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The cover picture is a reproduction of the painting 'A philosopher giving a lecture on the orrery' by the British painter Joseph Wright of Derby. See article on page 136.
A.I.P. + N.Z.I.P. = A.N.Z.A.P.? 

You may have read in our most recent Annual Report: “At the Council Meeting the President reported informal contacts with our sister organisation in New Zealand with a view to establishing closer ties. Council agreed that discussions should continue and that a concrete proposal should be brought forward... Comments from branches and individual members would be welcome.”

Let me hasten to add that we are contemplating nothing as crass as a takeover bid or a leveraged buyout - or whatever the corporate cowboys do just before they go bust. Not even an amalgamation, à la Dawkins, because there would be no point in submerging the identity of either of our fine organisations. No, what we have in mind is an affiliation, aimed at furthering our common aims and creating some economies of scale in our publications. (For the record, the N.Z.I.P. currently has 320 members, compared with about 2500 for the A.I.P.)

Nothing but positive comments were heard from individual members, and the branch chairman had already indicated their support at the Council meeting, so the initiative continued. It actually took two forms: The first was a sort of “shuttle diplomacy” by Dr Graeme Putt of the University of Auckland, a Melbourne graduate currently back on Study Leave in his alma mater.

The second form was as a sub-text in correspondence with Professor Paul Callaghan, the President of N.Z.I.P., inviting me to participate in the New Zealand Physics Conference, at Massey University, 27 - 29 August, 1990. In reply to my acceptance, back in March, Paul, who is known to many of us in Australia, wrote about “...a groundswell of support...” for closer relations and delegated to Graeme Putt the role of liaising with the AIP on this issue.

We reached very rapid agreement on matters of principle and Graeme drafted the Memorandum of Understanding reproduced on the next page. From there on, a veritable torrent of goodwill was unleashed and things moved very rapidly. The Executive of the N.Z.I.P., at its meeting on May 23rd, approved the draft and, with a strong endorsement, put it to their membership for comment. The Executive of the A.I.P., at its meeting on May 25th, was also in favour of the draft and resolved to endorse it, so now it is over to you!

Comments are hereby called for, and please hurry: there is a good chance that if we don’t hit any snags we will be in a position to launch A.N.Z.A.P. by signing a final version of the Memorandum at the N.Z.I.P. Conference at the end of August. So, go for it, bush lawyers: please read the Memorandum on the following page carefully and write, fax or phone your views directly to me, as soon as possible.

Tony Klein

Public Lecture Tour on PARTICLE PHYSICS

Eminent Swedish particle physics theorist, Professor Cecilia Jarlskog from the University of Stockholm, will visit Australia in August.

Under AIP sponsorship Professor Jarlskog will present public lectures on particle physics at the University of Adelaide (Friday 10 August – Contact Professor A.W. Thomas (08) 228 5113, for details), the University of Melbourne (Tuesday 14 August, Laby Theatre – Contact Dr G.N. Taylor (03) 344 5459 for details) and the University of Sydney (Thursday 16 August – Contact Assoc. Prof. L.S. Peak (02) 692 2624 for details).

Professor Jarlskog has made outstanding contributions to many areas of particle physics phenomenology. She is renowned for her ability to convey with clarity the great significance and appeal of particle physics, as well as her own fascination with this exciting field.
MEMORANDUM OF UNDERSTANDING

Draft prepared by Dr G.D. Putt FAIP FNZIP
A.N.Z.A.P.

Australian and New Zealand Association of Physicists

Whereas the Australian Institute of Physics and the New Zealand Institute of Physics have been formed as independent bodies to promote the advancement of knowledge of Physics through research, teaching and applications, within their respective countries; both organisations now recognise their common interests and objectives could be furthered by joint cooperation established on some formal basis. The purpose of such cooperation would be to ensure the free, regular exchange of professional information and by so doing encourage collaborative effort amongst the physicists of both countries.

Accordingly we agree to form the A.N.Z.A.P. to serve this purpose. Membership will be automatic to all physicists who are financial members of A.I.P. or N.Z.I.P. and all A.N.Z.A.P. members shall enjoy the equivalent but non-voting privileges of each other's Institutes. The presidents of both institutes (or their nominees) will become co-opted members of each other's Councils and be invited to attend each other's Council meetings scheduled at the time of their national Congress/Conference meetings. The means for disseminating information amongst the physicists of both countries will be an expanded version of The Australian Physicist which will include a proportionate content of New Zealand news and contributions communicated by the Hon. Editor of the New Zealand Physicist to the Hon. Editor of the Australian Physicist. The publication shall be known as The Australian and New Zealand Physicist to reflect this change. It will continue to be edited and administered by the A.I.P. and will be distributed in New Zealand by N.Z.I.P. following bulk delivery from Australia.

Both Institutes acknowledge and express their intent to exploit any new opportunities A.N.Z.A.P. provides for furthering their local interests at the national level and representing the joint interests of the Australasian physics community at the international level. For simplicity of operation and maintenance of institutional independence any financial matters concerning A.N.Z.A.P. shall be apportioned on the basis of the level of each Institute's respective membership. Both Institutes therefore will retain their existing identity and autonomy on matters concerning their constitutions, memberships, professional activities, finances and publications.

Whatsoever governance of A.N.Z.A.P. may be required shall be the joint responsibility of the current presidents of the A.I.P. and the N.Z.I.P. Any action, if needed, will be executed by the president of A.I.P. following appropriate consultation with the president of N.Z.I.P. If at any time either member body forming this agreement deems it an encumbrance to the advancement of Physics in their respective countries they have the unconditional right to withdraw from this agreement whereby A.N.Z.A.P. will become null and void and so cease to exist.

A.G. Klein
President, A.I.P.

P.T. Callaghan
President, N.Z.I.P.
THOUGHTS FOR THIS MONTH

This issue includes another innovation - the introduction of a Comment section. This month's Comment arrived unsolicited from Ted Maslen and the Editorial Board decided to build up the 'Comment' concept using this article as the first. We will accept articles offered within this format, and will also solicit articles. The articles will be read by the Editorial Board. We will decide on their acceptability as a Comment but will not referee the paper in the conventional sense. We will accept letters relating to the 'Comment' in one issue, as late as is possible for inclusion in the next issue. This will usually be the end of the month of issue.

This is your chance to comment on any matter of interest to Physics or Physicists. Use it! Do not rely on the Editorial Board to do all the work. If you wish to discuss a possible 'Comment', phone me if you like. Use the fax number quoted earlier in this issue to communicate directly with the Editor. If there is something you feel strongly about, try putting it on paper - the responses will hopefully carry forward the discussion.

In the June issue we published the first of the 'Fix-on-Physics' sections. These are intended as source material to extend the resources of Physics teachers in secondary schools. We will publish a second 'Fix' in August and a third in October.

Two things for you as Physicists to do:
(i) photocopy the section and give half a dozen copies to your local high school,
(ii) contribute a similar article or idea for an experiment to forthcoming issues of the 'Fix-on-Physics' section.

We are not looking explicitly for anyone to expand on syllabus material, though that might be helpful in certain cases. (Dr. Paix of SAIT has recently advised us of the failure of a great number of texts to explicitly state that mass remains constant in phase changes, for example). We want application notes on Physics suitable to illustrate or expand the existing secondary syllabus, we want simple but effective experiments. We want your contribution - don't lament on the quality of secondary education, do something to improve it.

In this issue the President has announced the likelihood of the signing of a memorandum of agreement linking the AIP and the NZIP into an Association of Australian and New Zealand Physicists. One of the immediate outcomes of that agreement will be the expansion of the reading population of what is now The Australian Physicist to include New Zealand physicists. From September (probably) you are likely to notice a new banner title on your journal - it will become The Australian and New Zealand Physicist (or something very similar - perhaps we should have a quick contest to suggest the best name).

The Editorial Board welcomes the opportunity to expand our audience and increase the reservoir of articles, comments, notes, etc., waiting to be sent to us for consideration for publication. We are entering a new era of co-operation - we extend the challenge to you to make the most of it.

On a different note, we seem to have the usual problem of politicians not remembering exactly what they said in the election campaign. The Prime Minister's promise of a 'clever' Australia through 50 Co-operative Research Centres emphasizing basic research is fading. There may not now be 50, unless there is substantial industry funding (or practical expressions of industry interest). A Co-operative Centre involving two Universities with no third external interested contributor is 'unlikely to be successful'. ARC funding to individuals involved in a Co-operative Centre is under a cloud. This almost certainly means that the preliminary planning by some groups in Universities involved in very basic research is not going to come to any successful conclusion. We are back in the arena of industry participation - most other incentives have not worked in terms of dramatic increases in industry-University-CSIRO collaboration. It now seems the Co-operative Research Centres will also depend to a significant extent on the identification and quantification (in real terms) of more industry involvement.

R.J. MacDonald
Honorary Editor
The Prime Minister urges Australians to work smarter. To comply we must answer the question 'What is smart?'. Heavyweight mining companies promise economic benefits in return for improved mining access to the Australian land mass. The Department of Employment, Education and Training believes that concentrating our research efforts will improve R & D performance. The 'solutions' to Australia's economic problems appear endless and almost contradictory. What is abundantly clear from the results, however, is that key management decisions affecting Australia's economic performance have been unsound.

In principle the large Australian mining companies have the financial strength and technological focus necessary to spearhead the nation's advance into the new technological age. In practice the technological base in most of these companies is far too narrow for that objective. The problem originates in the mining industry's recruitment, which historically concentrated on its traditional exports. With few exceptions the mining industry has not employed capable graduates expert in new materials science areas with high growth potential. The myopic view of the current management reflects this earlier weakness in recruiting.

The mining industry's case for increased volumes of raw material exports is unconvincing, because it is clear to anyone with a basic knowledge of economics that the preferred strategy is to increase the value of materials exported by further processing. Some progress is being made, e.g. in upgrading mineral sands to metals and pigments, but the scale of that effort falls far short of what is necessary. Until the industry displays more versatility in extending its traditional activities, progress in these important areas will continue to be slow. It is ironical that our more versatile graduates are keenly sought by foreign competitors who use their skill and enthusiasm to increase their lead over Australian technology.

Basically mining has been profitable because land costs in Australia are low, and its favourable climate and terrain offset higher transport costs due to remoteness. The industry has not got a good record either for astute management or for technical innovation, but its members appear regularly on research advisory boards, and its representatives frequently advise the Government on economic policy. There are serious grounds for questioning the objectivity, as well as the wisdom, of that advice. For example, while its representatives repeatedly call for economic restraint, directors fees have risen rapidly (by 25, 49 and 21 per cent respectively for RGC, WMC and Woodside Petroleum last year), and its executives' salaries at a comparable rate. It appears that the mining industry considers itself to be exempt from its own advice!

If mining were the lagging sector in an otherwise thriving economy, one would be less unhappy with the situation. Unfortunately in relative terms it is one of the star performers in a generally bleak picture. The other financially strong section of the economy - the banks - have been the main beneficiaries of the Government's high interest rate strategy. The banking industry's low investment in R&D is scandalous. It is hardly surprising that lately much of its support to entrepreneurial business has foundered.

