhat ambitious timeframe of 18 years to build a working fusion power station, given sufficient private capital. He did concede that it is more difficult to achieve fusion with helium-3 than with deuterium-tritium.

Wrong Number

The US House of Representatives has passed a resolution crediting an obscure Italian, Antonio Meucci, with the invention of the telephone ahead of Alexander Graham Bell. Meucci invented the "telefonofo" and demonstrated it in 1860. His working models were reportedly lost in a laboratory he shared with Bell at the Western Union company. The Scotsman won a patent on the phone 26 years later, while Meucci died in poverty.

[New Scientist', 22 June]

R & D Spending Still Low

Australia's spending on research and development has rebounded to a record high, but is still very low compared to other developed economies. Business and government devoted $4.83 billion to R & D in 2000-1, or 0.73 percent of gross domestic product. This compares to 2.1 per cent of GDP in the U.S. or Japan, and remains lower than the 0.85 per cent of GDP at Australia's high-water mark in 1995-6. The villain of the piece is well known, namely the very low levels of investment by business and industry. Nevertheless, R & D spending in the finance and insurance industry was boosted by 91%, and in the mining industry by 57%.

[Tom O'Loughlin, 'Sydney Morning Herald', 2 July]
SPIN-DEPENDENT INTERACTIONS: 
A FUNDAMENTAL BASIS FOR MAGNETISM AND SPIN-ELECTRONICS

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Introduction

Spin-electronics (or magnetoelectronics) is the modern aspect of electronics in which, in addition to the charge of the carriers, the spin is a determining factor. This field was initiated by the studies of Baibich et al (1988) and Binasch et al (1989) who showed that a system of alternating ferromagnetic and non-magnetic metal (inter-) layers, with appropriate construction and an applied magnetic field, could change an electrical resistance from small (with parallel magnetizations) to large (with anti-parallel magnetizations) and the changes could be large enough to be called a 'giant magneto-resistance' effect (GMR). The GMR effect found its way to computer applications when IBM incorporated a magnetic device known as a 'spin-valve' into the 'read head' of hard disks. It allowed the 'write/read head' to be made smaller and the storage density on hard disks to be increased from 10^6 bits/cm^2 in 1988 to more than 10^8 bits/cm^2 today.

The underlying fundamental physics of such applications is the spin-dependent interactions and spin-correlated behaviour of multi-electron systems. They have given rise to a number of strategic research directions in magnetoelectronics:

- Creation of spin polarization through optical or magnetic injection of polarized particles
- Spin transport in materials with reduced dimensionality (nanowires and ultrathin films)
- Spin relaxation in metals and semiconductors
- Magnetic properties of artificially structured materials
- Design of spin-based devices such as p-n junctions and amplifiers
- Spin-based quantum information processing and quantum computation

These applications have, in turn, initiated further research into the field of spin-dependent phenomena; the most intriguing are spin-dependent electron scattering and tunneling, spin-dependent response function of an electron system, magnetic anisotropy of ferromagnetic films and inter-layer magnetic coupling. This article gives some examples of how the fundamental physics can be explored at the most basic levels to reveal spin-dependent electron correlations in atoms and ultrathin films in order to understand how electron exchange and spin-orbit interactions, as well as the dimensionality of an electron system, influence collective electron behaviour.

From a vast and rapidly increasing literature, we select examples to indicate some current interests. Polarized electron phenomena at surfaces were reviewed by Kirschner (1985), low-dimensional and ultrathin structures and their magnetic properties by Heinrich and Bland (1994), and the immense activity in the field was indicated in forty six reviews contained in "Magnetism beyond 2000" (eds. Freeman and Bader 2000), while the "new frontier in artificially structured materials" was expounded by Shen and Kirschner (2002). We focus on the theoretical prediction (Valenta 1962) and later experimental confirmation (Fert et al 1991) that magnetic properties (i.e. the arrangement of electron spins) of a reduced dimensional system, such as two-dimensional ultrathin films, one-dimensional wires and zero-dimensional dots, differ from the bulk and new properties can even be made by changes in, for example, the surface topology and the characteristics of interface layers. Of many striking spin effects, two are indicated.

- A 'spin re-orientation transition', i.e. a 90° rotation of the magnetization direction of a ferromagnetic film from perpendicular to in-plane or vice versa, is controlled by film thickness, temperature (Pappas et al 1990) and chemical composition (Dittschlag et al 1998).
- Three hundredths of a monolayer of copper atoms are sufficient to rotate spins of a 20 monolayer thick Co/Cu(100) film by 90° (Weber et al 1995), i.e. one 'nonmagnetic' Cu atom can switch the spin direction of about 500 Co atoms, and the spin direction of a Co film can be finely tuned by adding more copper atoms.

From these 'spin effects' occurring in a thin film with adsorbed foreign atoms, even a single atom, we now look at spin effects observed in free single atoms. Scattering studies can determine how a change in the linear, orbital or spin angular momentum (polarization) vectors of the incident, target and outgoing particles may lead to an observational asymmetry (such as dichroism or handedness), identify exchange and
spin-orbit interactions and determine electric and magnetic multipole moments. Such advances are discussed by Berakdar and Kirschner (2001) for atoms, molecules, clusters and surfaces and by Becker and Crowe (2001) and Andersen and Bartschat (2001) for free atoms and molecules.

Underpinning such studies is the fermionic nature of electrons, which dictates that the quantum-mechanical wave function of a multi-electron system has to be antisymmetric with respect to exchange of the states of two individual electrons. This symmetry requirement has profound consequence for the properties of correlated electronic systems. In particular, the exchange coupling between electrons is essential for the ferromagnetic state of matter. Spin-orbit coupling, i.e. interaction of the electron spin with its orbital momentum, is responsible for the magnetic anisotropy in ferromagnetic materials.

These spin-dependent interactions are explored in spin-polarised electron scattering from single free atoms for a wide variety of processes such as excitation, ionisation-with-excitation, dissociation-with-excitation of molecules and inner shell ionisation-with-excitation. That approach enables the electron-electron separation and the spin couplings to be explored. It is shown, in excitation processes, for example (Yu et al 2001), that the polarization of the decay photons depends on the different LS mixing properties of the intermediate coupled states; the dominant triplet components make exchange and spin-orbit interactions important in the excitation process, while for states dominated by a singlet component the spin-orbit interaction is dominant. In contrast, a pure LS-coupled state is excited at threshold by exchange only. These studies show the excited state charge cloud can be highly aligned and oriented (i.e. different expectation values of the angular momenta) with strong electron correlations. The studies are direct observations and indicate the role of the angular momenta of the electron coupling in LS, jj or jk coupling schemes, the spatial and spin correlation caused by the Coulomb interaction and the Pauli principle, the role of electron exchange, spin-orbit interaction and how the experimental methods and analysis apply to complex atoms.

Such quantum spin dynamics are well established for gaseous atoms but there is a need for experimental approaches that expose details of the energy and angular dependences of the exchange and spin-orbit interactions and their consequences for single atoms which form surfaces and ultrathin films as well as for surfaces and ultrathin films for which many-electron correlations are inherent. That information forms the fundamentals of the atomic basis for spintronics.

Aspects of spin-dependent interactions.

An understanding of spin-dependent electron scattering dynamics in atoms, clusters, ferromagnetic films and surfaces gives rise to many questions. How does the probability of electron-electron scattering depend on the mutual orientation of electron spins? How is the energy shared in the binary spin-dependent collisions of electrons? How do the elastic, and inelastic, reflection of electrons from an interface depend on the spin orientation of the incident electrons? What are the exchange and spin-orbit contributions to the asymmetry of the electron reflection? What is the dynamical (energy and angular) dependence of this asymmetry? How do exchange and spin-orbit coupling influence energy-, momentum- and spin-relaxation in magnetic and non-magnetic materials, as well as in free atoms? Mott (1932) is credited with perhaps the first detailed fundamental scattering calculation of the scattering probabilities for spin-up and spin-down electrons in the exchange-split 3d band of transition metal ferromagnets. He showed that a net spin polarization existed for the electrical current-carrying electrons. But fifty years passed before technology enabled detailed observations and application of the knowledge.

Such information depends on observations enabled by instrumentation, and in surface science that dependence is perhaps greater than in other fields. A number of different techniques are usually required to unveil the information. Conventional techniques for surface analysis are single-particle spectroscopies, i.e. an incident particle probes the surface and a single particle ejected or scattered, is detected and analyzed. Averaging over the undetected electrons obscures details of the electron-electron scattering dynamics and electron-electron correlations. The "two-particle coincidence spectroscopy (e,2e)" technique introduced for gaseous scattering (Ehrhardt et al 1975) leads, by its very nature, to surface information unobtainable by any other method. It probes a broad spectrum of information as shown in observations where the electrons are transmitted (Weigold and McCarthy, 1975; Hayes et al 1991, Weigold and Vos, 2001), reflected after grazing incidence (Iacobucci et al 1995) or after normal incidence (Kirschner et al 1995) or (of particular relevance here) undergo "spin-resolved in-reflection" (Kirschner et al, 1995 and Samarin et al 2000).

The "low energy two-electron coincidence spectroscopy -in reflection geometry- with spin-polarized incident electrons" technique was designed to study surface magnetism, spin-dependent electronic correlation and scattering dynamics (Kirschner et al 1995). Fig. 1 indicates a typical geometry with one probing polarized electron (P), two back-scattered electrons (D) and a magnetic (M) surface. The two electrons resulting from the (e,2e) reaction form a quasi-particle with an internal degree of freedom (i.e. exchange of momenta between electrons) characterized by the conserved total momentum of the pair, and carry information about electron correlations in the target.

The (e,2e) technique can be implemented in several ways, for example:

(i) The evolution of the correlated behaviour of a multi-electron system from clusters (adsorbed on a surface) to ultrathin films can be studied by depositing, in a controllable way, the ferromagnetic material and recording spin-resolved (e,2e) spectra at different stages of evaporation.

(ii) To study surface magnetism, in particular the exchange interaction, a polarised electron beam is used as a probe. The effects of the exchange interaction can be imaged by controlling the states, i.e. the quantum numbers, of at least
two electrons and then changing the spin state of one of the electrons while monitoring the change in properties of the system. Features relating to the exchange interaction are studied by observing the dependence of spectra on the electrons' spin projection.

In both cases the two outgoing electrons are detected and their momenta (three-component vectors) measured. Each spin-resolved (e,2e) spectrum consists of two (spin-up and -down) six-dimensional (momentum) distributions of correlated electron pairs. These distributions contain the information about the electronic structure, correlations, and spin-dependent scattering dynamics. To visualize this information, such distributions are projected on a two-dimensional energy distribution, as shown in Fig. 2 [Samarin 1997] for example. This shows how energy is shared between the two electrons depending on the binding energy of the target electron and spin orientation of the incident electron (Fig. 3 and Fig. 4 [Samarin 2001]). If, using momentum conservation, this distribution is projected onto the two-dimensional momentum space of the bound electron, then it shows how electrons from different parts of the surface Brillouin zone participate in the interaction depending on the spin orientation and the binding energy. In that way this technique images the electronic structure and scattering dynamics rather than the morphology of the target with reduced dimensionality. Figure 3 is discussed more fully later.

However the main experimental feature in this spin-resolved (e,2e) spectroscopy is time-of-flight (TOF) electron energy measurement. The principle of TOF measurement is simple. From the measured transit time T of an electron to traverse a distance L between the sample and detector, the kinetic energy of this electron is $E = (m/2) (L/T)^2$ where m is the electron mass. For a reference point on the time scale the incident electron beam is pulsed. The energy resolution is $\delta E = 2(m/2)^{1/2} L^{-1} E^{1/2} \delta T$ and depends on the flight distance L, the measured energy E and the time resolution $\delta T$. On the other hand, the time resolution depends mainly on the modulating pulse width. Characteristically for a pulse width of 500 psec, a flight distance of 0.1 m and an electron energy of 10 eV, the energy resolution is about 200 meV. The great advantage of the TOF electron spectrometer is its high efficiency due to the fact that all energies are measured "in parallel" and the multi-dimensional distributions visualize the whole scattering picture.

