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THE OLD PRESIDENT'S LAST COLUMN

The 28th Annual General Meeting of the A.I.P. was held in Melbourne on the 14th of March 1991. It was with a great sense of relief that I saw Professor Tony Thomas elected President, so that I could hand over the affairs of the Institute with confidence, exactly two years to the day after the 26th meeting at which I was elected.

I would like to thank my colleagues on the Executive; Dr John Riley, Hon. Sec; Dr Robert Leckey, Hon. Registrar and Dr Robert Fleming, Hon Treasurer, as well as Professor Tony Thomas, as Vice-President, for the excellent job that they have done and for the unstinting support that they have given me. I predict that the new Executive, with Tony Thomas as President and Prof. Bob Crompton as Vice-President, will give outstanding leadership - they have all shown their willingness to work effectively for the good of the profession and I wish them well.

As for me, it was a great honour and privilege to have served the profession and I thank you all for your trust. However, just for the moment, I still have one last President's Column to write!

I must admit that while I don't actually enjoy writing these Columns, I do enjoy having written them. Thank you to all the people who bothered to write or call or tell me in person that they liked reading them.

I am sure that future historians of Australian science will find that we have lived through truly turbulent times, which began some years ago with great upheavals in the CSIRO and other Government Laboratories. The contagion then spread to Academia where sweeping reforms have changed the face of tertiary education. Secondary education was not far behind and even the somnolent sector of science in industry has begun to feel a bit of the breeze which may yet herald change.

Hence, there was never a shortage of things about which to grizzle or lament or, on a few occasions, to have a more or less intemperate bash. In fact, it was starting to get a bit predictable: Here comes the second Friday of the month, rev up the old semantic chainsaw and rip into the economic rationalists, or the shonky scientists, or the financial entrepreneurs, or even the ARC on one occasion. It was fun!

But there seems to be one class of politician whom I have not yet taken to task - not in public, anyway, - and that is Vice Chancellors and College Principals (are there any left?). I hasten to except the enlightened ones, the ones who recognise the vital role of a healthy physics department in a University worthy of the name. But I do mean to have one last go at the petty-minded politico-bureaucrats who are prepared to sell out academic values for the proverbial mess of dotage and thereby drag perfectly good institutions down to the level of fourth-rate business colleges.

Surely you are joking, I hear you say. Surely no Vice Chancellor would set out to be like that! Well, I could (but I won't) name several of them who are, or were, in the process of completely wrecking quite adequate physics departments and condemning them to a morass of mediocrity. How? Either by applying totally inappropriate management methods, or by rushing headlong to comply with misguided government measures or simply by having values which belong more to Paddy's market than to Plato's academy.

By not having a clear sense of mission, and by not recognising that Universities cannot be run like simple business operations, in which less...

What about that time in 1990 when you wrote rude things about Don Aitkin?
WHY DO RESEARCH?

I spent several days at a conference in Canberra on the interaction between Science and Government. I hope a review of the conference will be presented in the Australian and New Zealand Physicist in the near future. The conference, organised by the Royal Australian Institute for Public Administration served to remind us of three things - firstly, there have been over twenty reports on the state of science and on the development of policy in respect of science in Australia in the last decade; secondly, there is a new series of reports under way beginning with the issues and options paper from AZTEC and culminating in a White Paper in mid-1992. We have further guaranteed an industry in conference organising and survey generating by calling for a White Paper every four years subsequent to the first. Thirdly and finally, the future of public administrators in science policy generation seems assured.

The conference itself, however, contained a comforting number of scientists as arbiters on science policy development. But does the organisation of such a conference by RAIPSA signify a take-over? The conference was conventional. A mixture of good and not-so-good papers, statistics new and revisited, and acknowledgment that Australian industry does not perform well in the research game but a failure to address a solution to the problem. The importance of the current AZTEC exercise as a first step in development of a science policy on a four year rolling cycle was stressed. This may become an important parameter in Australian science, particularly as it seeks to define not only policy, but also ultimately areas of concentration and mechanisms for implementing the policy in those areas.

This conference, like so many others, failed to ask and answer the major question which should underwrite every science policy statement. This question is a simple one: ‘Why should Australia invest in scientific research at all?’ The answer is very complex. The best answer I have heard came from Professor Max Brennan, Chair of the ARC and himself a University researcher (and hence supported by the public purse) for many years. I hope Professor Brennan will allow me to give him credit for the content of the answer, but also allow me to paraphrase it.