Banks' profitability rose rapidly over a period in which they offered most customers poorer service at higher cost. For all but the most straightforward transactions banks make relatively ineffective use of new computing and communication equipment. For example it is exceptional to have a bank accompany international transfers with all the information necessary to guarantee trouble-free transmission of funds. Banking representatives offer financial advice to the Government even more freely than those of the mining industry. Their objectivity is suspect for the same reasons - that the interest of the nation and that of the banking sector coincide with remarkable frequency.

One would expect to be on safer ground when seeking advice from scientists, who should have identified the R&D opportunities best suited to Australia's industrial growth. Unfortunately they have conspicuously failed to recognise the economic importance of high quality computational tools. For instance this is the advice and instructions for Australian Research Council Grants: 'Assessors in most fields tend not to give a high rating to data compilations or the development of research aids and tools including computer programs.' This attitude persists in spite of overseas industry's recognition of the importance of scientific data bases and good software especially in biotechnology. The price of computing hardware has fallen dramatically in recent years, but specialised software is increasingly expensive. A molecular modelling package of modest quality slanted towards the pharmaceutical industry retails at about $100,000 per annum. Publishing houses now vie for control of scientific data bases started by academics who did not have the resources to maintain them.

The value of high quality software in scientific publishing and in computation-intensive disciplines is enormous. A doubling of productivity with the availability of good software is common. Expertise in scientific software, which could have been the starting point for the growth of a strong Australian software industry has virtually been ignored in formulating the ARC's funding strategy. Few people are aware that A.C Hearn, the developer of the archetypal REDUCE program for algebraic computing, was Australian.

Most of the nations' physical scientists over the age of 35 are completely unaware of new ideas emanating from computing science. Because of outmoded development techniques few existing scientific programs are worth
COMMENT

preserving. This gross waste of resources is perpetuated by the low competence of referees in the scientific computing area, and a resulting mis-allocation of research funds by the ARC. It is not uncommon for that body to fund targeted, as distinct from general, software. This leads to essentially a 'throw-away' product - poorly written and commented, and largely undocumented. At the same time efforts to develop more general scientific software with wider applications and long term benefits are ignored.

To test whether decision-making on science and research has served Australia well we can compare the potential benefits of scientific-computing with those from an area which has been well funded, namely e,2e scattering. Considerable effort is being expended in Australia on applying that technique to solids, which may appear to be a sound objective, because of the economic importance of solid materials. The research management question, however, is whether that effort would be more productively spent on other probes - or on scientific computing.

Electron scattering provides information on the structures of atoms and simple molecules. When applied in the electron microscope it provides the most powerful tool available for the study of matter down to just below atomic resolution. In that form electron scattering has very wide applications in science and technology.

Because the electron's interaction with matter is strong the probability of an electron being scattered more than once in solid materials is high. This complicates detailed investigation of the structure of matter by electron scattering. For electron microscope images the effect of multiple scattering can be calculated, using methods formulated by the Australian scientists J M Cowley and A F Moodie. Although those calculations can improve our understanding of high resolution microscope images dramatically, the computation required is tedious. It is not yet possible to calculate accurate, atomically resolved images for solids directly from electron scattering. The electron microscope does not provide the high resolution available in X-ray diffraction images.

The elegant e,2e extension to electron scattering permits the study of correlations between the motions of electrons in matter. It provides information which is definitive in testing the fundamentals of atomic physics. Being a coincidence technique however, the relevant cross sections are low, and decrease towards unobservability for many targets. It is also difficult to deconvolute e,2e scattering cross-section reliably for the more complex molecules of greater practical importance.

The effects of multiple scattering on e,2e scattering from solids must be solved if the experiments are to provide useful scientific information. So far there is no indication that this difficult problem can be profitably tackled. My assertion at an international Sacamore conference that, even if it were, e,2e scattering would be less powerful than several other probes used to study solid matter has not been challenged. If a fraction of the Australian effort on e,2e scattering had been redirected to applying the Cowley/Moodie technique to electron diffraction patterns and electron microscope images in a powerful and general computing packing, our understanding of solid materials would be much further advanced.

In most developed countries the merits of different approaches to technology are freely and expertly debated. There is, unfortunately, no forum in Australia where matters of science policy can be similarly resolved. The Australian Academy of Sciences has been less effective in this area than one might expect - partly because its advice is often ignored. The decision-making process seems designed to exclude well informed technologists, especially those inclined to challenge the establishment's view. The Hawke Governments have set an appalling example by making political appointments to key management positions and by entrusting decisions on research policy to committees under-qualified for their task. The system protects those committees and the administering bureaucrats from comment by experts on their decisions.

The Government is now on the verge of creating new research centres. How likely is it that these will achieve excellence? History is not very encouraging. I direct a small centre created to determine the structures of crystalline organic and inorganic materials. On a worldwide basis only one other laboratory has determined structures for more compounds. The centre is the headquarters of an international collaborative venture which shares the cost of developing the world's most powerful general purpose crystallographic software. What indication do we have of comparable or greater achievements by the centres already established under Government auspices?

The success of a centre should be measured, not by the kilodollar input, but by the amount and quality of the research output. Evaluated on that criterion, most of the Government's centres have been less 'excellent' than we had been led to expect. I would be happy to explain the management deficiences which I believe to be responsible if it is acknowledged that this might help improve those centres' productivity.

The solutions to technical questions in technology do not lie in the latest gee-whiz techniques of business management, many of which are superficial. Unfortunately such approaches are often invoked by the Government when confronted with research planning questions that it finds hard to answer. Research planning requires professional understanding of the technological factors relevant to the decisions. Although that knowledge usually exists in Australia, it is rarely utilised. There are no systematic methods for identifying those best qualified to advise the Government, and much of the advice it does receive is far from objective. Until that is recognised at the highest level and corrected by Government, by the management boards of industry, by those in charge of research funding, and by the higher education system as a whole, we will make little or no progress, even in those technological fields in which Australia has the greatest chance of success.

E N (Ted) Maslen
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Australian Physicist Volume 27, Number 7, July 1990
In April the Pawsey Medal for 1990 was awarded to Dr Wayne K Hocking of the Atmospheric Physics Group, Department of Physics and Mathematical Physics, University of Adelaide.

The Pawsey Medal is awarded by the Australian Academy of Science. It was endowed to commemorate the unique contributions to science in Australia by the late Dr. J. L. Pawsey FAA, and was first awarded in 1967. It is normally awarded annually; its purpose is to recognise outstanding research in experimental physics by younger scientists.

Dr. Hocking was educated at Bordertown High School, South Australia, and the University of Adelaide, where he was awarded the Ph.D degree in 1981. His thesis was awarded the William Culross Prize for the best thesis in Mathematical and Physical Sciences and Engineering. After a period spent at the Max Planck Institut für Aeronomie in 1982, Dr Hocking returned to Adelaide and was appointed Lecturer in Physics in 1985.

Dr. Hocking’s work has involved the use of the unique radar facilities at the Buckland Park Research Station of the University of Adelaide, which is situated about 45 km north of the city. He has made important contributions to the development of these facilities, which include radars working at frequencies of 2.6 and 54 MHz. The 2 and 6 MHz radars employ a large filled array 1 km x 1 km containing 178 dipoles, each individually connected to a central laboratory by coaxial cables. This gives the radars great versatility for use in a variety of experiments, which Dr. Hocking has been able to use to great advantage. His first work was on the structure of the irregularities which cause weak radar scattering at 2 MHz from the mesosphere (the ionospheric D region at heights from 70-100km). He then went on to make use of the same scattering phenomena to study turbulence in this region, and the techniques he developed for this purpose represent his most important and original work. In the presence of turbulence, the scattering irregularities have random motions which, by the Doppler effect, broaden the spectrum of the scattered radar signal. In principle, this broadening can be measured, and used to estimate the root-mean-square fluctuating velocities of the scatterers. These velocities can then be converted to turbulent energy dissipation rates and eddy diffusion coefficients. However, as Dr. Hocking showed, direct measurements can be very misleading, because there are several other effects which also cause broadening of the spectrum, and which may, in fact, be dominant. These include the effects of mean winds, wind shears, and internal gravity waves. Corrections for these effects must be made and Dr. Hocking developed new experimental techniques and new analysis procedures to do this.

Having achieved his aim of eliminating the unwanted effects, Dr. Hocking was then in a position to start to assemble for the first time a “climatology” of turbulence in the mesosphere region of the atmosphere. By collecting results on turbulent energy dissipation rates over several years, he can study how the intensity of turbulence varies with height, time of day, season, etc. This information is essential data for the dynamics of the region because it determines the rate of transport of momentum by turbulent processes. It also determines the rates of transport of minor constituents of the atmosphere. As an indication of the importance of this work, it may be mentioned that Dr. Hocking was invited to write a review of turbulent energy dissipation rates for a new edition of the International Reference Atmosphere, 1989.

In later work Dr. Hocking has applied similar methods to observations made with the Adelaide VHF radar. This operates on 54 MHz and observes the atmosphere from the ground up to about 20 km. Observations of clear air turbulence in this region are of great importance to aviation. In recent work Dr. Hocking has been involved in experiments in which an anemometer is flown over the radar in order to allow comparisons of the radar observations with direct in situ observations. He is also working on a novel theory of diffusion, involving Stokes drift, and on the possible importance of viscosity waves and thermal conduction waves in the atmosphere.

Most people probably think of Dr. Pawsey as a radioastronomer, but in fact he also did important work in ionospheric physics. Some of Dr. Hocking’s work is derived fairly directly from this, and it is certain that Dr. Pawsey would have been pleased at the award being made for the first time in this field.

B. H. Briggs
A PHILOSOPHER GIVING
A LECTURE ON THE ORRERY
A PAINTING BY THE PAINTER OF LIGHT

H.C. Bolton
Department of Physics, Monash University, Victoria

The painting reproduced on the front cover is by Joseph Wright. At the outset it is perhaps only fair to say that this brief article cannot do justice either to the artistic qualities of this or any other painting of Wright's or to the social conditions represented in it. Both are the subject of large literature, and if I draw on some aspects of this literature it is only to help me to define my response to the painting as a physicist.

I have always taken a great deal of interest in the paintings of Joseph Wright, which I first saw in reproductions. He was a painter who enjoyed the scenery about him and tried to capture the effects of light. He made portraits of the patrons of his art and painted industrial and even scientific scenes. Two events helped me to focus my attention on him; on a visit to the National Gallery in London I discovered that one of his scientific paintings was on view after a period in the Tate Gallery and I managed to get a fine reproduction of another of his scientific paintings from the Derby Art Gallery. My reading into the background of these two paintings led me to some historical comments on the development of physical science and I felt that I could share these with a wider audience.

Joseph Wright is always known by the addition 'of Derby' where he was born in 1734. Derby was a provincial town in England at that time and since there is no other major painter with the same name, the additional phrase 'of Derby' is scarcely necessary unless it expresses the raised eyebrow marking a feeling of doubt that a painter of any kind, let alone a good one, could have come from the English provinces. Wright died in 1797 having lived through an exciting period not only in art but also in science and technology. Wright was part of that discovery of the British countryside by an increasing number of travellers who found the examples of early industrialisation romantic and artistic. He drew and painted some of these industrial scenes in the Midlands of England (Moir, 1964). He was fortunate in having friends and patrons in a creative and exciting society of scientists and technologists in the Midlands around Derby and Birmingham, which was only thirty miles away. To use the word 'provincial' at all is unfair; if you had wanted to know what was going on in much of science in Britain in the middle of the eighteenth century you talked to Wright's friends whom we shall see emerge in the story of this and his other paintings (Nicholson, 1968; Shurlock, 1923). This particular painting is in Derby Art Gallery.