---

Fig. 2. An example of the time-of-flight and energy distributions of correlated electron pairs from W(100) for the normal incidence, $E_p = 17.6$ eV.
(1) Two-dimensional time-of-flight distribution of correlated electrons. The white point in the upper right corner corresponds to the accidental coincidence of two elastically reflected electrons.
(2) Two-dimensional energy distribution of correlated electrons.
(c) Histogram of the correlated pairs distribution as a function of the total energy of a pair: The height of a column represents the number of events within the total energy band $E_{tot} \pm 0.5$ eV.
(d) Energy sharing distribution of correlated pairs. The height of a column represents the number of pairs with the energy difference $E_1 - E_2$ within the total energy band $E_{tot} = 11 \pm 0.5$ eV.

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Fe(110), \( E_p = 26 \) eV, normal incidence

Difference: (spin-up)-(spin-down)

Fig. 3. (a) Difference of two-dimensional distributions of correlated electrons [(e,2e) spectra] measured with the incident spin orientation parallel and antiparallel to the sample magnetization.

(b) Difference binding energy distributions for two opposite magnetizations of the sample.

Some results and future directions

Within just a few years, the technique has led to many discoveries and new information relevant to spin-dependent electron scattering dynamics, electronic correlations and electronic structure of solid surfaces. Results have shown, for example:

- Great surface sensitivity, allowing determination of the energy and momentum location of occupied surface states on W(001) (Samarin et al 1998).

- The probability of the electron-pair creation depends on whether the spin projection of the incident electron was parallel or antiparallel to the magnetization of the sample, but the role of the total spin of the electron pair during its diffraction on magnetic and nonmagnetic surfaces remains unclear (Samarin et al 2000).

- Spin-resolved distributions of correlated electron pairs on a ferromagnetic iron surface could reveal the spin-asymmetry of the spectral density as a function of the electron binding energy and Bloch wave vector of the bound electrons (Morozov et al 2002).

- The ability to reveal a coherent superposition of ionized states from ordered oxygen atoms adsorbed on a W(001) surface (Samarin et al 1999).

Now let us look in more detail at a holistic picture of the spin phenomena at a surface.
The spin polarization vector of the secondary electrons from ferromagnetic iron, excited by spin-polarized primary electrons with low primary energy (Kirschner and Suga 1987), showed that the size and orientation of the polarization vector strongly depends on the kinetic energy, primary spin orientation and observation angle. Qualitatively these results were explained by the interplay between dipole scattering and a two-electron exchange scattering process, but the role of coherent superposition of spin states of scattered and ejected electrons was not investigated. The new technique of spin-resolved (e,2e) spectroscopy offers a unique ability to study the mechanism of secondary (correlated-) electron emission from ferromagnetic surfaces and the role of superposition states.

Spin-dependent electron scattering from interfaces is also important in determining the inter-layer oscillatory magnetic coupling for transition metals sandwiched between ferromagnetic layers (Parkin 1991). The spin effects are not completely understood but reflect the Fermi-surface topology and increase systematically from the 5d to 4d to 3d metals and exponentially with an increasing number of d electrons along each period.

The 3d transition metal (Mn, Cr, Fe, Ni, Co) atoms, thin films and surfaces have obviously important roles in magnetic and 'spintronics' materials. The characteristic spin behaviour and magnetic moments can be determined from the spatial and/or angular correlations of scattered polarized electrons and/or radiated photons. From a surface science viewpoint the quantum dynamics and scattering asymmetries can determine spin-dependent spectral density functions, spin-relaxation mechanism in magnetic and nonmagnetic materials, spin-dependent interaction potential. This kind of information related to surfaces and ultrathin films is lacking.

Spin transport phenomena in AlGaAs-based superlattices. These superlattices are used in spin-polarized sources. What are the depolarization effects during the transit of the electron excited by a photon from the bulk to the surface? How does the spin-dependent surface barrier determine the escape probability of spin-up and spin-down electrons? What is the energy distribution of spin-polarized electrons emitted after selection by circularly polarized photons and how can the width of this distribution be decreased?

Subashiev et al (1999) considered spin transport phenomena in AlInGaAs/AlGaAs superlattices after circularly polarised photo-excitation of the appropriate electron spin state in order to optimize a source of spin-polarized electrons. The St. Petersburg group has a long and successful history in exploring the low 'escape electron' mobility and the high spin relaxation rate. The process of Al doping changes the barrier in the conduction band, the In leads to conduction band lowering, and their relative effects are controlled by varying x (~30%) and y (~18%). The basic model of Subashiev et al [1999] with photo-excitation at wavelength depths explains some features. Nevertheless, further investigations of the excitation, transport, depolarization factors and escape of polarized electrons are needed to optimize composition, structure and activation procedure of these superlattices.

Spin-wave (collective excitations) characterization in ultrathin ferromagnetic films of Fe, Co and Ni. What is the spectrum of spin-wave excitations and their dispersion? How do they depend on ferromagnetic material and the film thickness? What are the damping mechanisms? What is the influence of adsorbed gas molecules on the spinflip excitation?

The excitation spectra of a ferromagnetic surface contain single-particle excitations (electron-hole excitations with spin flip - Stoner excitations) as well as collective excitations (spin waves, as predicted by Bloch in 1930). They are basic to the theory of itinerant-electron magnetism and concern phenomena where the spin-dependent correlations are essential and determine the behaviour of an electron system for wavelengths of the order of a lattice constant. The spectrum of spin excitations in thin ferromagnetic films controls their dynamic response, the spin-dependent inelastic mean free path of excited electrons and, by consequence, the spin transport in such systems. They play an important role in spin-electronic devices as one of the channels of energy dissipation. Low-lying spin waves in ultrathin films have been studied by ferromagnetic resonance [Heinrich and Bland 1994] and by Brillouin light scattering [Heinrich and Coehran, 1994]. Both methods study modes with very long wavelength compared to a lattice constant. Thus, they probe only macroscopic properties of the film and provide no information of a nanoscale nature.

The only direct observation of short wavelength spin-waves was made by Plihal et al (1999) in the spectrum of a thin Fe film using Spin-Polarized Electron Energy Loss Spectroscopy (SPEELS) measurements. SPEELS is a direct and flexible technique for studying short-wavelength spin waves. This technique is not widely used for studying spin waves because both a good energy resolution (~10 meV) and a high polarization (80%) of the incident electron beam are needed. These two requirements conflict with each other. One of the ways to avoid this conflict is to combine a high-resolution (~30 meV) time-of-flight electron spectrometer with a strained GaAs (80-90%) spin-polarized electron source.

Adsorption systems. How is the adsorbate-substrate bond affected by spin-transfer to and from the surface? How are the spin and total angular momenta and symmetry properties of the surface and of the adsorbed atoms and molecules linked?

The absorption of foreign atoms on a surface is generally accompanied by structural relaxation and rearrangement of the electron density that influences the magnetic properties (Donath 1994). Such effects have their basis in the long-range ordering of the magnetic moments of the atoms, while the magnitude of the moments is derived from a ferromagnet's valence electronic structure. For example, for CO adsorbed on Ni(110), the characteristic decrease in surface magnetism is due (Klebanoff et al
(1987) to a reduction in the minority-spin 3d-holes, and hence in the magnetic moments (or net spin) of the Ni atoms, rather than a reduction of the exchange coupling of the Ni atoms leading to disordering of otherwise unchanged moments. Similarly, a 50% enhancement of the magnetic moment of the underlying Fe(001) surface, compared with a clean surface, was obtained by oxygen adsorption (Bertacco and Ciccarelli 1999). The size of such effects encourages considerable further investigation, particularly with a technique, which probes scattering dynamical behaviour. The (e,2e) technique is very surface sensitive and energy selective so the spin-polarized version of this technique is ideal for studying spin asymmetry at the Fermi level.

The modification of the electronic (magnetic) structure of the ferromagnetic surface upon oxygen adsorption leads to new features in the spin-dependent electron-surface scattering. Oxygen adsorption in an ordered p(1x1) fashion on the Fe(100) surface has been studied by ‘empty states spectroscopies’ using a spin-polarized electron beam. The low-energy electron absorption and reflection show a much larger spin dependence in Fe(001)-p(1x1)O than in Fe(001) in the electron energy range of 9–11 eV above the Fermi level. Spin-resolved inverse photoemission reveals that in the same energy range the exchange splitting between majority- and minority-spin states in Fe(001)-p(1x1)O is about 50% larger than in the clean surface (Bertacco and Ciccarelli 1999). It makes this adsorbate system a new candidate for a stable and efficient electron polarization analyzer. In fact a novel electron spin-polarization detector with very large analyzing power was designed and realized (Bertacco et al 1999).

The strength of the (e,2e) technique allows a description of spin-dependent interaction potentials and electron correlations which determine the enhanced magnetic moments of atoms, surfaces and magnetic coupling between, e.g., a magnetic and a non-magnetic material or magnetic layers separated by a spacer layer. In contrast, the spin-resolved single-electron spectroscopies give spin-resolved band structure but not spin-dependent potential and electron correlations. For example, the spin-polarized (e,2e) technique, with symmetric scattering geometry for which the triplet cross-section vanishes, can determine the spin-resolved spectral density function of ferromagnetic surfaces and thin films; which is not otherwise directly observable.

The controlled addition of selected atoms allows the tailoring of electronic and magnetic properties of nanostructures and, conversely, unwanted atoms on surfaces may cause unwanted modification of the magnetic properties. Both have technological importance. The understanding of adsorption processes will advance the fundamental knowledge of the influence of adsorbed particles on surface magnetism and will be used in fabrication of nanostructures with specified properties.

Low-dimensional alloys.

In the case of multi-component systems one needs experimental techniques which provide magnetic and structural information with elemental resolution. Appearance potential spectroscopy (APS) with spin-polarized electrons is one of the few experimental techniques that meet these criteria. APS provides access to the local spin-dependent unoccupied density of states. It has been used to study binary alloys (Reimnuth et al 1997) as well as layered structures with (anti-) ferromagnetic coupling (Kang et al 2000). Surface and interface magnetometry is one of the strengths of APS. Electron-correlation effects are easily accessible, as shown in a temperature-dependent study on Ni (Potthoff et al 2001). Transitions in crystal structure and magnetic anisotropy are monitored by spin-resolved APS. Future work will study half-metallic ferromagnets like NiMnSb, bulk materials as well as ultrathin-films. Element specificity, as well as magnetic sensitivity of APS promises results that help evaluation of these systems for use in spin-electronic devices.

(ix) The need for interpretive theory of correlated electron motion in multi-layered systems has been well shown (Berakdar, 2001). The above experimental descriptions of electron-pair (e,2e) emissions from atoms, surfaces and interfaces requires an accompanying theoretical description for optimum interpretation and for insightful predictions. Berakdar, in a series of papers (Berakdar et al, 1995, 2001), has developed a theory with two essential aspects: (i) an accurate description of the ground state properties, i.e. the band-structure of the sample, and (ii) accurate dynamics of the low-energy emitted electrons. For the ground-state properties of materials the density functional theory (DFT) in the local density approximation is used, however the dynamics of the excited electrons are described by many-body techniques. The theoretical strategy is to apply density functional theory within a layer [Korringa-Kohn-Rostoker (LKKR) implementation] to deduce the electronic ground state. To ‘map these levels onto the detectors’, the perturbed ground state is propagated via the many-body Green function method. For low-energy electrons this procedure is implemented (numerically) in a fully relativistic way to allow for the description of the spin-split band structure (Berakdar et al 1999). This method has the advantage that it allows treatment of surfaces, interfaces and layered heterostructures and is directly linked to observation.