If one says that Australia should engage in scientific research for the returns it gives in the form of new technology to apply to existing industry or new developments to spawn new industry, then there is little financial incentive to do the existing research and little reason to fund new research or indeed to enhance existing funding. Australian industry in general does not do research beyond the short term problem-solving. This is not true of the big Australian companies (BHP, CRA, etc.), but the large international firms on the whole do their major research outside Australia - their Australian branches presumably pay royalties or licence fees on those developments.

Australia contributes about 2% of the total knowledge of research, in the form of published work. It must be remembered that 2% is across the whole spectrum of scientific endeavour. It is not concentrated into areas delineated by our industries. Neither should it be. Professor Brennan’s main reason for doing research is not the publication of the results and hence our 2% contribution. We should do research because of the ticket which that activity provides to laboratories and research centres all over the world. Publications are probably two years out of date in describing the activities at the forefront of research. One must have contacts and the confidence of fellow researchers in order to be able to visit the overseas centres of activity and be invited to discuss the work at the bench-top (or accelerator, or vacuum system, etc.) - these come from being active in research. From those contacts one can better identify the useful...

President’s Column continued profitable or less glamorous sections are eliminated, simple-minded financial formula-plugers masquerading as senior academics can wreak untold havoc in a very short time.

We all know that it takes many years to build up an enterprise as fragile as a good academic department, i.e. a harmonious collection of research groups whose continuous, secure financial base leaves its members the time and energy to devote to creative endeavours and enlightened teaching.

And yet, we have all recently read agonising letters in the daily press from distraught scientists, some from erstwhile leading universities, lamenting the parlous state of their departments. In my time as President of the A.I.P. I have, on more than one occasion, listened to colleagues in distress. They were faced with quite unreasonable material constraints and sought help from the A.I.P.

What could be done to prevent such things as the forced closure of undergraduate teaching laboratories or the abandonment of perfectly healthy research programmes, all because of a temporary down-turn in student enrolments? A few discreet phone calls and confidential letters appear to have done some good in one or two cases, but in others the situation was hopeless. In those cases, my advice was to wait for the impending nationwide shortage of physics staff and leave the sinking rats at the earliest opportunity.

The final outcome is totally predictable. We will soon see an unprecedented stratification of Australian Universities, much more pronounced than in the bad old days of the binary (i.e. University/C.A.E.) divide. Soon the bad ones will get so much worse that their misguided chiefs will end up presiding over broken-down trade schools. To predict which ones, just keep an eye on their physics departments!

Meanwhile, the good physics departments will continue to get better still, and their Universities will go up in quality with them. How do I know? It’s easy, really. Have you noticed that our tertiary system is getting more and more like the North American one? Do you know of any good U.S. Universities with poor physics departments? Does your Vice-Chancellor know of any?

Thank you all, and best wishes.

Tony Klein

Continued on page 67
SUBMISSION FROM THE AUSTRALIAN INSTITUTE OF PHYSICS TO THE ASTEC ISSUES AND OPTIONS PAPER ON RESEARCH DIRECTIONS FOR AUSTRALIA’S FUTURE

The Australian Institute of Physics (AIP) is deeply concerned with Research Directions for Australia’s Future. Physics, as the most fundamental of the natural sciences, underpins research and development in chemistry, in the life sciences and in all branches of engineering. Devices such as semiconductors and lasers, which are now routinely used in technology, as well as techniques such as magnetic resonance imaging (MRI) and positron emission tomography (PET) were either invented by physicists or are based on discoveries made by physicists only a few decades ago. Furthermore, research in physics plays a fundamental role in defining and clarifying the nature of our universe and our place in it. Research in physics is continuing to affect radically our ideas about the origin of the universe and the ultimate structure of matter.

Australia can hardly maintain its status as a developed country, either technically or culturally, without a vigorous and well-supported programme of research in physics. Australian physics researchers have not only been responsible for some of the major advances in physics; they also provide an essential link with the latest developments in physics throughout the rest of the world.

The AIP was therefore concerned at the decline in physics research reported in the ASTEC report Profiles of Australian Science. There are inaccuracies in the bibliometric data presented in that report, particularly due to the fact that many of the research papers published by Australian physicists appear in journals which were not classified under the category of physics, but rather as materials science, atmospheric and space science, generic techniques and others.