We ought to start by just looking at the painting in its own right. It shows a group of figures with a lecturer, the central figure at the back, talking about the orrery which is the large instrument in front of him. Various persons are grouped round it including three children, one with his back to us and shading the single source of light. The orrery is a model displaying the arrangement of planets and their moons which are able to rotate round the sun represented by the source of light. This source was probably an oil lamp as seen in the reflection in the polished base; this lamp is symbolic because it represents the sun as the source of the gravitational force on the planets and simultaneously illuminates the scene, giving light to the note-taker on the left. Illumination is a word we use to describe not only physical light but also understanding.

The first orrery was designed and made by John Rowley in or before 1713; it displayed the Sun, Earth and its Moon (Milburn, 1973). In gratitude to the nobleman, the Earl of Orrery, the instrument was named after him. The family name of the Earl was Richard Boyle; the scientist Robert Boyle was of the same family. This first orrery was soon enlarged and improved in several hands to include all known planets and moons, and the orrery in the painting shows all those known at the time of its display in 1766. An orrery was an expensive instrument. There was not a trade in mass-produced orreries but they could be made by skilled instrument-makers and they were advertised. It is not too far-fetched to think of the instrument as a piece of high-technology of the time, and this painting enables it to be seen in action by a wider public than could have been present at its actual demonstrations.

The motion of the planets in the orrery was determined by gears consisting of two cones of gear wheels, one tapering upwards and the other downwards. One cone was linked to the driving handle and other was on the central axis of the orrery to which the planets and moons were connected. The mechanism of the cones was developed by Benjamin Martin (Milburn, 1973; Martin, 1738). Martin's success as a scientific instrument maker had led to his being chosen to supply instruments to Harvard College in the American Colonies as they were then (Wheatland, 1968). The whole system of the planets was rotated by a handle at the side of the orrery; this is not visible in the painting but it would be under the control of the lecturer at the far side of the instrument. The gear ratios were rational fractions as close as could be made conveniently to the ratio of the planetary periods. Since the planets move in the plane of the ecliptic, the orrery could be made flat which was Martin's favoured arrangement. The orrery in the painting has an Armillary hemisphere over it carrying the equator, the Tropic of Cancer and the Arctic Circle which appear as metal bands. The Armillary sphere was an older model of the solar system with the earth at the centre. Even photographs of all these instruments are splendid and they display graduated circles which must have been
close to the limits of technology of the time (Turner, G., 1980; Wynter & Turner, A., 1975; Turner, A., 1987). Some orreries could display both the Copernican and Ptolemaic system, with interchangeable elements. These were probably unfair to the Ptolemaic system as the gears could not display the epicycles. No doubt the simplicity of the Copernican system and the way it could be displayed as a simple mechanism in front of an audience was occasionally used to emphasize the rationality of the Newtonian view, as the eighteenth century hymn says of the planets and stars (Addison)

In reason’s ear they all rejoice.

The orrery displayed and explained apparent mysteries such as eclipses, the retrograde motion of the planets, and the occultations of the moons of Jupiter, the last having played a significant part in Galileo’s confirmation of a sun-centred planetary system; the moons of Jupiter revolved round Jupiter, not the earth.

In the painting the inner planets Mercury and Venus are not seen as they are too close to the lamp representing the sun. On the left-hand side of the orrery are the earth and its moon in a little circular frame. Further to the left is Mars, and top left—being watched by the boy on the left facing us—is Jupiter and its four moons. On the right is Saturn and its five moons. In 1766 that was all that had been discovered of the planetary system. “The seven Stars in the sky” of the old rhyme ‘The Twelve Days of Christmas’ are the five planets Mercury, Venus, Mars, Jupiter and Saturn together with the Sun and Earth’s moon, an unabashed Ptolemaic chant. Uranus was discovered by William Herschel in 1781 and he also later discovered the sixth and seventh moons of Saturn. Neptune had to wait until 1846 for Adams and Leverrier to reveal it.

And what of the children? Were there children present at these evening lectures on scientific subjects? Indeed there were; we must accept this painting, and another of Wright’s on the air pump (to appear at a later date in the Australian Physicist), as pieces of reporting of occasions in which children were present. There was also a tradition of publishing texts for young persons even from the middle of the eighteenth century. A surprisingly long run is that of books written about ‘Tom Telescope’, a well-balanced, well-educated boy only too ready to explain scientific details to his readers (Second, 1985). This series of books ran from 1781 to 1838 and included translation into European languages (Tommasio Telescopio in Italian in 1932). Children in this rational environment were not to be ‘seen and not heard’. Tom Telescope’s illustrations show children, men and women discussing science.

When there was so much recent science to be spread amongst society, there was every encouragement to sit down in front of an orrery and listen to a visiting lecturer as did those in the painting. The man on the right is thought to be Joseph Wright himself. The man on the left, taking notes, was Peter Perez Burdett, surveyor, mathematician and artist (Derby, 1979). He is holding a notebook, a pen and a portable ink-well. There is always one diligent notetaker at every lecture.

But the interesting figure is the lecturer; who can he be, dressed in clothes that hint at academic dress? He has been identified as John Whitehurst, a Derby clockmaker, instrument maker and geologist. He was a member of a group or club of local persons from the district round Derby and Birmingham called the Lunar Society, and in making this identification we open up the most interesting part of the story behind the painting (Schofield, 1963).

The Lunar Society is the familiar name for a group of friends and industrial associates in the English Midlands. At the heart of the Society are fourteen persons, some still famous in their own right; they were Matthew Boulton, Erasmus Darwin, Thomas Day, Richard Lovell Edgeworth, Samuel Gaillon junior, Robert Augustus Johnson, James Keir, Joseph Priestley, William Small, Jonathan Stokes, James Watt, Josiah Wedgwood, John Whitehurst and William Withering. Some of the family names are still well known in science and education (Annan, 1955). The members of the Society were interested in a wide range of sciences and technologies and were active in applying scientific principles to industry. If a single modern phrase can encapsulate such diverse persons, they could be described as a complete industrial research establishment (Schofield, 1963). They were not provincial amateurs and dilettantes; six of them were Fellows of the Royal Society of London (Boulton, Keir, Priestley, Watt, Wedgwood and Withering). It would take too long and be too far from our purpose to discuss their science and technologies but the names Priestley, Watt and Wedgwood are household names.

Boulton was the most important person in the beginning of the Society (Dickson, 1937; Schofield, 1963). In 1750 this ‘born promoter’ was managing his father’s buckle and medal factory in Birmingham. By 1760 Boulton and Darwin had established a correspondence and had friends with scientific interests in both the curiously and the needs of local industry. These friends formed the nucleus of the group that later became known as the Lunar Society. It is hard to say which specialism each member of the Society represented. Ideas were shared and moved from one to another; the comparison with the colloquium meetings of a modern science department comes readily to mind.

The painting could show a possible expression of the early days of the Society. Whitehurst, the lecturer, was born in 1713 and was about 51 when the painting was made. Dinner and discussion at a member’s home took place once a month in the afternoon of the Monday nearest the time of full moon giving the members a chance of returning to their homes by moonlight, hence the name of the Society.

Such a group of controversial, rational thinkers, including the Nonconformists amongst them, was bound to attract suspicions in untutored minds of political sedition and even revolution, but their revolutionary ideas were not those of political action but of improving scientific industry, and hence of supplying benefits to trade and commerce. The members of the Lunar Society did not begin the Industrial Revolution in Britain but they were responsible for showing how it could greatly accelerated.

The lecturer in the painting, John Whitehurst, seemed to have had a talent for friendship, and this seems to have been common to many of the members. Later, Whitehurst’s house in London became a focus for
scientists. He met Benjamin Franklin, Josiah Wedgwood and D.C. Solander (a biologist with Banks on the Cook expedition) at another scientific society, the Thirteen Club, which began at Slaughter's Coffee House in London. He also attended the Club started by John Smeaton which was virtually the origin of the new profession of Engineering. Benjamin Franklin visited Birmingham in 1758 and 1760 when he did an experiment with Boulton. Franklin was acknowledged as a good if not prominent experimental physicist. He was on the side of independence in the 1776 American rebellion or patriotic war (depending on the politics on the side that was supported). Then as now scientific decisions were often political; in 1780 lightning conductors (according to the design of Franklin, but with points) were recommended by the Royal Society for tall buildings in Britain. Scientific debate had erupted because the protagonists of points had been British scientists who proposed round knobs on the tops of the conductors. The adjudication was made by King George the Third who insisted that round knobs be used at Kew Palace and not Franklin's points, no rebel science! The President of the Royal Society Sir John Pringle resigned and the following verse appeared (Bernal, 1964):

While you great George for safety hunt
And sharp conductors change for blunt,
The nation's out of joint
Franklin a wiser course purses
And all your thunder fearless views
By keeping to the point.

Turning back to the orrery in the painting, the horizon ring on which some listeners are resting was often engraved with angles and the signs of the zodiac, but it is hardly likely that zodiacal signs would be objects of discussion among persons with such rational and industrial backgrounds as were drawn to hear Mr Whitehurst.

Events of 1791 marked the beginning of the end of the Lunar Society (Schofield, 1963 Chapter 12). There was a Revolutionary Society in Birmingham, as there were in many towns in England, which commemorated the English Revolution of 1688. In July 1791 the Revolutionary Society of Birmingham had proposed to hold a dinner to celebrate Bastille Day. James Keir, one of the Lunar Society, was invited to be chairman, and this meeting became the focus for the Birmingham Riots which lasted three days. One of the catchphrases during the Riots was "No philosophers—Church and King for ever". Meeting Houses of dissenters were destroyed, dwelling houses ransacked, including that of Withering, and Priestley's house, library and laboratory were destroyed. Priestley left Birmingham for ever. Though the activity and influence of the Lunar Society declined from the time of the Riots, this decline was due not so much to the Riots but rather to the effects of the increasing age of the members and partly to the effects of pulmonary tuberculosis, a hazard of the times. But the influence of the Lunar Society extended well into the nineteenth century through families of its members and through scientific contacts with younger persons, so that the development of science and technology owes much to their rational discussions and scientific education. As an example, there can be few families to match the Darwins with the steady appearance of intellectual and scientific work in each generation up to the present day (Annan, 1955). Joseph Wright, in his painting of 1766 of the orrery, caught an expression of the spread of scientific ideas through education which happily still continues and flourishes.

There do not seem to be orreries built in this century, and following the Voyager Flypasts of Neptune a modern orrery would need many additions, especially of gear wheels, beyond those shown in the painting. For those who would like to see an orrery, there are three in Australia. The Powerhouse Museum, Sydney has two; the earlier is a small table-top model from the early nineteenth century and the other is a large mid-nineteenth century model on the same scale as a library globe. The West Australian Museum (Department of History) has an orrery which is an early nineteenth century table-top model accompanied by an instruction booklet.

Acknowledgements

I am grateful for advice on the orreries in Australia from Julian Holland, Curator of Technology, The Macleay Museum, University of Sydney.