It is expected that studies of the type described above will provide a strong understanding of how fundamental physics can be explored at the most basic levels to reveal spin-dependent electron correlations in atoms and ultrathin films, in order to understand how electron exchange, spin-orbit interactions, as well as the dimensionality of an electron system, influence collective electron behaviour. Then there will be a better basis for understanding how we can engineer, in a highly predictable manner, structures with simple or complex magnetic properties from arrangements of ultrathin layers, for example. Such capability places low-dimensional magnetism at the forefront of modern science and technology.
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Physics and Industry Working Together
15th Biennial Congress of the AIP

Management Chair’s Report July/Aug 2002

Well it’s over – and what a conference it was. It is amazing how 20 months of work can finally come together for a period of four days and then just as quickly disappear. It was with mixed feelings that I left Darling Harbour Convention Centre Thursday night and I was thankful for the dinner company of two lovely people that evening. Those of you who did not attend the Congress missed out on something special.

In November 2000 as the new Chair of the NSW AIP I was asked if NSW would run the next AIP Congress. I went to Adelaide in December with an A4 notebook and observed as many aspects of that Congress as I could. I asked questions of everyone I met, observed the organisation of the congress and kept notes of everything I saw. By Friday I was able to inform the National executive that the NSW AIP would be prepared to take on the Congress. It has been an interesting ride since then.

As Joint Chair of the Congress I brought to light a vision of what I wanted it to look like. I had seen and heard a number of negative reports on the state of physics in Australia, the morale of academics in universities and other institutions, the poor impression that the public and media has of us. I wanted to change all of this. I wanted the Congress to be vibrant and to provide people, at the Congress and outside, with a focus and a vision for the future. I believe I achieved this.

The theme “Physics and Industry Working Together” evolved from my desire to involve industry, both in terms of delegate participation and also greater funding in sponsorship and exhibition space. I knew that if I wanted to create a theme then it should pervade the Congress. I wanted people to go home aware of the theme and thinking about it. It did not matter that you were not involved in industry, what I wanted was to create an appreciation for people who are working with industry or perhaps more importantly people who are not but could be. If you are a theoretician or an educator I wanted you to understand a little better your colleagues down the corridor or better still when talking to them in the tearam room suggest that their research could benefit from links with industry. There was meant to be something in this theme for everyone.

The highlight of the Congress for me was to see the Physics and Industry theme pervade the Congress. The Minister for Science the Hon Peter McGauran introduced it. It was present in all the Keynote talks, many of the Plenary talks and some of the parallel session talks. It was interesting to see how education features in this theme and impacts our nations economic viability. The Forum on Tuesday provided an opportunity to showcase some examples of physics success stories in industry and generated many interesting questions especially from our younger members looking to build careers in physics. The statement by one student "I want to be valued" for her PhD in Physics rings in my mind as an important issue we need to deal with in our community - that is the early career Physicist. I also participated on the Industry tour on Friday - it was fantastic.

Some trivial statistics to do with the Congress. It took 20 months to organise. I sent or received 3500 emails and participated in over 1000 phone conversations. Two weeks prior to the Congress I was dealing with 10 to 15 phone calls per day. One week prior to the Congress we were down to between zero and two phone calls per day. 124 evaluation forms were handed in and 70 people took the time to write long responses. I gained 8kg, which I intend to lose over the next two to three months. I caught the flu 10 days prior to the congress having been healthy for the previous two years. For me this is an indication that things are going well – I always get sick after the crisis period is over. I bought a house nine days prior to the congress and am finalising the purchase now.

We are currently analysing the evaluation forms (lots of lessons to be learnt) and I have asked the members of the Congress organising committees to prepare reports for the next Physicist, to be dedicated to the Congress. If anyone out there would like to contribute a short article from a delegates perspective (academic, industry, student, female, etc) then I would love to hear from you.

Thank you to everyone who came and especially those of you who came up to me during the Congress. I appreciated the comments and feedback that I received.

Pal Fekete
AIPC 2002 Management Chair
Report from the Program Committee

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. The standards of both the oral presentations and the posters were extremely high making it both an enjoyable and stimulating event. The Program Committee attempted to strike a balance between retaining a traditional Congress role of recording highlights of recent academic achievements while also addressing the important interface between academia and industry. The Congress theme of "Physics and Industry Working Together" reflected this.

The meeting was held at the Sydney Convention & Exhibition Centre in Darling Harbour, a superb venue that worked very well. The functional and compact layout of the Convention Centre drew the delegates from the different streams together in the one area and this actively encouraged many lively discussions and interactions. The same area was the site of the Posters and the commercial exhibits.

A successful innovation at the Congress was the Industry Forum. Frank and surprisingly candid presentations from five physicists and senior representatives of leading technology-based Australian companies centred on the practical problems of commercialisation. There were two Public Lectures, Karl Kruszelnicki gave a highly entertaining presentation "Great Moments in Science(R) - The Four Forces and Murphy's Law" which was enthusiastically received by a large audience, and Harrison Schmitt, the last astronaut and only scientist to walk on the Moon spoke on his commercial vision of mining the moon in "Fusion: The Space Connection".

Another innovation at the Congress were one-hour keynote talks. These talks were selected by the Program Committee from the regular plenary talks on the basis of a wide appeal to the general educated public and also the possibility of interest from newspapers and television. Mark Scoats (Australian Photonics CRC) spoke on "Photonics - Physics and Industry - Today and Tomorrow", Sheila Tobias (Arizona) gave a talk on a vital challenge to academic physicists in "Who will Study Physics", and Richard Maughan (Pennsylvania) in a talk titled "Hadron Therapy" described recent exciting developments in Radiation Oncology.

The Massey Medal for contributions to physics by an Australian physicist was awarded this year to Bob Delbourgo (University of Tasmania), the Bragg Medal for the most outstanding PhD thesis in physics went to Nicole Bell (former University of Melbourne and now at FermiLab), and there was a new award this year, the Alan Walsh Medal for Service to Industry. This was awarded jointly to Ian Bassett and John Haywood (Australian Photonics CRC).

I want to thank all the participants at the Congress for creating such a successful and enjoyable meeting.

David Neilson
Program Chair
July 2002

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MEDALS AWARDED

THE MASSEY MEDAL

The Massey Medal was inaugurated at the AIP Congress in 1988 as a gift from the UK Institute of Physics to the AIP, to mark the 25th anniversary of the founding of the AIP as a separate institution. It is presented to the winner at each Congress by the President of the IOP.

Sir Harrie Massey, born near Melbourne in 1908, had a distinguished career in the UK and published the first experimental evidence for electron diffraction in gases with Edward Bullard in 1931. He saw the potential of using direct rocket probes of the atmosphere layers and eventually, as Chairman of the British National Committee for Space Research, he guided the entire UK space research program. From 1960-64 he was President of the European Preparatory Commission for Space Research. He was knighted in 1960.

The medal is awarded every two years for contributions to physics or its applications made by an Australian physicist working anywhere in the world, or by a non-Australian resident in, and for work carried out in, Australia.

The award this year was made to Prof. Robert Delbourgo of the University of Tasmania for his contributions to our understanding of particle physics. Delbourgo obtained his Ph.D. from Imperial College, London, and remained there until 1976, when he was appointed to a chair at the University of Tasmania. He received the Walter Boas Medal from the AIP in 1988 and the Thomas Ranken Lyle Medal from the Australian Academy of Sciences in 1989. His early work contributed to the development of the theory of relativistic SU(6) symmetry in particle physics. He has continued throughout his career to make significant contributions to the theories associated with quantized gauge fields and, most recently, he has proposed a way of understanding the generation problem in particle physics. His talk at the Congress was entitled "Four dimensions: more or less?"

THE WALSH MEDAL

The Alan Walsh Medal for Service to Industry was inaugurated this year by the AIP. The award recognizes significant contributions by a practicing physicist to industry in Australia. It is named for the late Sir Alan Walsh, Kt., FAA, FTS, FRS, one of Australia’s most eminent and distinguished scientists, who was the originator and developer of Atomic Absorption Spectroscopy (AAS) and pioneered its application as a tool in chemical analysis.

Born in Lancashire in 1916 and educated at Darwen Grammar School, Sir Alan studied physics at Manchester University. After a few years in industry in the UK, he was recruited in 1946 to join the newly created Chemical Physics Section of the CSIR (now CSIRO) Division of Industrial Chemistry in Melbourne. In 1952 he had the idea of using atomic absorption spectra, rather than atomic emission and molecular absorption spectra, in spectrochemical analysis. The subsequent development of AAS as a simple, rapid and inexpensive method for the analysis of minute traces of metals (and some non-metals) is a tribute to Sir Alan's extraordinary creativity, his business acumen and his infectious enthusiasm. He promoted the establishment of an Australian manufacturer of the atomic absorption spectrophotometer, the original company Techtron Pty Ltd eventually growing into Varian Australia, now one of the world's leading spectroscopic instrument companies. It is fitting that the first award of this medal at the 2002 Congress was under the sponsorship of Varian Australia.

The award consists of a medal and is open to competition every second year among persons resident in Australia for at least 5 of the 7 years preceding the closing date for applications. The award will be given for physics research and/or development that has led to patents, processes or inventions which, in the opinion of the judging panel, have led to significant industrial and/or commercial outcomes, such as devices that are being manufactured or have influenced a major industrial process.

The inaugural Alan Walsh Medal was awarded jointly to Dr Ian Bassett and Dr John Haywood from the Optical Fibre Technology Centre of the Australian Photonics CRC at the University of Sydney. The award was given for their work on the research, development and commercialisation of optical fibre sensors in general and the Fibre Optic Current Sensor in particular.
THE PHYSICIST'S CROSSWORD NO. 4

ACROSS
1. They stop the odds being even. (6, 5)
9. Wavelength with a rhythmic Brazilian movement. (7)
10. Disturbingly precise instructions. (7)
11. Elaborately ornate men could hardly be shorter. (9)
12. Vehicle identification makes a comeback for Nobel Prize winning physicist. (5)
13. No hesitation returning overweight electron. (4)
14. Catch with electron missing from 12's sea - wear it on your lapel. (6-4)
16. Plain crisp shared among heads. (10)
18. 4. Induced to act by passing through a field, Edward is in vogue. (4, 7)
20. Communist in the county I believe. (5)
21. One can run damaged speaker at radio station. (9)
24. Compound overtime pay, by the sound of it. (7)
25. King Henry's first wife was in debt, we hear, and will be charged. (7)
26. Meaner tomes written about meteorological instruments. (11)

DOWN
1. Reluctance to take turns, or just a short period of laziness? (6, 2, 7)
2. Quantity of paper printed about Labour leader in kingdom. (5)
3. Previous spouse to perform with absolute precision. (5)
4. See 18.
5. Resonant sound about the first half of December, rising and moving away. (8)
6. When performing without resistance, could Previn or von Karajan be thus described? (15)
7. Space filled with matter points at the centre of stone fruit. (6)
8. The mind of a dippy chemist. (6)
15. Honour bestowed on champion who consumes soft drink with hard end. (8)
16. Space distributed around a number of nuts. (6)
17. Dummy in control of clinical trial. (7)
19. Delivery that's got Kerry upset about nothing. (6)
22. Hamiltonian in nice position. (5)
23. Liberate by dismissing head of national broadcaster. (5)

SOLUTION TO CROSSWORD No. 3

The Physicist Volume 39, Number 4, July/August 2002
The Prime Minister and the "Second Leg"

The $2.9 billion dollar Innovation Statement was launched in January 2001. At the time FASTS welcomed the funding boost as a promising first step. But it needs far more than $2.9 billion over 5 years to allow Australia to catch up to the average OECD expenditure in science and research.