Nevertheless, the AIP agrees that there are problems with the state of physics research in Australia today, springing to a large extent from a decline in funding in various areas. The AIP has responded to this situation by supporting the development of a National Strategy Plan for Physics in Australia. The development of the Strategy Plan was suggested by the Australian Research Council (ARC) and responsibility for it has been accepted by the National Committee for Physics of the Australian Academy of Science. The Strategy Plan is being prepared by a steering committee, which is presently inviting submissions from groups representing sub-disciplines of physics and consulting widely with those who carry out and use research in physics. The draft Strategy Plan will be presented to a national meeting of physicists around the end of 1991 and the final version will be submitted in 1992.

Given that the development of the Strategy Plan is under way, it would be premature for the AIP to present detailed recommendations on future research directions in physics at this stage. Instead, the AIP requests AZTEC to take into account in preparing its Issue and options Paper that the physics community is involved in developing a Strategy Plan for the discipline and to recommend that the Plan receive a serious response when it is completed.

In addition to the above general comments, the AIP would like to make three specific points at this stage:

1. It has already become clear in discussions on the Strategy Plan that the future of physics (and the other natural sciences) is being jeopardised by the inadequacy of support for the teaching of physics in schools.
2. The increased emphasis on short-term returns from scientific research in recent years tends to undermine support for research in physics. The time lag between new discoveries in physics and the practical application has perhaps become less in recent decades, but it is nevertheless longer than in most other areas of science and technology, for the reasons given in the introductory paragraph.
3. In responding to this call for submissions, the AIP wishes to express its concern that several positive recommendations of previous reports have not yet been implemented, for example, those contained in the report Small Country - Big Science.

Finally, the AIP would like to be kept informed of the progress of the Issues and Options Paper and to have a further opportunity to contribute to the policy-making process when the Physics Strategy Plan has been developed further.

DR. R.A. O'Sullivan
On behalf of the Australian Institute of Physics.
NZIP Submission to Ministerial Science Task Group on Crown Research Institutes

Background

Following the process of Science reform started with the setting up of the Ministry of Research Science & Technology (MoRST) and the Foundation for Research Science and Technology (FRST), the N.Z. Government has decided to establish Crown Research Institutes (CRIs) to replace its existing government science agencies, the Department of Scientific and Industrial Research (DSIR), Ministry of Agriculture and Fisheries Technology (MAFTech) the Forest Research Institute (FRI), the Meteorological Services and other government agencies involved in scientific research.

The stated purpose of every CRI is "to establish research capabilities, carry out scientific and technological research and provide related services". The principles of operation of the new CRIs are to:

- Undertake research and provide services for the benefit of New Zealand
- Pursue excellence in all their activities
- Promote the application of research results and technology developments
- Operate in a responsible manner in order to generate sufficient operating funds to maintain continuing financial viability
- Act as a good employer
- Operate as an organisation that exhibits a sense of social responsibility by having regard to the interests of the community in which it operates and by endeavoring to accommodate or encourage these when able to do so.

A Ministerial Science Task Group has been constituted under the chairmanship of the Hon. Simon Upton, Minister of Research Science and Technology, to advise the Government on the implementation of its policy to establish CRIs. A major function of the Task Group’s brief is to consult with “science teams, science managers and technology transfer people as well as science and technology users and funders.” The Task Group has a budget of NZ$409,000 plus GST for the period December 1990 to 30 June 1991. It is required to draft legislation for introduction to the House of Representatives by 31 March 91 and make its final report on the number, size and specific roles of CRIs to Cabinet by 30 June 1991.

The Royal Society of New Zealand held a meeting of the representatives of its affiliated scientific societies on 29 October 1990. This meeting agreed to form a council representative of the affiliated societies of the Royal Society with the following objectives:

- To provide an independent voice on relevant issues to both Government and the people of New Zealand on behalf of the scientific community
- To engage in science policy development and lobbying
- To give a rapid response on technical and scientific matters where advice is sought

Twelve people were nominated as members of the new Council. Amongst those nominated were Professor Bruce Liley FNZIP, University of Waikato, and Dr Bob O’Driscoll MNZIP of Massey University. At the Annual Meeting of the Fellows and Members Bodies of the Royal Society on 19/20 November 1990 the above proposal was endorsed and the Federation of Scientific and Technological Societies (FOSTS) was established.