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A CENTURY OF COLD, SUPERFLUIDS AND SUPERCONDUCTORS

Guy K. White
CSIRO Division of Applied Physics, Lindfield, NSW

A hundred years ago, experiments in refrigeration were concerned with trying to liquefy the so-called 'permanent' gases and with cooling and preserving important things like meat and beer. Then success in liquefying hydrogen with the help of the Dewar flask led to liquid helium and an exciting new world of extreme cold and 'order'. The more unexpected forms of order included superflow in liquid helium and superconductivity in many metals. These phenomena and some aspects of magnetic order have presented a continuing challenge to the scientist. So far applications have been relatively few, without much impact on society excepting the economic convenience of storing and moving gases in liquid form.

**Introduction**

In this article we shall review the history of cryogenics (the science of cold) and superconductivity. In particular this review may reveal some lessons relating to the time scale for Research and Development. We may well conclude that it would not be wise to sit on the edge of your seat waiting for a pot of gold from superconductivity or you may fall off while waiting.

**Liquid O₂—1877**

This article is also all about getting colder, losing energy and gaining order. What is order? One example is a well-drilled class of children sitting quietly in their seats. A contrast would be a room full of small boys running around throwing chalk at each other! That is disorder—high entropy to use science language. 100 years ago, some scientists were much concerned with one aspect of ordering, namely turning gas into liquid. They were trying to liquefy some of the so-called permanent gases, e.g. oxygen and air, which had defied the efforts of Faraday and others, earlier in the 19th century.

December 1877 saw success. We may judge this from two telegrams to the Secretary of the French Academy of Science, announcing a few drops of liquid oxygen, produced by a combination of cooling and pressure. Firstly that of 2nd December, 1877: Louis Cailletet, an engineer of Chatillon sur-Seine wrote ... "I hasten to inform you that I have today liquefied oxygen. Maybe I am mistaken when I say liquefied, for I saw no actual liquid but ... a mist appeared ...". Then on 22nd December, 1877: Raoul Pictet, of Geneva, telegraphed to the French Academy ... "Oxygen liquefied today at 320 atmosphere and 100 degrees cold ...". These are a far cry from the thousands of tons needed 100 years later to launch a space vehicle.

**Liquid H₂—1898**

The next goal was to liquefy hydrogen. This would have been impossible without the invention of the Dewar flask—what we

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today call the thermos or vacuum flask—by the irascible Scotsman working in London, Sir James Dewar. He and his faithful assistant succeeded (in 1898) in cooling compressed hydrogen with liquid air and liquefying the hydrogen. He found this to boil at 20K (-233°C).

Liquid He—1908

This set the stage for the possibility of liquefying the most permanent of gases—helium. Dewar hoped for this achievement using the liquid hydrogen which he produced as a precooler but his hopes were in vain. The only source of helium gas in London then was Sir William Ramsay and the two did not speak to each other. So instead, a chance for success was given to the scientist-diplomat-manager, Kamerlingh Onnes—Professor of Physics at Leiden. He had recognised that a temperature of 5 or 6K would be needed to liquefy the helium gas; he obtained the gas through Dutch colleagues, who had produced it from monazite sands—costly stuff. He had built up a first-class school in Leiden for apprentices, glass blowers, instrument makers, etc., and had constructed a hydrogen liquefier making 4 litres of liquid hydrogen per hour—sufficient to cool his helium refrigerator.

When success came in July 1908, his refrigerator produced a hundred or so cm³ of liquid helium quietly boiling at 4.2K. His first action was to try to solidify it by boiling under reduced pressure, producing cooling to 1 or 2K. No luck. In fact, he tried on many occasions without success to solidify the liquid helium with bigger and better pumps until his death in 1926. Later it became clear that both cooling and high pressure (25...
The Making of an Industry

I will digress for a moment to cooling processes in more detail. Cooling and pressure each produce more compact, more ordered systems. Most refrigeration cycles depend firstly on compression of the gas (removing the heat produced with a water jacket or fan) and then its expansion, either continuously through a porous plug or valve (Joule-Thomson internal work process) or expansion in a piston engine or turbine (so that it is required to do external work). These different systems or combinations of the two were the foundations of two great industrial empires at the turn of the century. The first was begun by Carl von Linde in Munich and drew initial support from the brewing industry. The other was the work of Georges Claude in France, founding the firm of L’Air Liquide. With the increasing demand for oxygen in the steel industry, these two firms dominated the world in supplying the air liquefiers and separation plant necessary to produce the liquid gas. World War I resulted in the splitting up of Linde to create a United States Linde Company.

Another figure of great importance was Walter Nernst—Professor of Physics in Berlin and Director of the German Standards Laboratory. He was also inventor of the incandescent mantle (the patent for which he sold for great profit to Siemens before the tungsten lamp made it redundant). In 1906, he enunciated an important theorem, later called the Third Law of Thermodynamics, which roughly states that at absolute zero the disorder of a system becomes zero. A photo shows Nernst in later years with his ex-student, Lord Cherwell. They were very different personalities but had similar tastes in enjoying wealth, status and the company of the great—Nernst with Bismarck and Cherwell with Churchill.
1933 saw another unexpected discovery in Berlin by Meissner and Ochsenfeld. When they cooled a lead sphere in a magnetic field below 7K, the magnetic field lines were completely expelled from the metal so not only was electrical resistance \( R = 0 \), but also the magnetic field in the metal \( B = 0 \). Later it was shown that the field penetrates only a thin surface layer about one thousand angstroms thick and electrical currents circulate in this layer. The resultant field shields the interior to give perfect diamagnetism.

Figure 8 Walther Meissner of Berlin, distinguished for his work on electron-transport and discovery in 1933 (with Ochsenfeld) of flux-exclusion in superconductors.

In 1935/36, the picture of flux expulsion and flux penetration was complicated by observations on alloys in Leiden, Oxford and Kharkov. These showed that there seemed to be a mixed state of normal and superconducting regions. Mendelsohn called it a ‘sponge’. This was not a bad description in view of the magneto-optical microscopy done many years later. The recognition of this mixed state in so-called Type II superconductors and the control of the magnetic flux movement proved vital to the later development of supermagnets.

Type II Superconductors

During these pre-war years, many great theorists including Bloch, Peierls, Landau, Ginzburg, as well as Fritz London, applied themselves to understanding the electromagnetic phenomena associated with superconductivity on a macroscopic scale but did not solve the underlying mystery. The war years were a distraction from superconductivity, except for a little work done on infrared bolometers such as NbN. However, wartime R & D on cryogenics and microwaves each had a profound long-term effect on our understanding of superfluids.
superconductivity. Firstly, developments in expansion engine liquefiers were needed at the time for portable oxygen systems. These developments were later applied to helium liquefaction. The man chiefly responsible for the post-war boom in low temperature experimentation was Professor Sam Collins (M.I.T.), farmer turned engineer who looked carefully at the piston engines used by Kapitsa at Cambridge ten years before and evolved reliable two-engine (two pistons) systems with vacuum container and heat exchanger that could be made commercially. This was done by the Arthur D. Little Corp. Within the next ten years, the earlier pioneering efforts with liquid helium at Leiden, Oxford, Moscow, Toronto and Yale had mushroomed to 100 centres in universities, industry and government. Good graduate students found it exciting to work on superconductors and on liquid helium—the superfluid.

Figure 9 Peter Kapitsa, born in Kronstadt in 1894, founder of the Mond Laboratory (Cambridge), died in Moscow.

Superconductivity and superfluidity have a striking similarity—both show a lambda-shaped peak (Figure 10a and 10b) in heat capacity near the critical temperature showing that some sort of ordering occurs below this temperature, creating a superelectrical conductor in one case and a super- (zero viscosity) fluid in the other. Below this critical temperature, $T_c$, part of them seems to condense into a ground state separated by an energy gap from their normal excited state, a sort of bottom energy shelf.

The Energy Gap

In the late 1940's, those microwave techniques developed from wartime radar research helped people like Brian Pippard at Cambridge to explore field penetration depths and so-called coherence distance over which superelectrons seemed to correlate—a distance of say 1000 atomic diameters. They were also able to measure the size of the energy gap mentioned above. These results were confirmed later by infrared absorption and tunneling studies, all pointing to an energy gap of about $3kT_c$ or less than a thousandth of an electron volt.

Lattice Vibrations–BCS Theory

1950 saw a major advance in understanding of superconductivity. First Frohlich in Liverpool and Bardeen in Illinois, separately suggested that electron correlation must take place via ions as intermediaries, i.e. a moving electron effects a vibrating atom which, in turn, effects another electron. Almost simultaneously, two experimental groups at NBS and at Rutgers showed that in tin and in lead, increasing the isotopic...
mass by two percent reduced the critical temperature by about one percent. This was in agreement with the prediction of the two theorists. Clearly, the vibrations (phonons) played a vital role in electron coupling in these elements. It took another five or six years before this so-called pairing interaction was clarified by Leon Cooper and the complete description was given by Bardeen, Cooper and Schrieffer predicting an energy gap of 3.5kTc.

The 1950’s also produced another revolution which was to effect the large scale use of superconductors. This was the aerospace development which made many engineers aware for the first time of the behaviour of materials at very low (as well as very high) temperatures. This awareness resulted in part from the use of liquid hydrogen and liquid oxygen on a tonnage scale. A new generation of large scale hydrogen and helium liquefiers would make it possible to cool giant magnets weighing many tons – magnets for nuclear accelerators, magnetic resonance imaging, etc. During this period groups at Bell Labs (Mathias, Geballe), Westinghouse (Hulm) and other laboratories searched for new superconducting materials with higher values of critical field and critical temperatures, etc., culminating first in the NbZr alloys (produced commercially by Westinghouse in about 1960) and later replaced by NbTi alloys with Tc~11K. At the same time the A15 compounds such as Nb3Sn, V3Si, etc. (Tc~17-18K) arrived on the scene. NbTi is still the workhorse of the high field magnet industry. Nb3Sn is also used for maximum (more than 15 Tesla) field applications but its characterisation is still a problem in very large magnets where enormous forces and strains involved have the effect of degrading performance.

**Josephson Junctions**

On a smaller scale of size but of great importance was the prediction in 1962 by the young Cambridge genius, Brian Josephson, that superconducting electron pairs could tunnel their way through narrow bridges or so-called weak links with special current-voltage characteristics that would make these Josephson junctions supersensitive detectors for measuring minute changes in magnetic field, even to detecting the hitherto unmeasurable fields associated with currents in the human brain.

**To Higher Critical Temperatures**

In 1964 superconductivity was found in two semiconductors, namely GeTe and doped SrTiO3 (at NBS with Tc<1K). This was a surprise, as Meissner’s discovery of superconductivity in CuSn in 1929 was generally forgotten. Mechanisms for such superconductivity are still the subject of debate. It is surprising also that the discoveries of Tc~13K in lithium titanium oxide (a spinel structure at La Jolla in 1973) and in barium lead bismuth oxide (a perovskite at Du Pont in 1975) attracted little attention, except perhaps from Mueller and Bednorz. More attention was given to Professor Bill Little at Stanford who suggested that chain-like organic salts might produce a new class of superconductors possibly with higher critical temperatures. Indeed, groups in Paris and elsewhere have found signs of  

Figure 11. John Bardeen (1908-) of University of Illinois, recipient of 2 Nobel Prizes for the transistor and for the theory of superconductivity.