Recently I wrote to the Prime Minister asking him what his Government was planning to do about the next step, the "second leg" of the Innovation Statement. The letter read in part: "We are concerned that some elements in your Government may regard science and technology as a job that was completed with the announcement of "Backining Australia's Ability". Our concern was heightened when you outlined the priorities for your Government in a speech to the Liberal Party Federal Council on 13 April, and science and technology was not among them."

The Prime Minister has responded, saying that his Government is still monitoring the outcomes of the initiatives announced in 2001. He goes on to say: "It would, however, be premature for PMSEIC to consider a 'second stage' package of spending measures before the current initiatives have been implemented fully and evaluated."

FASTS will continue to press for a proper national investment in science and research. You can read the full text of both letters on our web site: www.fasts.org

National Research Priorities Consultative Panel

The Government is determined to maximise the return to Australia of our research efforts, by concentrating research in areas where we have a competitive advantage and putting new efforts into areas of weakness where we should have a stronger presence. FASTS supports this view.

The practicalities are interesting. I am a member of an eight-person consultative panel, along with FASTS' Board Member Melissa Little (both of us serving in a personal capacity). The Panel is chaired by Chief Scientist Robin Butlerham. We have been split into two groups, with each conducting consulting sessions throughout Australia (dates and times are on the FASTS' web site). There are two stages of the process, and two important dates for submissions:

- a) determining the framework for setting national research priorities (submissions close 28 June)
- b) views on what these priorities are (submissions close 9 August)

The Government intends to have priorities in place for the 2003 Federal Budget. There appears to be common acceptance that it is appropriate for the Government to set national research priorities and that these should be both thematic and inspirational and should not direct funding to the exclusion of other promising areas of good science.

In another part of the process, Science Minister Peter McGauran consulted FASTS directly. He hosted a dinner at Parliament House for 8 members of the FASTS' Board and Executive, to discuss informally these two matters.

Higher Education Review

I am a member of the Higher Education Review Reference Group. The first meeting in May was primarily to discuss the process to be adopted, and to offer initial comment on Higher Education at the Crossroads. DEST officers are now preparing five issues papers which will form the basis for national debate on higher education issues.

In the light of these it will be important for FASTS and its Member Societies to make submissions in which the importance of science is highlighted, both in terms of the need to produce scientists and mathematicians and for universities to participate fully in the national research effort.

I would appreciate Member Societies forwarding a copy of any submissions they may make to the FASTS office, so that I can read them personally. Submissions close on 28 June; and further information about making them is at: http://www.dest.gov.au/crossroads/how_sub.htm

"Science Meets Parliament" Day

This event will be on Tuesday-Wednesday 12-13 November in Canberra. It has several new features this year, including a science-industry-Parliamentarians dinner on Wednesday night, at the prestigious Members' Dining Room at Old Parliament House.

SmP provides an interesting opportunity to run regular business meetings of your Society, or to hold side meetings like last year's discussions on biotechnology and nanotechnology. Please discuss these with the FASTS' office. Full details of the program are on our web site.

Here are some comments from last year's participants:

Very well organised. The impact is becoming obvious.

The policies are taking this seriously. I have no doubt that past SmPs have helped put science on the political agenda.

A fantastic experience. I'm glad I came and congratulations to FASTS for making it possible!

Both MPs were cordial. The level of interest in science was high and unexpected to me.

And one from an obvious masochist:

Great, let's do it again. I would like more interaction with MPs - a boat trip?

New Edition of FASTS' Policy Document

The fourth edition of the FASTS' Policy Document will be launched later this year. One of the most comprehensive statements on science policy, the document will cover all aspects of science from education, to research training, funding for science and research, and innovation.

Ken Baldwin is coordinating the production of the document as Chair of the Policy Committee. A draft will be considered by the FASTS' Board next month, and all Member Societies will have the opportunity to comment on the draft before it goes to print. Launch of the revised policy is scheduled for mid-September.

State Government's Growing Interest in Science

It's wonderful to see State Governments competing over the new synchrotron, instead of those disputes about who will host golf tournaments or the Australian Grand Prix.

An illustration is the recently-reported size of the State delegations attending the world's biggest Biotechnology Conference in the US - 140 delegates from Victoria and 90 from Queensland, with both delegations headed by the premier. SA Premier Mike Rann will also be there, along with delegations from all other States and the Federal Government.

NSW will not be sending the Premier, and not even the Science Minister - because it stands alone among all States in not having one. This reflects the low profile of science in the Premier State. The expansive budget NSW announced this month contained many spending initiatives, but little to stimulate the research an innovation community.

One hopes State efforts will also contribute to a national vision and priority setting.

Chris Fell
President
Mr Toss Gascoigne
Executive Director
Email: fasts@unm.edu.au (Toss Gascoigne)
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The M-661 translation stage comes complete with a motor driver. An OEM electronics board is available, too.

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The Physicist Volume 39, Number 4, July/August 2002
1. Introduction

The gender ratio of women to men doing Physics in Australia is quite disappointing. In one recent survey it was reported that the proportion of females doing year 12 Physics in Australian high schools has shown little variation over the past decade, the average being approximately 29%. In addition to this, the percentage of females that have withdrawn from year 12 high school physics has increased in the last decade from 69.8% to 78.5% [1]. The same survey reported that at the end of the last decade the proportion of girls doing year 12 high school chemistry in Australia was as high as 48.8%, in comparison to 29% for physics [1]. These statistics highlight the need for a concentrated effort to ensure that the participation rates of women in Physics are comparable to other science disciplines.

The ratio of women to men at tertiary level is even lower than that in high school physics. Additionally, in the last three years the participation rate of Australian university students doing Physics has declined [2]. Having said this, the female participation rate in third year physics in Australian universities has increased from 15% in 1991 to 22% over the past three years (1996 to 1999) [2]. The proportion of females undertaking fourth year (including honours, diploma and masters preliminary students) in Australian universities has increased from 16% in 1991 to 25% in 1999 which correlates with the gender balance situation at third year. Furthermore, the proportion of females undertaking higher degree studies in physics continues to increase steadily from 12% in 1991 to 19% in 1999 [2]. One of the reasons for this steady increase has been the restructuring of Physics courses at universities to provide new courses that are flexible and attractive to both male and female students [2]. These sorts of statistics are pleasing and the initiatives that result in these trends should be encouraged. It should be noted that the profiles of students are changing and such initiatives benefit both male and female students. The critical issue is that despite the increase in student enrolments in universities [2], the overall trend of Physics enrolments at Australian Universities is on the decline. Unfortunately, Physics has not been able to promote itself well enough to attract the attention of students. In addition there is a perceived lack of career paths and relatively poor pay for relatively difficult work. Scientists' pay scales have dropped relative to other professions. Students who might have considered Physics in the past are choosing professions that offer better security, pay and prestige.

There is a real need to promote physics as an enabling discipline providing fundamental advances on which science and technology thrives. It is also necessary to take initiatives to promote physics to both men and women. We need to balance the ratio statistics of women to men in Physics, by attracting more women into the discipline rather than disadvantaging men. Furthermore, there is a shortage of qualified physics teachers in senior high schools. This is expected to get worse as the current physics teachers are retiring. One step that has been taken in an effort to promote Physics and women in physics was to establish a Women in Physics (WiP) Group.

2. The Australian Women in Physics Group

Dr Ann Roberts, from the University of Melbourne, attended the Australian Institute of Physics (AIP) Council Meeting in February 1994 reporting on the possibility of the formation of a National WiP group and the activities of the WiP group from South Australia (WiP SA). In March 1994, Dr Roberts provided feedback from the Council Meeting to a meeting of WiP SA, in Adelaide. In this meeting she outlined the plans for a WiP session at the forthcoming AIP Congress and for the formation of a national WiP group. She went on to convene the WiP session at the Brisbane Congress in which WiP was founded. The Australian Women In Physics was formally founded on July 7, 1994, during the 11th AIP Congress held at Griffith University, Brisbane. The office bears elected at the first General Meeting of the group were Dr Cathy Foley the Chair, Dr Anne-Marie Grisogono the Vice-Chair, Dr Ann Roberts the Honorary Secretary-Treasurer and Ms Moira Welch, Dr Liel Fols and Ms Heather Symons the Committee Members. The terms of reference, see below, were discussed at this meeting. At the September 1994 meeting of the AIP Executive, the terms of reference of WiP were unanimously approved and the Australian WiP was launched.

During the time of the formation of WiP, Prof R. W. Crompton, who was keen to promote Women in Physics, was National AIP President. Prof Crompton supported the idea of inviting Prof Bunny Clark the chair of the American Physical Society's Committee on the Status of Women in Physics (CSWIP) to the Brisbane Congress as a Women in Physics Lecturer. She was an Invited Speaker at the Women in Physics "Specialist Session" and gave a series of talks on Women in Physics at different institutions.

A General Meeting, in which Dr Judith Pollard was elected Chair, was held on July 5, 1996 during the 12th AIP Congress held at the University of Tasmania, Hobart. The remaining committee members did not change. During a Biennial
General Meeting held on 12 December 2000, at the University of Adelaide, Dr Suzanne Hogg was elected Chair, Dr Deb Kane the Vice-Chair, Dr Manjula Sharma the Honorary Secretary-Treasurer and Drs Anna Binns, Elizabeth Chelkowska, Christine Creagh, Judith Pollard, Ann Roberts and Margaret Wegener the committee members.

The terms of reference of the Australian Women In Physics are
1. To facilitate contact between, and provide support for, women in physics
2. To raise the profile of women in physics among the physics community and the general public.
3. To encourage the implementation of gender inclusive teaching strategies at all levels of education.
4. To have an input into policies that affect the physics community.

Membership is open to all members of the Australian Institute of Physics who may elect to be members of WiP when subscriptions are renewed. There are no membership fees.

3. Activities of the Australian Women in Physics Group

The WiP group coordinates the "Australian Institute of Physics, Women in Physics Lecture Tour" which was inaugurated in 1997 and has become an annual event. Plans for the Women in Physics Lecture Tour were discussed at the 1996 Biennial Meeting of WiP during which it was decided that the inaugural speaker be Australian. The Lecture Tour has become a tradition of the Australian Women in Physics group with a national and an international speaker in alternate years. The travel to and from Australia of the international speaker is funded by the AIP executive, while the local travel, accommodation and incidentals are funded by the state branches of AIP. Each state branch of AIP has a WiP representative who coordinates and hosts the speaker in their state. Some states have active WiP branches that undertake this role. The overall coordination and management of this process is carried out by the Lecture Tour Coordinator, in consultation with the WiP executive. Dr Judith Pollard coordinated the Women in Physics Lecture Tour from 1997 to 2000, Dr Pina Dall’armi-Stoks in 2001 and the current coordinator is Dr Marion Stevens-Kalceff.

The main purpose of the Lecture Tour is to recognize women physicists and the contribution that they have made to the science. It also aims to increase public awareness of Physics and to promote women in physics. The successful nominee is selected based on her research and its contribution to Physics, and her ability to speak to the wider community, especially high school students. During the tour the Women in Physics Lecturer delivers a public lecture related to her area of research in each state capital city across Australia. Attendance at the lecture is open to the general public, high school and university students. The lecture tour now has been running for five years and we have seen some excellent women physicists, both national and international.

WiP has affiliations with other Science Professional agencies such as the Women in Science Enquiry Network (WISENET).

The current executive is focusing on procedures for selection of plenary and invited speakers at the Congress with the view to establishing a mechanism for appropriate female representation. In addition a Young Australian: Women in Physics Programme, YaWiP, will be launched in 2002 as a curtain raiser to the Lecture Tour.