In late January 1991, a discussion paper on CRIs prepared by the Ministerial Science Task Group was distributed through the FOSTS Council to NZIP as one of its affiliated societies. This discussion paper invited the societies to make written submissions, within a maximum of 2000 words and a deadline of 25 February 1991, setting out their views on:

- The specific roles for, size and number of CRIs
- Specific operational matters pertaining to CRIs or individual CRIs
- Any proposals you may have for amalgamation of existing work units or teams against a description of the purpose, mission and strategic directions of a CRI in which you propose these merged groups may reside
- Relationships between CRIs and the tertiary education sector, research associations etc and industry.

The following submission was communicated to the Ministerial Science Task Group by NZIP president, Professor Dan Walls, on 25 February. It was primarily drafted by John Clare, Esther Haines, Bill Allan and Peter Gilbert (Wellington), with advice contributed from Keith Lassey and Roger Sparks (INS), Howard Larsen (Met Service), Wes Sandle (Otago) and Dan Walls (Auckland). The process of consultation was hampered by the tight time schedule for submission, and the above are thanked for their untiring efforts.
Organisational Basis for Crown Research Institutes

Communicated by Professor D F Walls, President NZIP

Executive Summary

Keeping physical and mathematical scientists together in an institution will produce greater success in the application of the physical sciences to New Zealand problems than will be obtained if physical and mathematical scientists are dispersed amongst sector-oriented CRIs. Such a discipline based organisation facilitates cross-fertilisation and allows a greater depth of expertise. It has greater flexibility in staff deployment and its wider client base makes it less vulnerable to adversity in any one market sector. An organisation that incorporates the former Physics and Engineering Laboratory, Institute of Nuclear Sciences, Applied Mathematics Division and Division of Information Technology of the DSIR largely intact would retain and be able to use the goodwill associated with their international reputations.

The successful application of the physical sciences to New Zealand problems and to the development of New Zealand is of great importance to the New Zealand Institute of Physics. We believe that the correct organisational structure is crucial to this aim. In particular we submit that scientific and technical success will be greatly assisted by keeping physical and mathematical scientists together in one institute rather than dispersing them through a number of output-sector oriented institutions. The following considerations lead to this conclusion.

1. Innovative and successful application of a science is greatly stimulated by interchange of ideas amongst specialists in that particular field. Physicists and mathematicians share a common culture even though they may spend their working lives on quite different problems. For example, engineering seismologists, radar specialists measuring sea surface conditions or properties of the upper atmosphere, scientists processing acoustic signals or deblurring images all base their work on the same mathematically formulated discipline of signal processing. If these specialists are in the same organisation they can routinely contribute to one another’s work. A “critical mass” of scientists can be achieved in that field even though there are only small numbers working on each application. Separated into different organisations according to the application of their subject, there would be little cross-fertilisation between those specialists and no chance for a centre of excellence to develop.

2. Paradoxically, the keeping together of people trained in one discipline but working in different output areas can stimulate interdisciplinary research by facilitating communication between people working in different output areas. This is enhanced by the fact that a physical science based institution will have to maintain contact with and service clients in a wide range of output sectors to stay in business.

3. An institute has greater flexibility and hence greater economic viability if it has specialists working in a variety of output areas. When research in one area is completed or no longer important, or when one market sector cannot afford research, then the institute can use the existing skills of these specialists in other sectors. To take the previous example, if the use of radar observations to measure sea surface conditions is no longer funded the CRI has the flexibility to contract for research using these people in engineering seismology or image deblurring to other application of signal processing. If however, they were the only signal processing experts working in a marine sector based CRI such flexibility is not possible: they would be redundant. The rigidity of a CRI structure focused only on output areas could severely disrupt careers and the consequent insecurity would adversely affect morale and scientific output.

4. There are advantages with major experimental facilities in locating most physicists in one institute. Such items as particle accelerators, electron microscopes, magnetic resonance spectrometers, etc. may be needed from time to time in the work of many sector-based CRIs but not often enough to justify the expenditure. A physical sciences CRI working across output areas may well have enough application to justify investing in both the cost of purchasing such instruments and the cost of developing expertise in their use.