Figure 12. Brian Josephson of Cambridge, UK, born 1940 and received Nobel Prize in 1973 for prediction of the Josephson Effect.
A CENTURY OF COLD, SUPERFLUIDS AND SUPERCONDUCTORS

superconductivity in such salts but only at liquid helium temperatures. I must not neglect the potential applications of superconductors which were subject to considerable work in 1966-86 in such diverse places as Westinghouse, Madison, Brookhaven, Karlsruhe, Rutherford Lab, etc. The first large dc superconducting motor (3000HP) was made for the International Research and Development Company in England in 1966. Now 20 years down the track the US Navy is considering more seriously the use of such motors in its ships, (perhaps because of the high $T_c$ publicity) using NbTi and liquid helium technology. This brings me to 1986 and the surprise that Bednorz and Mueller produced at IBM Zurich in that year. They had put many years of effort into the study of perovskite oxides and finally observed in a LaBaCu oxide signs of vanishing resistance below 30K and later in LaSrCu oxide at 40K. Soon after their initial publication in September 1986, others confirmed this; Wu and Chu pushed $T_c$ up to 90K in a YBaCu oxide and later researchers in Japan, China, USA and Europe reached 108K in BiCaSrCu oxide and ~120K in TiBaCaCu oxide. These 'high $T_c$' ceramics have rapidly become the flavour of the month and produced a new era of excitement for many young graduate students as did liquid helium and superconductivity 50 years ago. To date this mass attack has shown how complex is the magnetic structure of these anisotropic materials; also that electron pairing is still essential but what is the pairing mechanism and will $T_c$ ~120K be the practical upper limit for applications? Can useful devices be made that are significantly more economic that the present ones?

In Conclusion

One lesson from this brief history of low temperatures is that we need first class scientists, creative scientists, plus time and support to find answers. Another lesson is that the search for order near absolute zero, the mysterious world of superfluid helium, superconductors and the exciting saga of reaching lower and lower temperatures—proved very stimulating and attractive to young graduates of ability, young graduates in great centres like Oxford, Cambridge, Leiden, Yale, Berkeley, etc. In those post-war days there were fewer counter attractions such as financial rewards of law, accountancy and the money market. The new age of high $T_c$ superconductivity on which we are now embarked, seems also to provide an exciting challenge but can it attract and hold sufficient top-rate young physicists, particularly in Australia where rewards in salaries and support are poor.

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Victorian Branch
Forum on the ASTEC Report: Profiles of Australian Science

On April 19th 1990, the Victorian Branch held a Forum entitled "Aspects of the ASTEC Report" on the Report: "Profiles of Australian Science". This Report has already been the subject of the November President's Column and the Guest Editorial by Dr John Riley in the March issue of the Australian Physicist. The Forum was chaired by Professor Fred Smith and other speakers were the AIP President, Professor Tony Klein, and the Secretary, Dr John Riley. The three speakers are members of the AIP Science Policy Committee which corresponded with the Prime Minister, other ministers and shadow ministers on this topic last year.

Professor Smith and Professor Klein were to attend an ASTEC Forum in Canberra on 1st May 1990, chaired by two members of the Working Party which drew up the Report, Professors Ray Martin (Chemistry, Monash) and Graham Rigby (Electrical Engineering, UNSW). The Victorian AIP Forum thus provided a good opportunity to canvass the opinions of AIP members for transmission to Canberra.

Professor Smith began with the main conclusions of the Report regarding physics, which are summed up by a statement in Professor Martin's covering letter to the Prime Minister: "It is becoming increasingly difficult to maintain a place at the forefront of world science. ...Physics is particularly at risk." He noted that the Report assumes that the percentage of GDP spent by Government on basic research is appropriate and hence suggest that, if there are problems, they are due to too many scientists doing basic research!

He next discussed the sources of information used by the Report:
1. Input indicators, i.e. statistics on expenditure and employment in Research & Development,
2. Output indicators, i.e. bibliometric data, and
3. Interviews with active researchers (including only two physicists).

The Report presents data showing that R & D expenditure on physics and on the number of research staff have remained relatively constant over several years, whereas those in most other fields have increased. It also suggests a tendency to select research projects that can be tackled with the available equipment.

The Report's major criticisms of physics are based on bibliometric data from the Science Citation Index (SCI) for the years 1976 to 1984. The Report states that, in 1984, Australians produced 1.13% of the world's physics publications. This is a lower percentage than for any other field listed, the percentage over all disciplines being 1.99%. Physics also scored lowest in terms of citations (1.02% of the world's, compared to 1.88% for all disciplines). The Report also presents statistics of publications and citations in different branches of Physics, which show large variations over time. For example, the percentage of physics publications classified as solid state physics declined from 12% in 1975 to 9% in 1984.

Prof Smith pointed out, however, that publications in journals such as Physics Review Letters, The Australian Journal of Physics and Proceedings of the Royal Society were classified as "general physics", irrespective of the subject of the paper. An analysis of the classification of Monash physics papers demonstrated that this data requires widely spaced error bars.

The Report relies upon data (previously published by DITAC in its report on Scientific Indicators) on citation indices (i.e. percentage of world's citations/percentage of world's papers) for various disciplines. In 1980, for example, these were:
- mathematics: 0.7
- physics: 0.8
- biology: 1.0
- earth & space science: 1.0
- engineering & technology: 1.0
- biomedical research: 1.0
- chemistry: 1.2

The citations indices for different branches of physics were:
- solid state physics: 0.5
- optics: 0.6
- nuclear & particle physics: 0.75
- "miscellaneous" physics: 0.75
- fluids & plasmas: 0.8
- chemical physics: 0.8
- "general" physics: 0.8
- applied physics: 0.92
- acoustics: 1.1.

The unreliability of these figures is apparent from some of the categories used as well as from detailed analyses of publications from a particular department. Prof Smith also pointed out that a significant number of publications by physicists would have been listed.

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Australian Physicist Volume 27, Number 7, July 1990
Please help...

Dear Sir,

I have received a letter from a member of the Institute of Physics and Energetics, the Latvian Academy of Sciences, which may interest other physicists in Australia. In the letter he acknowledges the help Australia and Australian science has given in assisting his country to "freedom and independence". He then writes of the present difficulty of obtaining copies of scientific papers and journals. Anyone interested in helping him should write to me for his name.

Dr Richard Payling FAIP
Research and Technology Centre
BHP Coated Products Division
PO Box 77, Port Kembla 2505

His letter continues:

"But I must say that the present situation in Latvia is not very favourable for the development of surface science. For last 5 years scientific bonds with the world behind "iron curtain" were possible only with consent and under the guidance of central apparatus of Academy of Sciences in Moscow. Now, when our country turns from a totalitarian regime to free market economy we feel that many ties with Soviet Union are under blockade, and so is the previous way to the west. Now, then we feel more free we are also free from new Surface Science and many other international journals. Some time will pass before economical situation will become stable and our new republic will have more money for science. Now, for example, we have only one copy of Surface Science for three Baltic states: Lithuania, Latvia and Estonia. With some other journals the situation is worse.

So, if you have some spare copies of your articles for last years, would you be so kind and send them to us.

I thank you in advance, because I am sure, you will give a helpful hand to new Latvia which is struggling for freedom. I am awfully sorry for my bad English I will try to do better next time."

A 'post' editorial and tribute

Dear Editor,

I read the fine obituary for George Bell in your last issue and felt a sense of loss at his passing not only because he was very much "the warm and friendly man, well liked as a person ..." but because of the support he offered me in the difficult birth of this journal. A little background history would have amused him as much as it does me to look back and record something of our interaction during the early stages of the Australian Physicist.

During my period as Chairman of the NSW Division of the IPPS, the planning for and initiation of the AIP was very much in hand. Alan Harper called together a sub-committee to discuss the publication of an AIP journal. When I arrived for the meeting, three members of the Executive were present, the Hon. Sec. A. Harper, the Hon. Treas. G. Bell, the Hon. Registrar S. Dryden and Guy White. Alan invited comments and it was very apparent that there was complete agreement that the AIP should have a journal. The meeting was rather informal as everyone stood around. I was alongside George Bell at the end of the line.

"Now we come to the next point of the meeting - Who is to be Editor?", Alan commented that it was not his role as he was Hon. Sec. Then of course there was Hon. Registrar and then Dr White and then Hon. Treasurer - all fully occupied. Suddenly I realised that there had been a "sub-committee" meeting of NSL staff who had decided on the appropriate action, first JLS then, if he declined, GW. My question to Alan was, "When do you want the first issue out?", this being about February, "Oh I'd say on April 1!", replied Alan, George looked at me with a wicked grin I remember well and said, "I'm right behind you" to which I replied "I'll remember that". Alan in true press gang style remarked that it was nice to have full agreement on the position. So there it was and the first issue came out in April.

Three years later as Editor, I was finding it difficult to justify the expenditure on the AP and there had been some rumblings about the AP cost to members, I found that I had a strong ally in George at the Council meeting. Afterwards, he suggested to me that a strongly worded editorial would not go amiss and offered to vet it for me, if necessary to add "some cur/- (see Vol.4, No.1, page 3). When it came out, his comment was that there must surely be some correspondence now. It did come, much to the delight of both of us. Keith Mather, Director of the Geophysical Institute at the University of Alaska and a full AIP member, put our points so clearly that it needed no further expansion. (Vol.4, No.5, pp 79-80).>

Continued on page 156
Finally, George Bell had his 'right behind you' offer called. When Professor Davies had to relinquish the Book Review Editor's job, he told this to me at the Christmas Party with George standing alongside me again. Turning to him, I told him I was calling in his offer. He gave me the warm smile and agreed to do it as he could no longer claim to be "Hon Treas." I will always remember him well as a loyal friend and ally in adversity.

That brings me back to Keith Mather's letter of 1967. I quote, "It seems to me entirely defensible that the Australian Institute of Physics should expend a considerable fraction of its resources on ways and means of bettering communication between its members. The problem of disseminating information is so acute that we are unquestionably on the threshold of something that might be called a revolution". He then went on to explain the US situation on communication between scientists and to say that it "was one of the outstanding problems of our time, and its solution, if one can be found, will involve very sophisticated computer processing as part of its solution."

Today we have journals, fax and computer linkages between laboratories and even individuals.

Mr Editor, looking at the May issue, it is clear that your printing process techniques are far in advance of those I could call on in 1964. I am sure computers are part of the process! Even my letter is thus written and sent by fax.

I wish to offer you and all the past editors my compliments on the use which each of you has made in adopting new techniques for the improvement of the journal. But most of all, the journal is established as that very necessary means of communication between members who are as far apart in outlook as they are in space! May your efforts further prosper!

John L. Symonds

Ukrainian Encyclopaedia of Physics

Dear Editor,

I visited the USSR recently and while I was there a member of the Institute of Physics of the Ukrainian Academy of Sciences asked me if I would assist him in his job as editor of a new Ukrainian Encyclopaedia of Physics. It seems that he would like any information possible from Australia and other countries outside the Soviet Union on physicists with Ukrainian backgrounds.

I was given a letter on the subject to promulgate in Australia. Accordingly, I wonder if the Australian Physicist might be able to publish this letter which I enclose.