4. The South Australian Women in Physics Group

Women in Physics groups are or have been active in several states. The South Australian Women in Physics Group, WiP SA, is an example of a dynamic and active branch of WiP. The WiP SA Group was formed in Adelaide, South Australia (SA) in February 1992. Currently it has up to sixty (60) women on its mailing list, which also includes women from the Northern Territory (NT). Its members include women physics students, postgraduates, teachers and scientists in universities, government and industry. The SA WiP group has regular support group and social/dinner meetings. Presentations by special guests or members are also part of the meetings. It has been an active group since its establishment and has taken the lead in implementing some major initiatives. Some of those initiatives include:

a) Promoting Women in Physics and the South Australian Group through publications.
b) Organizing Year 10 girls Physics Workshops in 1992 and 1993.
c) Visiting High Schools
d) Establishment of the Clare Conner Memorial Prizes for the top two year female Physics student from each of the three South Australian Universities. The awardees are nominated by their respective Physics Departments and the presentation of the awards is made during the Women in Physics Lecture in Adelaide.

5. Conclusions

The Women in Physics group has been formed in an effort to promote Physics and increase the representation of females in Physics. Initiatives that such a group can undertake ranges from an annual Australia wide Lecture Tour to year 10 girls Physics workshops. A WiP group definitely has a leading role to play in promoting Physics and achieving a balance of genders in the Physics discipline. However, it does need more support from governments and technology industries. Governments and technology industries working with and supporting Physics professional groups, like the WiP group, can put strategies and programs in place in an effort to address the critical issues that are preventing students been attracted to Physics.

One strategy is to establish a program(s) to ensure that secondary schools and universities attract qualified physics teachers and academics. In addition, programs should also be in place to ensure that the educators and students, especially females, at these learning institutions are supported, encouraged, made to feel confident and enthusiastic about doing Physics.
Another strategy is to determine the long-term skills and knowledge requirements of Australia’s technology industries and then put in place programs, especially in universities, to educate students to meet these requirements. This is not a new concept in Australian Universities. But it is critical that this concept is enhanced and is supported long-term to cope with the advancements of science, especially Physics research and development. By recognising and understanding some of the fundamental reasons behind the problem we are in a better position to address them. Then by having long term strategic planning and programs in place in an effort to address these problems we are then able to promote Physics more effectively and attract more students into the Physics discipline, both male and female.

Attracting females to do physics benefits not only women in physics but also the whole Physics community. As a consequence we will see that physics is and stays a thriving science, which is crucial in creating the technologically literate society that will be demanded in the future. Our ultimate aim is to see a thriving physics community with gender ratios comparable to other professions, and a general public, which is better educated about the role of physics in society and in the world.

6. References


Postgraduate Programs in Photonics and Optoelectronics at the University of New South Wales

Beginning in 2001, the School of Physics of the University of NSW has been offering a range of postgraduate programs in photonics and optoelectronics by coursework. These programs provide thorough theoretical and laboratory based education in the relevant areas, taught by specialists from the School of Physics and School of Electrical Engineering and Telecommunications. The courses are built around three core areas: modern optics and optical communications, semiconductor physics and microsystems, and laser theory and applications. The laboratory classes consist of individualised experiments that aim to train students in modern optical and spectroscopic instrumentation and measurement techniques. For example, students build a diode pumped Nd:YAG laser, make their own holograms, use an optical spectrum analyser to study optical fibre systems, study various semiconductor lasers using a scanning Fabry-Perot interferometer, study quantum confinement in semiconductor quantum well heterostructures using low temperature photoluminescence spectroscopy, etc. This year approximately 30 students enrolled in the various programs that range from the Graduate Certificate to the Master of Science and Technology degree. These postgraduate coursework degrees are designed for people who already hold an undergraduate degree in science or engineering, and who are interested in a career in photonics and optoelectronics or who want to upgrade their skills in these emerging technologies. While most of our students either come from the photonics industry or are trying to get into it, many of the students in these programs are interested in optoelectronics for reasons other than telecommunications, such as medical research, optical physics or manufacturing. Due to increasing interest from outside of the Sydney area and from overseas, starting from July 2002, these postgraduate programs are available via distance educations.

Teaching these specialised courses via distance education has also allowed us to offer these courses to students who are currently enrolled in a science or engineering degree at other smaller universities where these types of specialist subject are not offered. Senior undergraduate students or postgraduate students can now enrol to study photonics and optoelectronics at the University of NSW without having to 'leave home'.

Prof. Mike Gal
School of Physics
Uni NSW

Graduate Profile

Zoe Brady graduated in 2000 with 1st Class Honours in Physics from Griffith University (Brisbane) and is now working for Intellectual Property Australia. Her position is Patent Examiner in the Physics and Mechanical sub-section in Canberra. She found out about the position from the Australian Institute of Physics employment service to members.

Zoe says that she likes the job as it allows her to be involved in new technologies without having to pursue a career in research. She says that her starting salary at IPA was highly competitive and that the advancement scheme provides relatively fast career progression. IPA provided a comprehensive training program for the position, which also has a significant legal component. She says she finds her work highly enjoyable.

At Griffith University, Zoe achieved a near-perfect Grade Point Average throughout her degree of Bachelor of Science with Advanced Studies in physics and maths. Of the degree, Zoe says "it gives you laboratory or theoretical research experience very early in your degree, which helps in deciding what really interests you." Her Honours (4th) year, with a thesis in theoretical quantum optics, was essential to her getting the job with IPA.

Howard Wiseman

Zoe Brady
THE CAT IN THE MACHINE: CONSCIOUSNESS AND
THE COLLAPSE OF THE WAVEFUNCTION

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Schroedinger's famous thought experiment about a cat in a box is included in almost all books and courses on quantum mechanics, but is generally presented as a paradox without a solution. This informal essay discusses the problem and suggests that it is not really insoluble at all, but rather that it leads to a common-sense interpretation of the 'real' meaning of the quantum wavefunction.

Introduction

One of the most celebrated thought-experiments in quantum physics is the case of Schroedinger's cat. It illustrates in high degree the fact that physical theories that have exquisite perfection and ability in explaining and predicting the behaviour of the real world sometimes lead to perplexing conclusions when applied to apparently simple situations. Let there be some to whom the predicament of the cat is not familiar, let me begin with an exposition.

According to the standard development of quantum mechanics, any system can be described by a wavefunction \( \psi \) that depends upon the positions of all the particles involved. This wavefunction develops in time in accordance with Schroedinger’s equation, so that once the system is completely described at one instant its future development is uniquely determined. The problem of interpretation arises with the wavefunction \( \psi \), for it is a complex (in the mathematical sense) rather than a real quantity. In the standard interpretation developed by Bohr and others in Copenhagen, the relation to reality comes from the absolute value of the square of the wavefunction, \( \psi^* \psi \) which should be interpreted as a probability of finding particular particles in particular places, or in particular energy states, at some later time.

The problem arises when we are considering discontinuous changes, such as the decay of a radioactive atom. If we suppose the initial state \( \psi(t_1) \) to be completely specified, then Schroedinger’s equation allows us to calculate the precise form \( \psi(t_2) \) of the wavefunction at some later time \( t_2 \). If the interval \( t_2 - t_1 \) is chosen equal to the half-life of the radioactive atom then, since decay is a completely random event, there will be a 50% probability that the atom will have decayed by time \( t_2 \) and a 50% probability that it will still be intact. The wavefunction \( \psi(t_2) \) is thus an equal superposition of two functions, one corresponding to an intact and one to a decayed atom. Quantum mechanics in its simple form, or indeed in any of its more complex forms, can tell us no more than this. Once we look at the atom in question, or make an appropriate measurement upon it, however, the wavefunction “collapses” to one or other of its possible values to give a definite answer, the probabilities of collapse to either of the two simple states (intact or decayed) being equal.

This formalism describes everything very satisfactorily, since we are not concerned with the state of anything until we want to measure it, look at it, or interact with it in some way. But the dualistic superposed state of the uncollapsed wavefunction causes unease in many minds.

Here the cat enters. For suppose the radioactive atom is in a sealed box containing a live cat. Suppose further that decay of the atom will trigger a Geiger counter that will drop a hammer to break a tube of cyanide. Then, immediately after the decay of the atom, the cat will die. But the whole system inside the box can, in principle, be described exactly by quantum mechanics. At the beginning of the experiment, the wavefunction shows an intact atom and a live cat, but gradually the wavefunction of the atom develops into a superposition of intact and decayed forms, and by extension, that of the cat becomes a superposition of “live” and “dead”. It is only when we look into the box that the cat wavefunction collapses so that the animal becomes unambiguously alive or dead.

This situation is hardly satisfactory to realist philosophers, or indeed to physicists, though most have given up worrying about it. Others, however, have developed ideas like “parallel universe” models in which the world itself bifurcates at each decision point, in this case at every sequential instant, into parallel universes in which the atom has or has not decayed. While this seems to avoid the problem of superposed wavefunctions, it does so at an immense cost in parallelism and can hardly be seen to improve matters. A survey of these alternative approaches has been given by Tegmark and Wheeler. The question is by no means dead from a physics point of view, however, and Roger Penrose has recently proposed a resolution based upon the uncertainty principle, which his colleagues are proposing to test experimentally.

This is, however, not the point that I wish to take up here. Rather, I want to examine the mechanism for collapse of the wavefunction, for here it seems that there is a specific role for human consciousness in a universe that is otherwise perfectly predictable, at least in a statistical sense. Is this significant, or are we misleading ourselves?
The Observer

In quantum mechanics, the fundamental action is one of measurement. Even personal observation is a kind of measurement, for what we do is to determine at one instant the positions of all the particles in our field of view, albeit with imperfect precision. More sophisticated measurements may determine velocities or energies or other physical quantities, but these measurements become real only when they are noticed by a human mind. Does mind then and human mind in particular, play a vital part in the development of the universe through its role in causing the collapse of myriad wavefunctions in a continuous stream? If so, what is the attribute of the human mind that makes this possible?

Before attempting an answer, let us conduct another thought experiment in which the cat is replaced by a human observer. This dedicated person observes the hammer fall and deduces that the atom has decayed, immediately before succumbing to the cyanide. Does this cause a collapse of the wavefunction? By orthodox reasoning, the observation will collapse the wavefunctions of the radioactive atom, the hammer, and the cyanide, and it is a reasonable deduction that the observer, knowing death is inevitable, will sense, or even cause, the collapse of his own wavefunction.

So far so good, but how about the cat? The cat too can see the hammer fall and be terrified by the smell of cyanide. What is so special about a human brain? Why cannot a cat act as an observer? It is hard to think of any reason, other than an unjustified home-centric view of the universe, that would lead us to expect any different outcome in this case.

But here we come to a problem. It is certainly easy to see a continuity of sorts between the mind of a human and that of a cat, but if we grant this where can the regression stop? An ant? A microscope? A virus? A tree? It seems impossible to draw a line.

And then the big question: if an organism as simple as a virus can cause the collapse of the wavefunction by "observing" it, then why not a silicon chip in a computer?

This dilemma can be put in another way. Where do we draw the boundaries of the box? In the initial formulation the observer was unambiguously outside the box and the cat inside. But what if we draw the adiabatic boundaries of the box on a much larger scale so as the encompass the original observer and his laboratory? What indeed if the box contains the whole observable universe? Does the wavefunction remain uncollapsed for ever?

A Universal Mind?

An apparent way out of this dilemma must have occurred to most people: perhaps there exists a "universal mind" for which all physically realised minds are simply agents. Indeed the philosopher Berkeley (1685-1753) maintained that there is no such thing as reality except as "an idea in the mind of God". Since a realist might reasonably remark that "God is an idea in the mind of Bishop Berkeley", this conclusion does not get us much further! Setting this aside, one might imagine some sort of coupling between physical minds, such as those of humans and cats, and the universal mind, which controls the collapse of the wavefunction. If we were to take this view, then we might suppose that the strength of the coupling would depend upon the abilities of the mind in question: human minds would be strongly coupled and readily able to influence the universal mind, those of cats would be weaker, and those of viruses virtually without influence at all.