5. Dispersal of physical scientists amongst sector-oriented institutes can lead to an attitude in which they are regarded as technicians or technologists assisting other scientists in their research. Once this attitude is prevalent the opportunity for physicists as research leaders are diminished. Physicists in medicine are only too aware of this attitude. The problem with this attitude is that really able physicists will not be recruited into or retained long in such a culture. Opportunities will be missed and innovative approaches will not be conceived or developed. Such losses are not quantifiable.

6. The present DSIR Physical Sciences Division could well form the nucleus of a physical sciences CRI. The old Physics and Engineering Laboratory, Institute of Nuclear Sciences, Applied Mathematics Division, and Division of Information Technology are all internationally recognised for their expertise, and competence in their areas. This recognition is a form of goodwill which has...
substantial value to New Zealand. As visitors from a laboratory known for its expertise, staff of the organisations are accepted into discussions because it is known that they have something to offer in return. In other words this recognition facilitates transfer of technical information to New Zealand by opening doors overseas that would remain closed to scientists from unknown institutions. This goodwill should not lightly be thrown away by restructuring these groups into an unrecognisable organisation.

Career Structures for Scientists in Crown Research Institutes

Communicated by Professor D F Walls, President NZIP

Executive Summary

Prerequisites for the success of a CRI are the development of appropriate career structures, institutional culture and working environment. Essential elements of these include continuity of employment and of research in a specific field, few restrictions on the free interchange of information, and a career path for scientists based on achievement and reputation in research. A CRI having a monopoly on the employment of specialists in a field has special responsibilities as a fair employer.

To be successful a CRI must have a high level of scientific capability, the prime requirement for which is a professional staff of high calibre. To recruit and retain this staff the CRI must create an institutional culture and career prospects which will attract such people and allow them to achieve the work satisfaction that is so important to scientists. The following are essential features of the work environment.

Openness

There should be as few disincentives to the free exchange of information as possible. Much progress in science depends on cooperation, interaction and the exchange of ideas and information. Contestability regimes which operate against this openness may supply easy or routine science more cheaply but they will make the solution of the harder problems much more difficult.

Fairness of Employment

Consideration of the position of certain classes of specialist professionals adds a new component to the "fair employer" requirement. In general, to be successful scientists must specialise. This often limits them in New Zealand to just one employer, apart perhaps from the universities who however recruit very few senior scientists. In this respect most scientists are very differently placed from other professionals such as accountants, lawyers, doctors and medical consultants, architects, etc, who can look to a large number of employers in New Zealand for positions or create a viable practice on their own. This monopoly position as employer puts the CRIs in a powerful position. The power must be exercised with great care; its misuse or abuse would be damaging if it made professional science unattractive as a career. Students contemplating a research career seek the advice of working scientists in their chosen field; disillusionment with career prospects might not cause a large or rapid loss of practising scientists but it would result in their killing the recruitment of the next generation.

Career Paths for Specialists

Few people enter a profession that does not offer reasonable career expectations to those who develop
their experience and knowledge. As outlined above, for scientists this career may well be limited to one employer in New Zealand. There should be a career path apparent to scientists in CRI's with a progression in salary, responsibility and autonomy as their experience and versatility increases. In addition to paths based on progression through an administrative hierarchy there needs to be a career path along which scientists can progress as their reputation, achievement and value to the CRI develops whilst still putting most of their effort into scientific or technical work rather than into administration.

In as much as their training, attributes and work are similar to that of university staff in science departments, a CRI should consider similarity with universities in setting career progression and reward structures.

Reasonable Accountability Procedures

The accountability of CRI's to FoRST and other funding sources must be done in such a way that it is scientifically and financially meaningful and does not impose an unreasonable overhead on the research or provision of scientific services. At the moment accountability procedures consume a significant fraction of scientist's working time and yet are widely perceived as failing to give a true picture of progress of diligence.

Part-time Employment

Women in any profession have a problem maintaining their skills over the years in which family responsibilities prevent their full employment. This is particularly acute in science which is not only information-intensive but also dynamic - the knowledge required to work effectively is changing rapidly. It is therefore important the CRI's be prepared to employ on a part-time basis. Such employment not only benefits the employee, it often provides a return to the employer that is out of proportion to the formal hours of employment and, in addition, maintains a larger pool of skills for the future.

CRI - UNIVERSITY LINKS

Communicated by Professor D F Walls, President NZIP

Executive Summary

CRI's should be structured in such a way that the existing links between present government research organisations and the universities are maintained and strengthened. Close links between CRI's and universities are desirable to ensure the effective use of personnel and equipment, and to promote a stimulating intellectual environment. However, links can be inhibited by factors such as different funding bases and career structures. The educational functions of CRI's should be explicitly recognised and funded.