L M Besley, MAIP

Dear Members of the Australian Institute of Physics

I would like to ask for your help. Over the period 1990-1995, the Ukrainian Academy of Sciences has undertaken to publish, in the Ukrainian language, an Encyclopaedia of Physics in five volumes. I will be its principal editor. It will be the first time that such a book has been attempted and it is hoped that it will include complete information on the physical sciences as they relate to the Ukraine.

It is both appropriate and important to include in this book information on Ukrainian physicists, both those working in our country and those working outside it. Unfortunately without external help our chances of obtaining information of scientists in other countries are small because the only information to which we have access is that in the 'Ukrainian Encyclopaedia' edited by Prof. Kubyvych. We would therefore be most grateful if any scientists of Ukrainian origin could send to me any pertinent information, particularly that relating to the last 20-30 years, on their situation and their work. Any other suggestions you might have for material to be included in the Encyclopaedia would also be most welcome.

Please send any information to me at:
Institute of Physics, Academy of Sciences of the Ukrainian SSR, Prospect Nauki, 46, Kiev - 28, USSR 252 028.

Thank you in anticipation of your assistance.

Dr W Shenderovski

Stop the myth!

Dear Editor,

Please stop perpetuating the myth that there are only two secondary science teachers in NSW with degrees in physics (John Campbell's article 11/89, Phillip Kennedy's letter 3/90 and John Campbell's letter 5/90). While this myth may help funding arguments for tertiary physics departments it does nothing for the reputation of physics teachers in NSW.

Those of us who are well qualified in physics and love teaching at the secondary level work under enough difficulties without the AIP questioning our very existence.

Please put an end to the two physicist myth by publishing the number of secondary teachers in the public and private sectors with physics degrees.

I assume the AIP has this information? If not, it is high time you did some research to obtain it.

Mark S Butler PhD (Physics)
Senior Physics Teacher & Deputy Principal
Aust. International Independent School

Dear Editor,

Do you suppose that, having written his column for the Jan-Feb issue of the Australian Physicist, Professor Tony Klein removed his clothing and ran through the streets? We ask because the discovery he has made regarding the teaching of physics is at least as worthy of attention as that of Archimedes.

Yes, Physics teaching is a worthwhile occupation. Any number of secondary physics teachers of Professor Klein's acquaintance have, no doubt, already informed him of this fact. The role of the secondary physics teacher is just as vital to the enterprise of physics as the role of the post-doctoral researcher etc.

There is nothing "perhaps" about it!

Helen Ormiston Smith
School of Education
and Dorothy Kearney
School of Physical Sciences
La Trobe University

WANTED

Interesting transparencies or good colour photographs to be used for the Physicist front cover.

Please send submissions together with a descriptive caption to:

Production Manager
Australian Physicist
Impress Studios, PO Box 189
Jesmond NSW 2299

Australian Physicist Volume 27, Number 7, July 1990
1990 is a special year in New Zealand history. It represents the sesquicentennial of modern New Zealand which dates from the signing of the Treaty of Waitangi between the Maori and Pakeha. The NZIP National Conference is but one event that will be held to celebrate this and a number of other significant milestones in New Zealand’s development.

**Theme**

In keeping with the 1990 concept the theme of the Conference is “Physics: Working for New Zealand”.

**Session Topics**

The morning sessions of the conference are devoted to invited papers by distinguished physicists. At least two parallel sessions will run each afternoon. One or more session will be devoted to research in physics and will consist of keynote addresses, contributed papers and posters.

The second parallel session will be devoted to physics education and will consist of a range of physics education activities aimed specifically at establishing a resource base for teachers.

**Overseas Speakers**

**Professor Neil Ashcroft**

Department of Physics

Cornell University

*(Solid State Physics)*

Professor Ashcroft is well known for his work in the theory of condensed matter as well as for his teaching text on solid state physics. He is Chairman of the Condensed Matter section of the American Physical Society.

**Professor Paul Davies**

Professor of Theoretical Physics

University of Newcastle, England

*(The New Physics)*

P.C.W. Davies is internationally renowned for his work in particle physics and cosmology as well as for his remarkable list of textbooks popularising the new physics. Paul Davies is due to take up a chair in Theoretical Physics at the University of Adelaide this year.

**Palmerston North**

Founded on the banks of the Manawatu River to serve an agricultural community, Palmerston North is today the second largest inland city in New Zealand (population 63,000) and the principal junction in the North Island’s transport network.

**Registration**

Any member of the AIP who wishes to attend the Conference should contact, as soon as possible

Dr Rod Lambert
Department of Physics and Biophysics
Massey University
Palmerston North, New Zealand

preferably using

Email R.Lambert@massey.ac.nz or
Fax (0604) (63) 505 613 or
Phone (0604) (63) 69 099.

The registration fee is NZ$170 (~$125).

**Social Programme**

The Welcome Function on Sunday evening will be held at the University Staff Club between 6.00 pm-8.00 pm. Light refreshments will be served. The Conference Dinner on Tuesday will be held in the Student Centre Dining Room at 8.00 pm with pre-dinner drinks at 7.00 pm upstairs in the Kiwitea Lounge.

**Accommodation**

Accommodation is available in the Halls of Residence on campus and at the Coachman Motel.

**Student Halls of Residence**

NZ$38.70 per night (includes bed & breakfast). The full amount is payable with the Registration Form.

**Coachman Motel**

NZ$85.00 room/night, single/twin/double

A deposit of the first night’s accommodation is required to secure the reservation. Please complete the details on the Registration Form.>
Call For Papers

Research contributions (short talks or posters) are invited from physicists in their area of interest.

Abstracts should be submitted to:
Dr S Whineray
Dept of Physics & Biophysics
Massey University
Palmerston North
before 16 July 1990.

Poster and apparatus contributions are invited from secondary and tertiary teachers for the Physics Education sessions.

Abstracts should be submitted to:
Mr M C Bowling
CERTECH Learning Centre
Massey University
Palmerston North
before 16 July 1990.

TENTH AIP NATIONAL CONGRESS
Melbourne, 10-14 February 1992

On behalf of the Organising Committee, I am pleased to announce that planning for the next AIP National Congress is in progress. It will be hosted by the Victorian Branch and held at the University of Melbourne. Your support for, and contributions to, the congressional sessions are essential for its success. The Organising Committee has resolved the appointment of officers and will shortly be calling for assistance for Professor A.G. Klein who will chair the Program Committee. A comprehensive and exciting program will be released in the next few months.

Please note the dates.
Keep an eye out for the first circular.

Further enquiries to:
Dr J Liesegang, Chairperson, 10th
AIPC 1992 Organising Committee,
Department of Physics,
La Trobe University,
Bundoora Vic 3083
Tel (03) 479 2620/2622,
Fax (03) 471 0097.

ERRATUM

The Editorial Board apologises for the incorrect spelling of Dr Ray Haynes' name in the Of Interest section on page 117 of the June issue of the Physicist.

Science Foundation for Australia’s Future

Australia faces great challenges if it is to prosper. The Australian Academy of Science has committed itself to an expanded range of activities, involving the whole scientific community, to support this country’s response to the demands of a competitive, rapidly changing world.

Science and technology have made many contributions to Australia’s prosperity—new technologies for mineral exploration and processing, more productive agricultural plants and animals, the biological control of pests, and advanced techniques of chemical analysis among many others.

Australia now needs to strengthen old export industries and build new ones based on knowledge and skill, and find ways to maintain the natural heritage under pressure from growth. If Australia’s science remains world class it can contribute more to industry and to society.

Change Needed

However, Australia has yet to make many critical changes of direction. Participation in science education is seriously deficient and declining. The technological skills needed by much of the manufacturing sector are not being developed. The morale of scientific researchers is low and those who should be replacing them in the next decade are looking to better-paid occupations.

The emerging industrial economies to the north are demonstrating that a rapid expansion of scientific and technological capability is the key to change. Their aim is to match and surpass North America and Europe.

The Academy of Science believes that solutions to Australia’s economic, social and environmental problems will require a better integration of economic, social and environmental goals, based on research. This integration will require cooperation between all those able to assist.

New Foundation Created

To address these problems on behalf of all Australian scientists and the community, the Academy has created the Australian Foundation for Science. The Academy is seeking the support and collaboration of its Fellows, of other scientific and technological bodies, of industry and commerce, of charitable foundations and of the general community to tackle these problems with urgency.

The Academy already contributes in a number of ways to Australia’s development, by the publication of quality Australian school texts, by promoting public awareness of science and technology, by convening research conferences on specific problems, through the National Science and Industry Forum, by advising governments, by encouraging high achievement in science, and by representing Australia in international scientific organisations. The Academy wishes to strengthen these roles and to cooperate with other like-minded groups in the urgent tasks ahead.

The Academy has defined four priority programs of activity for the Australian Foundation for Science, encompassing more than 20 specific projects. The programs are:
1. Improving public awareness and education in science and technology
2. Science for industry, government and society
3. New horizons in science and technology
4. Regional and international cooperation in science.

The projects are summarised in a program summary available from the Academy in Canberra.

Need for Support from the Scientific Community

The Academy invites support for the Australian Foundation for Science, in terms of membership, ideas and projects, from all concerned about the direction of science in Australia. All gifts are fully tax deductible.

The Academy is particularly keen for support from the variety of scientific societies, research institutions and individuals around the country. The Academy’s links with societies and institutions extend beyond the personal links of Fellows who are also members of the societies and researchers in institutions. The Academy’s system of National Committees represents scientists in the various disciplines, helping to place their ideas and expectations on the national agenda. The effectiveness of these National Committees has long depended on the efforts of senior scientists who are not Fellows of the Academy.

Over recent weeks the Academy has organised special events for scientific societies around the country. These functions have been organised to explain the importance of the Australian Foundation for Science. We encourage the widest possible attendance at these events.

The effectiveness of the Academy, in its special roles of excellence, in
New White Light Scientific Laser

Anaheim, California . . . At the 10th Conference on Lasers and Electro-Optics (CLEO '90), Coherent, Inc., of Palo Alto, California, introduced a new product in the Innova 70 series of ion lasers. The Innova 70 'Spectrum' provides TEM$_{00}$ performance in the red, yellow, green, and blue regions - with hundreds of milliwatts of power in most lines - all from a single ion laser source. This capability is ideal for spectroscopy, confocal microscopy, optical storage research, and other applications where multiple wavelengths allow the researcher to quickly gather a significant amount of frequency-dependent data.

The Innova 70 series of compact, reliable, low-cost ion laser systems also includes argon and krypton versions providing up to 5.0 watts and 0.75 watts of visible power, respectively. Since its introduction in 1984, the Innova 70 has established an excellent reputation in the scientific, industrial, and OEM marketplaces in terms of reliability, productivity, performance and value.

Coherent manufactures a wide variety of lasers and laser systems for science, medicine, entertainment, and industry.

For more information please contact:
Norman Jones or Paul Wardill at Coherent Scientific Pty Ltd 138 Greenhill Road Unley SA 5061.
Ph (08) 271 4755
Fax (08) 271 1202

Fingertip Control for Gas Analysis

The QX2000 Quadruple Mass Spectrometer analyses the composition of process and residual gases - quickly and precisely. A single fingertip control lets you know immediately what gases are present in your vacuum chamber.

For ease of operation, the QX 2000 is menu driven via an integrated touch sensitive screen and uses a powerful computer (IBM AT compatible) with 640 kb RAM.

Any important data can also be stored on a 3 1/2" diskette drive floppy disk for recall and use at later time.