So far so good, but what about the collapse of the wavefunction? Does it collapse when viewed by a beetle, or not? The only reasonable conclusion seems to be that there is some sort of probabilistic aspect to wavefunction collapse. After all, a human observer might easily mistake a sleeping cat for a dead one and discover the error only after a subsequent observation!

There are interesting features of this possibility that deserve examination. The first is the nature of the coupling between physical minds and the universal mind. The existence of degrees of coupling suggests that there might be ways in which coupling could be varied, for a species or an individual, and this in turn suggests that it might be possible to develop new species with greater coupling to the universal mind. But need these new species be biological? Why not technological? Why not computers or their descendants? The only possible answer seems to be "Why not, indeed!" Of course it may be that computers and other machines, as they have developed, have zero coupling to the universal mind for some reason, but this does not mean that devices with non-zero coupling cannot be produced.

Let us take the optimistic view, then, and suppose that such machines are possible. Let us go further and suppose that they were to be built in large quantities. How different would be the universe in which we live?

A little thought suggests that, at least to a first approximation, nothing would change. While it is said that a watched pot never boils, careful experiment suggests that this aphorism is untrue. Experiments that are carefully observed without intervention generally take exactly the same course as those that are left to themselves. It is only when observation implies intervention, for example by shining light where previously there was darkness, that things develop differently. So perhaps we do not need to worry from a practical point of view.

Even when we examine things on a subatomic scale, the picture is not much different. The concern would be that phenomena such as electron diffraction, which rely upon the spatial spread of a probabilistic wavefunction so that it passes through two slits or is scattered from many atoms, might become impossible. This fear is, however, unfounded. Collapse of the wavefunction (which would certainly extinguish the phenomenon) would occur only when an observation was made, be it by a human or a machine, and this is known to be exactly what happens anyway if a machine is introduced into the experiment to measure through which slit the particle passes, then this measurement prevents the observation of diffraction phenomena.
Tentative Philosophical Conclusions

It is possible to draw several different and indeed conflicting conclusions from this discussion. Let us examine some of them.

A Christian fundamentalist theologian, and probably an Islamic fundamentalist as well, would be drawn to the conclusion that the argument proves the necessary existence of a Universal Mind, which is God. *Quod erat demonstrandum!* The argument that there is a continuity in the coupling of all life-forms to this universal mind would be embarrassing, but might perhaps be overcome by making a very large distinction between the coupling constants for humans and other animals. Eternal life would be seen as an incorporation of individual minds into the universal mind. The apparent fact that the universal mind must spend nearly all its time in book-keeping activities such as collapsing trivial wavefunctions would be overlooked.

The idea of a universal mind is, perhaps, much more closely allied to a Buddhist or even animist view of the universe, in which the individual ultimately counts for nothing. This view has much to commend it, but appears, with a few notable exceptions, to have been largely neglected.

There is another view, to which most scientists would subscribe. In the first place, everyone agrees that quantum mechanics, supplemented where necessary by relativity, is immensely successful in explaining and predicting the behaviour of the universe. The underlying formal assumptions and mathematical edifice are therefore nearly unassailable. But this is not necessarily true of the subsequent layer the Copenhagen interpretation of wavefunctions and probabilities. True, this interpretation gives the correct results in all cases so far tested, but this is a practical matter of predicted outcomes and numbers and does not necessarily support all of the intermediate steps. It might, therefore, prove possible to modify the interpretation of the wavefunction, and with it the phenomenon of collapse, without changing either the underlying mathematical theory or the predicted practical outcomes.

In just this way, a geocentric view of the universe, with the planetary orbits and epicycles refined to elliptical form, could be made to describe the motions of all the planets and their moons. But the origin of its assumptions would remain obscure until a change of viewpoint (literally!) to a heliocentric model revealed the simplicity of the organisation. The underlying mathematics would, in this case, undergo a transformation to a new coordinate system in which all the kinematic descriptions became simple and all the epicycles vanished, thus paving the way for Newton's theory of universal gravitation.

Applying this argument to quantum mechanics, as indeed Einstein would have wished, might very well eliminate at one stroke the whole notion of wavefunction collapse and substitute something more immediately comprehensible, though at present there is no indication of how this might be done. There might, indeed, be a complete modification of the conceptual foundations of quantum mechanics to some new theory, though this new theory would necessarily have to reduce to quantum mechanics in the domain where this theory has been so successful, just as both quantum mechanics and relativity necessarily reduce to classical Newtonian mechanics in the world of macroscopic experience.

A fourth possibility is the "many worlds" proposal, namely that the universe bifurcates whenever a wavefunction collapses, one universe for each possible outcome of the collapse. Such a view is hardly worth considering from a philosophical point of view, since it would involve the generation of countless parallel universes every second and the splitting of each of these parallel universes at a corresponding rate.

A Realistic Conclusion?

Fortunately there appears to be a simple way out of this confusion, and that rests upon a reinterpretation of the significance of the wavefunction. This proposal is not original, but seems to have been overlooked by many. Because there is a close correspondence between the wave-like and particle-like properties of a wavefunction and what is observed in countless experiments, there is a natural tendency to assume that the wavefunction *is* the particle in some sense. But is this necessarily so? Quantum mechanics provides a coherent and wonderfully accurate means of calculating what is going on in the world of sub-atomic particles, or even in the larger world of microstructures. The calculated results are always essentially in the form of a wavefunction that can be projected upon certain sub-spaces to calculate the probabilities of possible outcomes. Thus, the wavefunction at any instance does not really represent the system concerned, but rather our knowledge of that system. This knowledge is always incomplete, and reasonable physical constraints prevent us from having complete knowledge, particularly of complementary variables such as position and momentum.

It is always possible for us to perform additional experiments to increase our knowledge of the system under study. For a small system these measurements almost always influence its state if we know the momentum of an electron, then a measurement of its position will make that knowledge out-of-date. The forced collapse of the wavefunction for one observer alters the system irreversibly for all observers, though they may not be aware of it.

For a macroscopic system such as the cat, however, it is possible to make a limited observation that the cat is alive or dead without greatly affecting the system. If we close the top of the box again, then the wavefunction assigned to the cat by other observers who have not been present remains uncollapsed. Certainly, their wavefunctions will now be a little inaccurate, since they will not know about the photons that have entered and left the box through the window to give us our information, but their superposition of two states will still give a good assessment of the probabilities of finding a live or a dead cat when they themselves open the box. If we artificially collapse their wavefunction by revealing the result of our observation of the cat, then this has no physical consequences for the cat, whether we tell the truth or not!
Does this interpretation solve the dilemma of wavefunction collapse? It seems to me that it does. The wavefunction represents information and is not a physical attribute of the system. Different observers may possess different information at the same time, but when this happens there is always a region of uncertainty dictated by the uncertainty relation between complementary variables. In the case of macroscopic systems, observations can cause collapse of our “knowledge wavefunction” without significantly altering the state of the system itself and without causing wavefunction collapse for other observers. Quantum mechanics provides a model of the universe and a set of rules for interpreting the outputs of the model in terms of what can be observed and measured. For all practical purposes this is enough. It is only the relentless human desire to seek to “understand” everything that drives us on, even though we are not quite sure what the word “understand” really means! We should be thankful that the famous Cat Paradox can be resolved in a satisfactory manner.

**References**

1. “100 years of quantum mysteries” by Max Tegmark and John Archibald Wheeler *Scientific American* 284(2), 54–61 (February 2001).

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**Earth-like Planets?**

A team of New Zealand and Japanese scientists headed by Philip Yock at the University of Auckland have claimed a sighting of a small Earth-sized planet orbiting a distant star. They used a microlensing technique to detect the gravitational ‘warping’ of the light from the star as a planet passes in front of it.

About 90 extra-solar planets have been found so far, but they are all giants like Jupiter. The greater prize is to find smaller Earth-like planets, and the claims of the Yock team have aroused some controversy. Critics say that the microlensing blip was probably due to statistical noise. Planet hunter Geoff Marcy at UC Berkeley has left the planet off his list of sightings, and refuses to comment on the microlensing result. The Yock team estimate the chances of their signal being random noise at less than 1 per cent.

Meanwhile, a team of American, British and Australian astronomers have announced discovery of another star system, 55 Cancri, that could harbour an Earth-like planet. The team includes Chris Tinney from the Anglo-Australian Observatory (see *The Physicist*, November/December 2001) and Brad Carter of the University of Southern Queensland. They have found a Jupiter-like planet orbiting its sun at about the same distance as our Jupiter, which would allow an Earth-like planet to exist in a stable orbit within the system. “It’s very exciting, but it won’t be known whether a small sister planet to ours is hiding there or not until NASA sends up its Planet Finder space telescope later this decade”, says Chris Tinney.

*Deborah Smith, ‘Sydney Morning Herald’, 13 June; Eugenie Samuel and Jeff Hecht, ‘New Scientist’, 22 June*

**Copenhagen**

The play ‘Copenhagen’ by Michael Frayn has been breaking box-office records at the Wharf Theatre in Sydney. The play centers on the wartime meeting between Werner Heisenberg and Niels Bohr in Copenhagen, which led to an estrangement between them. Heisenberg was directing Hitler’s atomic program, while the half-Jewish Bohr was suffering under Nazi occupation. Frayn’s play asks the question as to what really happened between the two men, and is said to be a tour de force in playwriting, production (Michael Blakemore) and acting. The stars are John Gaden as Bohr, Colin Friels as Heisenberg, and Jane Harders as Bohr’s wife Margrethe. The production has been reviewed as “one of the most intelligent and stimulating productions seen on Sydney stages for a while. One deeply satisfying big bang indeed.”

*Stephen Dume, ‘Sydney Morning Herald’*

**A Prize for the President**

An Institute of Physics (UK) Public Awareness of Physics Award for 2002 has been given to the President of the AIP, John O’Connor, and two colleagues from Newcastle, Terry Burns and Bob Nelson. The award was given for their creation of the SMART program (Science, Maths and Real Technology), for the establishment of the Hunter Chapter of the Australian Science Communicators, and for their work with the Science and Engineering Challenge. The selection panel was very impressed with the scope, breadth and success of SMART's science communication projects. The Award comprises a certificate, a cheque for £30 and a gift, and was announced at the AIP Congress in Darling Harbour.

**SILVER and BRONZE FOR PHYSICS!**

News from the International Physics Olympiad in Bali, Indonesia: an exceptional result for the 2002 Physics Team!

**SILVER MEDAL:** Bojan Djordjevic (Rooty Hill High School, NSW)

**SILVER MEDAL:** Jolyon Bloomfield (Wollumbin High School, NSW)

**BRONZE MEDAL:** Ben Weiss (Kinross Wolaroo School, NSW)

**BRONZE MEDAL:** Pearl Gallagher (North Sydney Girls High School, NSW)

**BRONZE MEDAL:** Barry Smith (Arnamare Catholic College, WA)

**TEAM RANKING:** 15th of 66 competing nations

This team result is the first time since 1995 that all Aussie team-members have come home with a medal, and the first time since Australia started competing at the IPhO (1987) that 5 medals have been attained on foreign soil!

*Colin Taylor*
Careers are a bit like betting. It's too late once the race is over. So when it comes to making a career choice, how do you know that you are onto a safe bet? Is it a safe bet that you are after? What exactly is a safe bet? It can be a good salary, challenging work or just knowing that at the end of a working day, you have made a real difference to a lot of people. The first thing you need to do is decide what is important to you as an individual.

As with all betting, by shortening the odds, you stand a better chance of making the right choice. So you also need to identify what the current needs are out there in the real world and how those needs are expected to change in the future. Where are the best prospects now and what will they be over the next twenty years? After all, you don't want to find yourself at 35 with a mortgage and family to support, unemployed, simply because your choice of applied physics is not the funding body's flavour of the decade. A crystal ball would come in handy, but ... physicists generally view crystallography differently.

Medical physics is one of the few applications of physics that has immediate and direct influence on people's lives and depending on the sub-speciality you choose, you can either be directly involved with patients or hardly know that they are there. Certainly, your work will make a real difference to a lot of people, in some cases a life or death difference. Medical physics has been a bit of a Cinderella in the past: numerically few doing significant work, while drawing little attention to themselves. But as Bob Dylan put it so succinctly

The times - they are a changing

There is no doubt that our society is becoming increasingly dependent on technology. Whether it's a matter of putting a woman on Mars or a man in the kitchen - technology plays a vital role. Medicine is no different. From the use of CT, PET and MRI images to diagnose patients to the use of various means of delivery of ionising radiation to treat and kill cancer, medicine will become increasingly dependent on technology.

The obvious corollary to this biotechnical or meditechnical link is the need to have drivers for the technical progression to maximise performance. With the rigorous training of a physics degree, who better to be the Michael Schumachers (Formula One that is, we'll get to the comets later) of physics than a medical physicist? The doctors, the nurses and the allied health professionals may quite happily operate the technology, but as medical technology becomes increasingly complex, professionals who have a sound knowledge of physics and technology are needed i.e there is an increasing need for medical physicists.

Medical physics is a generic term. In practice there are several sub-specialities, of which the principal areas of employment are diagnostic radiology, nuclear medicine and radiation oncology, in the ratio 1:4:13 respectively. In diagnostic radiology and nuclear medicine, medical physicists rarely see patients and are principally challenged to develop procedures to optimise the diagnostic quality of patient images. This process is not only concerned with the physics of the image formation, but also image processing after capture. Most patients will move during imaging, so artefacts and noise issues are important considerations in avoiding misdiagnosis. After all, the last thing you want to hear is that you have a mass in your lung, you have 3 months to live, to be then told, "sorry that was a breathing artefact!"

The success of radiation oncology, the principal area of employment for medical physicists, is critically dependent on accurate radiation dosimetry, and good utilisation of basic physics in radiation treatment planning, in order to deliver the correct dose to the correct site in the body, avoiding healthy tissue. It might not appear to be rocket science, but in reality, it's much more and for the patients it is a matter of life and death. Each patient has an individual disease type, location and progression, so each treatment must be custom designed. Because of this responsibility medical physics is incredibly rewarding work.

While in the past government funds have been made available to purchase new high tech equipment, unfortunately there has not been a corresponding readiness to finance the training of professionals to look after these machines. Various studies suggest that Australia-wide there is a dearth of about 80 positions in radiation oncology alone, with the number still growing. The current Federal Inquiry into Radiation Oncology Services heralds a new health administration attitude. One that recognises that buying equipment may look good on paper and even win votes, but it is not the whole answer. The government, along with the Australasian College of Physical Scientists and Engineers in Medicine is in the process of formalising in-hospital training supported by post-graduate education programs, leading to accreditation. With the tightening of state regulations on radiation safety, and government efforts to encourage accountability and cost-effective use of new technology, the future demand for medical physicists is assured. With the average age of the population increasing, the increased need for medical diagnosis and treatment will ensure the continued growth in medical physicist numbers.

Not all of us can be rocket scientists - there aren't enough rockets to go round. More importantly not all of us WANT to be rocket scientists. So if you are one of those physicists who still hasn't decided who is going to get the benefit of your expertise, have a think about medical physics. With the ever growing potential of the application of technology to medicine, we need you...and as far as you're concerned the sky's the limit (figuratively speaking or if you're into comets).

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The Physicist Volume 39, Number 4, July/August 2002
TASMANIAN BRANCH

On Thursday, May 30th, the Tasmanian Branch held a public lecture entitled 'Geometry and Physics: From Newton to Einstein and beyond' which was presented by Professor Gerd Rudolph of the Institute of Theoretical Physics, University of Leipzig, Germany. An audience of about 50 attended this presentation. Prof Rudolph demonstrated that from a geometrical perspective, a continuous evolution can be discerned between the earliest thinking about dynamics and current ideas about particle physics. Starting with Galilean space-time (and introducing the concepts of 'affine space' and 'fibres'), and then Einstein's special relativity, the discussion moved to electrodynamics (Minkowski space and geometrical expressions of Maxwell's equations). Lack of time limited the presentation of modern gauge theory models of the strong and weak interactions, but the audience were left with one of the exciting challenges of modern physics: to successfully incorporate gravity in gauge theory. Professor Gerd Rudolph's visit to Hobart was supported by the Alexander von Humboldt Foundation.

A new initiative of the branch is the "Winter Public Lecture Series". Each year four talented speakers will present public lectures at approximately monthly intervals through winter. These lectures aim to excite the audience about aspects of Physics that should have appeal to the wider community. The lectures are in honour of Alexander and Leicester McAuly.

A cold wet wintry evening heralded the commencement of the Winter Public Lecture Series. Dr Bruce Scott introduced the series by reminding us of the achievements of the McAulyas. Their combined achievements which were significant in Physics, Mathematics, Engineering and Biology make multi-skilling seem less of a modern phenomenon. Alexander McAuly was appointed as the first lecturer of Mathematics and Physics at the University of Tasmania 1893 and became the first professor in the discipline in 1896. He undertook a formidable research and teaching program, publishing two internationally acclaimed books on octonions. His pocket volume, five-figure logarithmic and other tables (London 1909), was used by engineers and scientists for at least 50 years. In his later years when failing eyesight hampered his research, he adapted the Braile system to include his complex mathematical notation. Professor McAuly was a distinguished scientist, and among his numerous achievements was his pioneering role in the evolution of hydro-electricity. He became Emeritus Professor in 1930.

His son, Professor Leicester McAuly, was also a distinguished physicist. He lectured in Physics from 1922 and was appointed to the position of Chair of Physics in 1927. He became interested in biophysics in the 1930's at a time when most physicists felt that their field of study did not extend beyond the inanimate world. In 1940, when Australia had no optical industry and was suffering from a paucity of components for military equipment, Professor McAuly carried out military optical work in his laboratory. McAuly, working with F.D. Cruickshank's team, produced precision prisms and lenses for gun sights and cameras. They developed an entirely new method of lens design. The Department's subsequent national eminence in both optical and radio astronomy reflects his genius.

Following this introduction Dr Marc Duldig, Program Leader for Space and Atmospheric Sciences at the Australian Antarctic Division presented a lecture entitled "Space Weather - Who cares about the Weather in Space?". In this talk Dr Duldig described the variations in the near Earth environment, the so called "Space Weather". Changes at the Sun produce variations in the solar wind plasma speed and density, the solar magnetic field and the radiation density in the near Earth space environment that in turn can have consequences for human technological systems. With the aid of some impressive computer animations and movies Dr Duldig described the propagation of Coronal Mass Ejections or CMEs from the Sun and the different propagation, along the interplanetary magnetic field lines, of relativistic solar cosmic rays generated during solar flares. He then described some of the effects that these processes have on our space and ground based systems. These effects include but are not limited to: electricity grid disruption; telecommunication disruption; increased pipeline joint corrosion; satellite memory failures, surface charging, solar cell degradation and increased atmospheric drag; navigation disruption; increased aircraft passenger radiation exposure; astronaut radiation hazards; and the benign but beautiful aurorae. Many of these effects have significant economic impact and reliable forecasting of space weather storms is highly desirable. The quality of space weather predictions has improved dramatically over the past five to ten years but still needs to be developed much further. Dr Duldig described the significant role Australia has in both space weather research and prediction. He briefly showed the types of instruments employed at the Australian Antarctic bases, at Macquarie Island, in Tasmania and mainland Australia that are essential to space weather research and prediction. He also showed the range of Ionspheric Prediction Services world wide web products that are presently available for space weather prediction. Dr Duldig noted that Australia's geographic isolation has made it heavily reliant on satellite technology and that this dependence will only increase in the future. He pointed to increasing evidence that the space era may have been an unusually quiet time for space weather activity and that a greater level of disruption may be possible in the future. He concluded that it is in our national interest to develop a space weather strategy that optimises national research, ensures rapid distribution of observational data for space weather forecasting and develops appropriate forecast warning procedures for industry and government use.

Marc Duldig, Bruce Scott and Gary Burns

The second lecture in the winter series was given by Prof Roslynn Haynes on 16 July and was titled "Mad, Bad and Dangerous to Know. Why do Scientists have such bad press?". Roslynn Haynes is an Associate Professor of English Literature at the University of NSW and has published a book "From Faust to Strangelove: Representations of the Scientist in Western Literature". Her talk was both interesting and unusual for an AIP public lecture and was well attended. Prof Haynes categorised seven stereotypes that are used to describe scientists in Western literature. This kind of stereotyping can influence our societal view of scientists. The seven categories are: the evil alchemist; the noble scientist; the silly scientist; the invalid scientist; the scientist as adventurer and hero; the mad, bad and dangerous scientist; and the out of control scientist. Many literary representations of
scientists combine more than one of these stereotypes.

Prof Haynes described the development of these stereotypes over the past several centuries. The evil alchemist is characterised by secrecy but also by fascination in the wealth and power that may be achieved. Historically this was through transmutation of metals into gold but in recent times the secrecy arises through jargonistic language and mathematical formulae. The rewards are seen as unlimited energy for industry, longevity etc., The noble scientist is perceived as benevolent and altruistically pure. The idea of scientists as rulers developed between the world wars whilst the latter 20th century saw the noble scientist portrayed more as a victim protesting against the misuse of knowledge. The silly scientist was often represented as a collector of wonders who is not searching for truths. More recent is the absent minded professor, an eccentric who usually ends up winning over his adversary more by good luck than good management. The inhuman scientist has discarded relationships and emotions in a single minded obsessive search. The ends justify the means and there is no sympathy for the effects their work has on others. The unrelenting development of weapons of mass destruction is the late 20th century model of this stereotype. The adventurer and hero scientist is debonair and defeats nature or evil enemies with scientific guile and knowledge. There is still a strong emphasis on might is right. This stereotype is almost timeless but best seen in Jules Verne's stories or Arthur Conan-Doyle's Sherlock Holmes. More recently we have a plethora of space heroes. The mad, bad and dangerous scientists are largely extortionists holding a group to ransom. This is a representation of societal fear of the power of knowledge and its destructive capacity. In written literature of the 20th century the scenarios have become extremely bleak as the destructive power, either physical or biological, has become greater. In film the issues are treated far more simplistically. Finally, the out of control scientist is seen as a mental titan who has created a monster, either accidentally or deliberately, that they are no longer able to control. In modern times the development of drugs, genetic manipulation or artificial intelligence are the most common themes employed. Throughout the talk Prof Haynes gave literary examples from the renaissance to the present to illustrate her thesis. This was an interesting and thought provoking lecture in a different mould from the typical physics talk.

Marc Duddig

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Reviews

Braking the Wheel of Fortune
The Johns Hopkins University Press produces some very readable titles in the light science genre - light, but not shallow. Bart Holland has written a book “What Are the Chances” on probability and statistics aimed at intelligent lay-persons. There is a minimal dose of mathematics essential to discuss, for example, the concept of standard deviation and the formulae for the binomial and Poisson distributions. The fact that the latter is a special case of the former is handled more painlessly than by any other book on statistics that I know. Holland uses a mix of historical and everyday examples to illustrate his treatment - anywhere that chance plays a part. The relation between smoking and lung cancer deaths is most persuasive when expressed in graphical form. Games of chance are dealt with, up to and including a Nobel-Prize-winning stock options formula. Read this book and think twice before plunging into the share and option market.