The QX ensures early detection of problems which could otherwise jeopardise the operational integrity or safety of a process, such as:

- air leaks,
- changes in the water content of the process atmosphere,
- contamination due to oil or solvents,
- outgassing of materials under vacuum.

Magnetic Bearing Turbo Pump

Designed to substantially improve pump life and virtually eliminate maintenance; bearing system consists of a combination of passive permanent magnetic bearings and one actively controlled bearing. Lubricant-free pump can be mounted in any position desired. Built-in power generator assures active bearing control even in case of complete power failure. Highly resistant to shock, hydrocarbon-free pump features maintenance-free, low vibration, and low noise level operation. Pump incorporates integral inert gas purge system.

Compact Turbomolecular Pumping System

Leybold Vacuum Products introduces its compact, flexible-configuration TOSS 50 turbomolecular pumping system. It is especially designed for hydrocarbon-free ultrahigh vacuum laboratory and instrumentation applications. The basic system consists of a 1.24 CFM Trivac rotary vane pump, 55 litre/s Turbovac turbomolecular pump for N$_2$ and a solid state converter mounted on a stand. Flexible vacuum capacity is 8 x 10$^{-7}$ mbar.

Vacuum Thin Film Research

The L560 is for all thin-film research and development, and features a minimal-volume box-coater type design, clean room compatibility, short pumping cycles, and high processing flexibility. Applications include electronics and optics. The system is available in three different versions: the manually operated L560, the automated L560, and the ultra-high vacuum L560 UV.

ULTRATEST UL 100 Helium Leak Detector

is a light-weight, versatile instrument for servicing and maintenance of process equipment, vacuum annealing, semiconductor production facilities.

A new vacuum gauge brochure details digital vacuum gauges and provides an overview of the gauges' modular design, which allows each gauge to be customised to specific vacuum requirements.

For further information on any of the above, please contact:

VICTORIA

Javac Pty Ltd
54 Rushdale Street
KNOXFIELD 3180
Ph: (03) 763 7633

NEW SOUTH WALES

Javac Pty Ltd
24 Fred Street
LILYFIELD 2040
Ph: (02) 818 1066

Of Interest continued

education, in public awareness, and in representing science to government, will increasingly depend on the success of the Foundation for Science. That is why Fellows have already made substantial contributions to it. Even more importantly, the Foundation will make possible a range of initiatives arising from the membership of the Foundation itself. A united and vigorous scientific community could demonstrate the leadership and resolve that the nation needs to reach its potential through science and technology.

David Craig
President
Australian Foundation for Science
Innova-300’s system CPU to continuously monitor the stability of the single longitudinal mode oscillating in the laser cavity.

The laser will not hop to a different longitudinal mode as long as the peak of the etalon transmission curve coincides with the laser oscillation frequency. ModeTrack detects any deviation between the frequency of the etalon transmission peak and the laser frequency. The error signal derived is used to correct the etalon temperature, thus locking the etalon transmission curve to the single longitudinal mode of the laser. ModeTrack works in conjunction with PowerTrack, the Innova 300’s actively stabilised optical cavity, which provides very rapid warm-up of the ion laser - within 1 minute, and sets new standards in long-term power stability - ±1% over an 8-hour period.

The Innova-300 itself is the first in a new generation of intelligent ion laser systems designed specifically to provide optimum performance and productivity in areas such as tunable (dye and titanium:sapphire) laser pumping, CPM laser pumping, Raman spectroscopy, holography, non-destructive testing, flow cytometry, laser semiconductor processing, and desktop manufacturing.

The Innova-300 is available in either an argon or krypton gas version, providing up to 8 watts of multi-line visible power and 300 milliwatts of multi-line UV power.

Coherent manufactures a wide variety of lasers and laser systems for science, medicine, entertainment, and industry.

For more information please contact:
Norman Jones or Paul Wardill at Coherent Scientific Pty Ltd
138 Greenhill Road
Unley SA 5061
Ph (08) 271 4755
Fax (08) 271 1202

New Single Frequency Ion Laser Performance Standards

Anaheim, California . . . At the 10th Conference on Lasers and Electro-Optics (CLEO '90), Coherent, Inc., of Palo Alto, California, introduced a new stabilisation feature, which eliminates mode-hops during single frequency operation, for the Innova-300 Ion Laser System. 'ModeTrack' utilises the...
Major Frederick Ronald Bond FAIP

Frederick (Fred) Ronald Bond was born on 23 January 1918 at Nottingham, U.K. He was educated at the King's School, Grantham where he became the Head of Newton House, named after Sir Isaac Newton, an old boy of the school. Fred was awarded a 'Revis' scholarship and a School Governor's Grant for University College, Nottingham. He studied at University College, Leicester and graduated as a B.Sc. (Special) External from the University of London in July 1940.

After graduation Fred was called up for military service and joined the Leicestershire Regiment as a Private. He advanced to Second Lieutenant in February 1941 until he was appointed Staff Captain (Scientific Research) to the Army Operational Research Group (AORG) and in 1945 was promoted to Major serving with the No.10 Operational Research Section (Burma). Following further service in AORG, Fred was commissioned into the Australian Army. His final army appointment as Major (Deputy Assistant Director of Scientific Research, Australian AORG) was finally terminated in 1956 through ill health which was to accompany him through the rest of his career.

Fred commenced employment with the Australian Public Service in December 1956 as a Temporary Base Grade Clerk in the then Department of Labour and National Service. His temporary employment continued and he was transferred, again temporarily, to the Antarctic Division of the Department of External Affairs to take effect from 2 January, 1958. On 6 January 1958, Fred signed the form acknowledging the Crimes Act and the witness signature was that of F Jacka. His appointment was as Physicist Grade 3 in the Upper Atmosphere Physics Group, working in the Science section in a house near the Hawthorne tram depot.

In 1964 he was a member of the summer party of the Australian National Antarctic Research Expedition (ANARE) to Wilkes, and on the return journey had the good fortune to be directly beneath part of a quiet rayed-bend aurora. In 1966 he was again a member of a summer party of an ANARE, this time to test a lens he had designed for the all-sky camera, which later formed part of an unmanned automatic geophysical observatory. In 1968 he became Head of the Upper Atmosphere Physics Section, which had observatories at Macquarie Island, Mawson, Davis and Casey.

In December 1974, Fred took out Australian citizenship. Three months later he obtained his long sought permanent appointment, after only 17 years of temporary employment. Fred was elected to the Fellowship of the AIP in February 1980.

When the Antarctic Division moved from Melbourne to Hobart, Fred reclassified as a Senior Research Scientist holding this position until his retirement in January 1983 when he became the first Honorary Research Associate of the Antarctic Division. While with the Antarctic Division, Major Bond published some 15 scientific papers of which he was the sole or principal author.

Fred was a prolific writer and his records in the Antarctic Division constitute a social history containing all sorts of fascinating non-Antarctic references such as a 1962 leave application to allow him to fight fires on his 6 acre Park Orchards property. Another is an application to be able to accompany his wife to work in her car, thus cutting the cost of public transport. This required approval to vary his hours of work by some 10 minutes. The application was rejected. He accepted that philosophically!

Those of us who were fortunate enough to know Fred will remember his concern for others. He devoted time outside his work to Rotary and as an advocate for aggrieved soldiers in dispute with government bureaucracies.

His insistence on cooperation with external research agencies in the early days enhanced Australia's Antarctic research program and the careers of the expeditioners he supervised. As an indication of Fred's sense of humour, he apparently recently inquired at the front desk of the Antarctic Division if there was any mail for him in the Physics Expeditioners Room. The astonished reply querying if Fred was a current expeditioner appealed to him greatly.

Fred Bond was a very conscientious man, painstakingly correct as a scientist and writer and in dealings with his fellows. His health was a continuing source of concern to those of us who were close to him, but he accepted his problems in a way that was both a credit to him and an example to those around him. We deeply regret his passing.

Dr M. L. O'Donoug
Associate Editor
Reviews

Does God Play Dice? The Mathematics of Chaos
Ian Stewart
v + 317 pp, A$39.95 (hardcover)

This book is recommended reading for any physicist (for that matter, for any scientist or mathematician) who wants to find out about the field of nonlinear dynamics and chaos.

"Does God Play Dice" is aimed at a general audience, and makes for easier reading than Hawking's "Brief History of Time". That's not to say it makes for easy reading for a non-scientist. There are a few formulae, but nothing that should worry physicists.

The book can broadly be divided into three parts: Chapters 1-4 History, Chapter 5-10 Mathematics, Chapters 11-14 Applications. A multitude of topics are discussed, including fractals, chaotic weather patterns, chaos in the solar system, diffusion-limited aggregation, period-doubling, K.A.M. tori, strange attractors, Smale's horseshoe, sensitive dependence on initial conditions, the Bologna-Zhabotinskii reaction, renormalisation. You name it, it's there. This makes it a fairly condensed book, perhaps not very suitable for a reading in one sitting, but quite useful to dip into from time to time.

Let me end with a few loose remarks. One ingredient I found interesting is Stewart's discussion of statistics versus Newtonian predictability as a historical precursor of the paradigm of chaos.

On the subject of the sensitivity of a chaotic trajectory to initial conditions, the author rightly claims that the measurement of such a trajectory is in principle an unrepeatable experiment (though the measurement of a strange attractor is not). I would add to this that the fundamental equations of physics were of course never based on such infinitely accurate measurements.

The famous mathematician Poincaré foresaw many of the modern developments in nonlinear science. But who knows where the theory and applications of chaos may lead us in future?

Reinout Quispel
Mathematics Department
La Trobe University

The Aharonov-Bohm Effect
M.Peshkin & A. Tonomura
Springer-Verlag, Heidelberg, 1989 (Lecture Notes in Physics: No.340)
vi + 122 pp, DM39 (hardcover)

This slender volume appears 30 years after the seminal paper of Y. Aharonov and A. Bohm (AB). In that paper it was shown, as a straightforward consequence of the well-established Schrödinger equation, that the motion of charged particles which had at no stage encountered an electric or magnetic field, could be modified by the presence of a vector or scalar potential.

This conclusion surprised the physics community on several grounds. Firstly, the conclusion had no precedent in classical mechanics, where the fields alone, electric and magnetic, could affect the motion. Secondly, the gauge dependent scalar and vector potentials had to be accorded some new type of physical reality, and that they were not simply mathematical devices for solving the homogeneous Maxwell's equations.

In a typical AB experiment, a charged beam is coherently split into two beams, which pass around opposite sides of a tube of magnetic flux and recombine downstream on a screen. At no stage are the various beams allowed to enter a magnetic field region in such experiments. The interference pattern on the screen is dependent on the vector potential of the magnetic flux.

This third surprising conclusion emphasized the importance of topology in quantum physics.

This present volume is in two halves. In the first half, Murray Peshkin gives a clear, well-illustrated, well-referenced account of the theory of the electric and magnetic AB effect, and fills in many of the details of the actual diffracting situations. In the second half, Akira Tonomura gives a well-referenced account of some other aspects of the theory, and reports on all the experiments, including his own extremely elegant work with electron holography. Tonomura's theory includes a discussion of topology (fibre bundles), flux quantisation, and the putative magnetic monopole.