War is the greatest game of chance of all - whether it be soldiers kicked to death by horses or civilians killed by rockets, they all get a run. Such current topics as global warming, chaos theory, airport queues and million-dollar lotteries are subject to Holland's often-humorous but persuasive analysis.

All 140 pages of “What Are the Chances” are enjoyable and convey much wisdom in an area where gut feelings and rash actions frequently prevail. It costs US$24.95 in hardcover and I'm sure it would sell well in the future as a paperback. Order it using its ISBN 0-8018-6941-2. Highly recommended, especially as a gift for a thinking person.

Colin Kenny
Reviews Editor

Reviews

Unified Grand Tour of Theoretical Physics
I D Lawrie

The author recalls the Grand Tours to cultural centres of Europe that became fashionable for wealthy young Englishmen of the eighteenth century. At their best they contributed to the development of a certain ideal of a liberal education and its completion. In that spirit here we have a view of the grand edifices of theoretical physics. In this second edition, with the String theory also included, it takes us right up to the end of the twentieth century.

In contrast to the style of text books this is a first person narrative. The author freely acknowledges his own doubts and the limitations of the structures he presents. But he has a very definite conviction and point of view - “we come to feel that things could not really have been any other way”. The basis of this is mathematics, in particular differential geometry with which the book starts, presented with a refreshing emphasis on the verbal description of the concepts - but also formulas and plenty of them. There is a collection of snap shots from the tour at the end - a lively sort of summary of the main points. The list of references is reasonably short and well chosen. The routes to further pursuit of knowledge are thus well marked.

It is not a mere popularisation of the edifices but a serious introduction to them. The reader will need some background (undergraduate) in theoretical physics and a lot of motivation to understand the conceptual structure and scope of this great enterprise but he will be well served.

Kailash Kimwar
Department of Theoretical Physics, Australian National University

Extremely High Energy Cosmic Rays

This publication consists of 27 reviews summarising an International Workshop on Extremely High Energy Cosmic Rays which was held in March 2001 in Japan. The reviews, typically about 8000 words in length, cover most of the current and proposed experiments to study the highest energy cosmic rays, single particles from the cosmos with individual energies greater than about one Joule but with minute fluxes measured in particles per square kilometre per year. There are also some reviews of related theory but the emphasis is really on techniques.

The study of such low fluxes is a major challenge, but the field has become one of the fastest growing aspects of astrophysics because of its intrinsic astrophysical interest.

Great effort is going into the study of cascade showers resulting from the interactions of those particles in our atmosphere. This is a field with a strong, and continuing, Australian interest.

These reviews contain high quality physics and are written by many of the leaders in the field. Publication has been rapid and they give an excellent overview of its current status. The other side of this coin is that editorial work just has not been done on the material. The English expression is very poor in many of the articles, although it detracts rather little from the essential physics.

There is a real need for a book at this level. It will need a proper introductory essay and then could contain edited articles like these. This volume is a stopgap which would be useful in the libraries of astrophysical groups.

RW Clay
Department of Physics and Mathematical Physics
University of Adelaide

Atom Optics
Pierre Meystre
Springer-Verlag, New York 2001 xvi + 311 pp., US$59.95 (hardcover)

Atom optics is now an important sub-field of atomic, molecular and optical physics. The field itself comprises the manipulation and control of atoms via the interaction of the atomic de Broglie wave with a potential. For these interactions to be observable, one requires atomic waves with long de Broglie wavelengths. Laser cooling, awarded the Nobel prize in 1997, allows one to prepare ensembles of atoms with long de Broglie wavelengths and has led to an explosion of research in atom optics.

Pierre Meystre is a theoretical physicist at the University of Arizona. His book entitled “Atom Physics” is the first book published on the subject. It consists of four parts, (I) Quantum Atom Concepts, (II) Linear Atom Optics, (III) Non-Linear Atom Optics and (IV) Quantum Atom Optics. The first part is aimed at introducing the reader to the general theoretical framework of laser cooling and trapping. In the author's own words part II describes the realm of atom optics, where the dynamics of a single atom remain unaffected by the other atoms in the sample. The third part of the book discusses atom optics in a regime where the atomic ensemble has a high density and atom-atom interactions become important. Finally, part (IV) is reserved for atom optics that require high degree of coherence between atoms.

This book is well laid out and elegantly written. I believe that this book, combined with Hal Metcalf's "Laser Cooling and Trapping", forms an excellent introduction at a postgraduate level to atom optics.

AG Truscott
R S P S E
Australian National University

The Physicist Volume 39, Number 4, July/August 2002
Quantum Philosophy
Roland Omnes (trans. A. Sangolli)
Princeton University Press, Princeton NJ 2002
xxiii + 296 pp., US$16.95 (paperback)
As an experimental physicist, I believe three things:
1) I exist.
2) What my senses tell me is true.
3) Reality exists without my needing to observe it.
I also consider that all our theories are simply models we construct to help us shuffle through this mortal coil.
Omnes guides us through his vision of the quantum mechanical (QM) world using an angel (female) who is instructed by an archangel (male) as we move from math to reality. He believes that all of physics can be explained by QM but misses the chance of getting into the prickly problems that live up the tea room such as demonstrating the difference between the QM world and the world of chance.
As Rene Descartes stated so succinctly “je pense, donc, tu sais” and the style, dear reader, though rather pompous, “surprises by its particular limpidity.”
Perhaps “realism is an epiphenomenal epistemology” using “principles that are simply the inordinate worship and the unqualified hypostatising of our thought habits and language tics”. In contrast to William of Ockham, the philosophy of philosophers seems to be “pourquoi faire simple quand on peut faire compliqué”. He basically gives up on explaining the wave particle duality, Schroedinger’s cat and the EPR ‘paradox’ and states that since we were not brought up in the QM world it is forever mysterious to us. Finally he deduces that there is a chasm between theory and reality, all else is vanity!
Exeunt Omnes!
Rod Boswell
Space Plasma and Plasma Processing
Australian National University
Trapped Particles and
Fundamental Physics
S N Aturo, R Calabrese and L Moi
255 + 286 pp., EUR 110 (hardcover)
ISBN 1-4020-0441-9
This volume is an eclectic collection of selected papers from the NATO Les Houches 2000 summer school of the same name. The publication of the work two years after the event makes the material a little out of date, but given the didactic nature of the lectures, this isn’t a significant drawback. The subject material primarily centres on advances in the trapping (laser cooling) of atoms and ions (including quantum degenerate gases) with articles by well known contributors to this field such as Vladlen Letokhov, Randy Hulet, Jean Dalibard and David Pritchard. However, there are also articles addressing fundamental physics of a more general nature such as parity violation, the measurement of fundamental constants, the electroweak interaction and radioactive decay in trapped atoms.
The book thus provides a snapshot of some wide ranging topics in physics that can be studied using trapped particles. Herein lies its usefulness, to expose the reader to a breadth of fundamental physics, while also touching on the techniques used for atom and ion confinement. It is not a pedagogical device for the latter tools, which are much better covered in textbooks elsewhere.
To this extent, the book would appeal to students and practitioners of atom and ion trapping who may wish to broaden their perspective into other fields, and to be inspired by new ideas that utilise this technology. At 110 Euros for the hard copy version, you would want to be inspired.
Ken Baldwin
Research School of Physical Sciences and Engineering
Australian National University
A Quantum Approach to
Condensed Matter Physics
Philip L Taylor and Olle Heinonen
Cambridge University Press, Cambridge 2002
x + 414 pp., AS$100 (paperback)
ISBN 0-521-77827-1
This book is an enlarged and updated version of an earlier text, “A Quantum Approach to the Solid State”, written by the first author and published in 1970. In fact, the complete text and diagram format of the original book has been incorporated into the new book with some minor sectional additions and deletions. Several new chapters have been added on density functional theory, mesoscopic physics, the quantum Hall effect, and the Kondo effect and heavy fermions. A section on the high-temperature form has also been added to the chapter on superconductivity.
Like the earlier book, it has been written mainly for the postgraduate or research experimenter working in the area of condensed matter physics. The intention is to assist the reader to become acquainted with the application of the essentials of quantum physics relevant to these types of physical systems. It does so in a user-friendly (rather than strictly rigorous) way, to equip them with an understanding of particularly the quantum theory relevant to the design of their experiments and help interpret the results of the subsequent measurements. The original book achieved this task well and the current book maintains the standard with the inclusion of the new material to bring it up to date with the developments that have occurred in the field during the intervening years.
The subject-matter structure of the book is good, the text reads easily and well with a plentiful supply of suitable illustrative figures. I would recommend this book as a useful first reference for experimentalists in condensed matter physics.
Brian W Lucas
Physics Department
University of Queensland
The Biggest Bangs
Jonathan I Katz
Oxford University Press, Oxford 2002
xi + 218 pp., US$28.00 (hardcover)
ISBN 0-19-514590-4
The author describes this book as “... a popular account, by a working scientist, of a field in which he was interested, and did research, over a quarter of a century”. This tells us much about the author and insight of the author. For that insight alone, this book is worthwhile. I have reservations, but it is written from the perspective of a player in the field and we learn things not otherwise accessible in the conventional scientific literature.
The topic of the book is the development of our understanding of astrophysical gamma-ray bursts, surely near the top of the 20th century scientific detective stories. They were discovered by satellite nuclear test ban monitors in the late 1960’s and remained frustratingly enigmatic for at least the following 30 years of study, in which we threw at them all the techniques of a golden age of astrophysics. Like the best detective fiction, the tale takes up blind alleys, past red herrings, washes some dirty linen, and finally presents an (the?) answer to what they are and from whence they came.
Of course there are flaws. Why do we still use ergs and refer to scientists as he in ‘popular’ books on science? The book would be a struggle for someone without a level one university science education because of jargon which we insiders have ceased to notice.
On the other hand, as someone with at least a peripheral interest in the field, I found new insight in some of the hand waving and enjoyed the flow of the book after the obligatory rocky first few chapters.
R W Clay
Dept. of Physics & Mathematical Physics
University of Adelaide
CONFERENCES & MEETINGS

2002

Oct 4-6  3rd UQ Mathematical Physics Workshop  
Coolangatta  
Contact: cmpworkshop@maths.uq.edu.au  
http://www.maths.uq.edu.au/~cmpworkshop

Adelaide  
Email: aas2002@mecheng.adelaide.edu.au  
http://www.mecheng.adelaide.edu.au/aasconf

December 11-13  COMMAD 2002, Conference on Optoelectronic and  
Microelectronic Materials and Devices  
Sydney  
Contact: Mike Gal, University of New South Wales  
Email: COMMAD@phys.unsw.edu.au  
http://www.commad.unsw.edu.au

2003

February 9-13  AMN-1, Advanced Materials and Nanotechnology  
Te Papa, Wellington, New Zealand  
Contact: amn@conferences.co.nz  
http://www.macdiarmid.ac.nz

August 19 - 21  Workshop on Recent Advances in Absorbed Dose Standards  
ARPANSA, Melbourne  
Contact: Mr. Robert Huntley, ARPANSA, Lower Plenty Rd., Yallambie,  
VIC 3085, Ph: +61 3 9433 2224, FAX: +61 3 9432 1835  
Email: robert.huntley@health.gov.au  
http://www.arpansa.gov.au

August 24-29  World Congress of Medical Physics  
Sydney

For information on Presentation Skills Workshops and Media Skills Workshops for scientists and technologists, run by Toss Gascoigne and Jenni Metcalfe, see http://econnect.com.au, or contact jenni@econnect.com.au
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Tuneable Dye Lasers
Lambdachrome Dyes
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