This book is also timely, for the Aharonov-Bohm effect was until recently a theoretical curiosity. It is now a matter of practical consequence (Mr Dawsins please note), being central to our understanding of high and low temperature superconductors, anyons, and the behaviour of mesoscopic electronics.

The book is a delight and is highly recommended to all physicists, especially students of quantum mechanics, and those working on the foundations of physics.

Geoffrey I. Opat
School of Physics
University of Melbourne

Ultrasound Measurements for Process Control
L.C. Lyneworth
Academic Press, San Diego, 1989 xix + 694pp. US$84.50 (hardcover)

This book sets out to examine the theory, techniques and applications of ultrasound with respect to the control of industrial processes, but, rather than a textbook, it is a compendium of devices, methods, data lists, short cuts, guide lines, lists of references and sources and just generally useful advice. Compiled by Lawrence Lyneworth, who is well known to the ultrasonics community for his extensive work using ultrasound, particularly in flowmetry, it represents the accumulation of many years of hands-on practical experience. As such its usefulness is not confined to industrial processes but, in fact extends well into just about any endeavour or problem to which an ultrasonic approach may be the solution.

The author has recognised that many potential users of ultrasonic techniques come to the area with little or no experience. Thus, he begins his book with a chapter to help the beginner decide whether or not ultrasonic methods are appropriate to his problem. This includes reference to the "emotional factors" involved in choosing an ultrasonic solution since "the purchaser wants to feel comfortable with the selection." The author seeks "to remove the mystery shrouding some types of ultrasonic technology, so that, through understanding, fear of the unknown can be conquered."

The second chapter is presented as a short version of the book, covering the range and practicality of ultrasonic systems and the third chapter, on Theory and Measurement Techniques, introduces the necessary theoretical understanding of waves and devices, using a minimum number of equations.
BOOK REVIEWS

Most attention is given to the nickel-based alloys and deals with processing, fatigue, creep, corrosion and the prediction of lifetime. Two chapters talk of dislocation mechanisms but for the most part the treatment is more empirical than fundamental.

The composites are tungsten wire in superalloy, carbon fibre in carbon and mixed ceramics. The ceramics are based on Si, N, SiC, ZrO and Al₂O₃. Less than 20% of the book is devoted to this section.

J D Browne
Department of Mechanical Engineering
University of Newcastle

Radiation Protection for Medical and Allied Health Personnel
NCRP Report No. 105
National Council on Radiation Protection and Measurements
Bethesda, 1989
xi + 129pp, US$15 (paperback)

The NCRP has been busy in 1989! Up to the publication of this report in October, there have been six reports in one year. This makes it, to my calculations, their second busiest year. This particular report is "aimed particularly at those individuals with limited training or experience in radiation matters". It covers all of the common and not-so-common areas in hospitals where radioactive materials or ionising radiation are used. There is some initial information at the beginning of the report on biological effects, principles of radiation protection and management of a radiation safety program. The rest of the report covers each of the specialty areas and the particular hazards, protective measures and necessary training appropriate to that area.

The report draws heavily on previous NCRP publications, referring to 31 of these. The background information is at a very basic level, and the guidelines for specific personnel are reasonable.

In what appears to be an afterthought, there is an appendix covering (in three and a half pages!) non-ionising radiation hazards.

This is not really a useful report for radiation safety professionals, but could be used as a source document for those who are preparing radiation safety procedures for medical or allied health personnel, or for those who are teaching in some of the specialties such as radiography and nuclear medicine technology.

Lee Collins
Department of Medical Physics
The Parramatta Hospitals

Quantum Theory and the Schism in Physics
Karl R. Popper
Unwin Hyman, London, 1990
xviii + 230pp, $34.95 (paperback)

The material of this book consists of work prepared by Popper many years ago, and published here under the editorship of W.W. Bartley III. Popper's central thesis is that nature has the ability to bring forth genuinely new physical qualities. The physical universe does not, he maintains, consist merely of a succession of states, but of the actualisation of potentialities. Thus objective physical change is taken seriously, in contradiction to the old adage that "nothing can come out of nothing".

Popper here directs his thesis towards the conceptual foundations of quantum mechanics, with its notorious constellation of puzzles and paradoxes associated with the act of observation. While many physicists are inclined to reject realism in the quantum realm, Popper defends it staunchly, to the extent of constructing an entire cosmology upon it. His opinions on quantum mechanics cut across the various traditional interpretations, and may even change the reader. Nevertheless, Popper's ideas should never be dismissed lightly, and this book provides an interesting commentary on one of the most challenging philosophical topics in contemporary physical theory.

P.C.W. Davies
Department of Physics and Mathematical Physics
The University of Adelaide

A History of the Photographic Lens
R. Kingslake
Academic Press, San Diego, 1989
xi + 344pp, US$29.95 (hardcover)

Rudolf Kingslake was the head of lens design at Eastman Kodak and also a professor of the Institute of Optics of the University of Rochester. He is a leading authority on camera lenses and the ideal person to write its history. In this book he organises the many different types of camera lenses into logical classes and describes the development of each class in a clear and interesting way. For each design the various names used by different manufacturers are given, enabling a reader to identify his own lens. (The era when camera owners knew their lens type may be past; it was true that when they were made in Europe rather than in Japan.) The last third of the book is an excellent survey of the development of the photographic camera itself.
book consists of short biographies of past lens designers.

The book is clear and well written and will be of general interest as a history of camera lenses and optical design to a wide class of readers. For designers themselves, although the methods of lens and instrument design have been covered in the author's earlier books, "Lens Design Fundamentals" and "Optical System Design", there is still much of interest here: an expert's explanation of why different designs are used, the large number of examples given, with references, and valuable gems of information scattered throughout. For the physicist in general, this book explains what is inside their camera and makes clear why lens systems are so complex. The biographies read like a catalogue of camera names and provide a history in themselves of the development of optical instruments.

W. H. Steel
School of Mathematics, Physics, Computing and Electronics
Macquarie University

John Wiley, Chichester, 1989
xvi + 359pp, £25.00 (paperback)

A History of the Photographic Lens R. Kingslake
Academic Press, San Diego, 1989
xi + 334 pp, US$29.95 (hardcover)

Superionic Solids and Solid Electrolytes
A. Laskar and S. Chandra (Eds)
Academic Press, San Diego, 1989
xvi + 711 pp, US$85.00 (hardcover)

Ultrasonic Measurements for Process Control
L.C. Lynworth
Academic Press, San Diego, 1989
xix + 694 pp, US$84.50 (hardcover)

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D.R. Uhlmann and N.J. Kreidl (Eds)
Academic Press, San Diego, 1990
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US$115.00 (hardcover)

Glass Science and Technology Vol 4B - Advances in Structural Analysis
D.R. Uhlmann and N.J. Kreidl (Eds)
Academic Press, San Diego, 1990
xx + 385 pp, US$115.00 (hardcover)

Resonant Heterogeneous Processes in a Laser Field
V. Kravchenko, A. Orlov, Y. Petrov and A. Prokhorov
Nova Science, New York, 1989
viii + 233 pp, US$56.00 (hardcover)

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H. P. Myers
Taylor & Francis, London, 1990
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N.A. Doughty
Addison-Wesley, Sydney, 1990
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X-Ray Lasers
R.C. Elton
Academic Press, San Diego, 1990
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Space Groups for Solid State Scientists, Second Edition
G. Burns and A.M. Glazer
Academic Press, San Diego, 1990
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Nonlinear Ordinary Differential Equations
R. Grimshaw
viii +328pp. A$47.95 (paperback)

Electrostatic Atomization
D. Michelson
Adam Hilger, Bristol, 1990
x+155pp. £30.00 (hardcover)

AIP NEWS continued from page 146 should be drawn up (following the lead shown by the astronomers).

After the presentations of the three panel members, the meeting was opened for general discussion. The question was raised whether the problems of Australian physics were found in other countries. Prof Smith suggested that they were also present in the UK and the USA but not in continental Europe. Other issues raised were that graduates who would have made good physics teachers in the past were now working as computer programmers and that the public image of physics, which had been allowed to narrow over the last few decades, should be broadened.

The outcome of the Forum seemed to be a consensus that the Report had confronted us with the delicate task of acknowledging a decline in Australian physics while pointing out the Report's flaws. Prof Klein said he would argue at the Canberra meeting that research in basic physics has declined as we have been forced into fringe areas, but that quality has been maintained. Increased financial support is urgently needed and the greatest danger lies in the argument that the solution to the problem is to reduce the number of researchers.

R A O'Sullivan
Convener
Science Policy Committee

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## CONFERENCES & MEETINGS

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<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Event Description</th>
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<tr>
<td>1990</td>
<td>Aug 2-8</td>
<td>25th International Conference on High Energy Physics, Singapore. Professor K.K Phua, Department of Physics, National University of Singapore. Kent Ridge, Singapore 0511 Rep of Singapore, Tel 2716311, Fax 2716971, TX 28561 Bmnet PHYCONF@NUSVM</td>
</tr>
<tr>
<td>Aug 12-16</td>
<td>International Conference on Optics for the Life Sciences, Munster. G. von Bally, University of Munster D-4400, Munster, Fed. Rep. Germany</td>
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<tr>
<td>Aug 13-17</td>
<td>4th Asia Pacific Physics Conference, Seoul Korea. Dept of Physics, Yonsei University, Seoul 120-740 Korea, Fax 52-2-392-1592</td>
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<tr>
<td>Aug 27 - 29</td>
<td>New Zealand Institute of Physics National Conference, Palmerston North, N.Z. Prof P.T. Callaghan, Department of Physics &amp; Biophysics, Massey University Palmerston North, New Zealand, Tel: (063) 69 099, Fax: (063) 505 613.</td>
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<tr>
<td>Sept 24-28</td>
<td>Joint Conference of Australian Radiation Protection Society and Australian College of Physical Scientists and Engineers in Medicine, Adelaide. SAPMEA, GPO Box 498, Adelaide, 5001.</td>
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<tr>
<td>Oct 8-12</td>
<td>5th Australian Remote Sensing Conference, Perth. Dr Norm Cambell, CSIRO Division of Mathematics &amp; Statistics, Floreat, WA.</td>
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<tr>
<td>Oct 16-18</td>
<td>Communications '90. Electronic Communications in the 1990s. Conference Manager, IE Aust, tel (062) 70 6549.</td>
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<tr>
<td>Dec 2-6</td>
<td>OPS-7/ACOFT-15 1990 - Conference on Optical Fibre Technology, Sydney Convention and Exhibition Centre- Darling Harbour. Cherie Morris, Convention Administrator Fax +61 2 362 3229</td>
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<tr>
<td>Dec 4-7</td>
<td>Fourth International Symposium on Neutron Capture Therapy for Cancer, Sydney. B.J. Allen, Nuclear Applications, ANSTO, PMB 1, Menai, NSW 2234 Tel: (02) 543 3426, Fax: (02) 543 9262.</td>
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<tr>
<td>Dec 27-31</td>
<td>International Conference on Teaching Physics - &quot;Changing Face of Physics Education in Developing Countries&quot;, Karachi. S.A. Hasnain, Department of Physics, University of Karachi, Pakistan.</td>
<td></td>
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<tr>
<td>Feb 10-15</td>
<td>Polymer 91, IUPAC International Symposium on Polymer Materials, Melbourne. Polyomers 91, PO Box 224, Belmont VIC 3216.</td>
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