CRI's should be structured in such a way that the existing links between present government research organisations and the universities are maintained and strengthened. Close links between CRI's and universities are desirable to ensure the effective use of personnel and equipment, and to promote a stimulating intellectual environment. However, links can be inhibited by factors such as different funding bases and career structures. The educational functions of CRI's should be explicitly recognised and funded.

Currently there are many links in place between government research organisations (GROs) and the universities. These include joint research projects, joint seminars, sharing of equipment, guest lecturing and examining of theses by GRO scientists, reviewing of GRO projects by university lecturers, short-term employment of post-graduate and undergraduate students, and ad hoc appointments.

These links enhance research in New Zealand through the sharing of expertise and equipment. For example, DSIR Physical Sciences staff have access to equipment at Victoria University Physics Department and Victoria University students use equipment at DSIR Physical Sciences. Such contacts also promote the free flow of new information and ideas, and intellectually stimulate members of both institutions.

The quality of CRI staff will in the future depend largely on the calibre of the graduates that CRI's can obtain from New Zealand universities. Thus CRI's have a vested interest in seeing that the quality of scientific research in New Zealand universities is internationally competitive. Maintenance of such high quality research in the universities should assure the retention in New Zealand of the most able research students. A strong programme of collaboration between CRI's and university research groups will help to achieve this.

For these reasons it would be desirable to have stronger links between CRI's and universities, for example, recognised joint appointments, exchange appointments between institutions, joint ownership of expensive facilities. Current barriers to stronger links between GRO's and the universities include the different funding mechanisms; the lack of funding for the teaching commitments of GRO staff; different career structures, salaries, and working conditions in GRO's and the universities. CRI's should be structured in such a way that such barriers can be overcome. The educational functions of CRI's should be explicitly recognised and funded.
This international conference held at the CNRS headquarters on the left bank of the Seine was co-organised by the CNRS Signals and Systems Laboratory, the Société Française de Théorie de l'Information, and the Department of Information and Communication of Tamagawa University, Japan. The meeting was attended by 80 mathematicians, physicists and engineers from France, Japan, Italy, the UK, USA and other countries (including two from Australia: Craig Savage (ANU) and Paul Edwards (University of Canberra/Royal Signals and Radar Establishment, Malvern)).

This conference is a sign of the developing links between European and Japanese science and technology. The establishment of CNRS laboratory and other facilities outside Tokyo will strengthen these links between France and Japan.

The main thrust of the Workshop was theoretical with invited papers presented on the first day by Cohen-Tannoudji (Collège de France), Ozawa (University of Nagoya), Arthurs and Goodman (Bellcore USA), Lindblad (Stockholm) and Ohya (University of Tokyo) addressing the fundamentals of quantum optics, quantum measurement and quantum information theory.

Quantum Measurement

Ozawa established the importance of quantum limits on measurement in optical communication systems. He used the recent controversy surrounding the standard quantum limit (SQL) for repeated measurements of the position of a free mass (as in a gravitational wave detector) to illustrate gaps in current understanding of the Heisenberg Uncertainty Principle (HUP). Interpretation and generalisation of the HUP became a central theme of this meeting. Arthurs and Goodman (Bellcore) presented a new "Quantum Experiment Uncertainty Relation" suitable for multiple observables and measurements at different times. They applied this relation to calculating noise covariances in optical communications systems using an 8-port homodyne receiver as an example. Mantsurov and de Muynck (Eindhoven University of Technology) considered the application of the uncertainty principle to measurement of photon number in a "quantum non-demolition" (QND) measurement. They drew an analogy with Heisenberg's famous "gamma-ray microscope" to illustrate the limits to precision attainable in a joint measurement of phase and photon number. Yuen (Northwestern University), Teich (Columbia University) and others carried forward the relations to the three different communications areas of light generation, amplification and detection.

Quantum measurement and communication was reviewed in an information theory context by Lindblad (Stockholm), Ohya (Tokyo), Levitin (Boston University) and Yuen (Northwestern University), Phoenix (British Telecom) and Barnett (University of Oxford) discussed the information content (entropy) of quantum and classical correlations in an interesting paper which addressed the Bell inequalities and "hidden-variable" classical theories. Recent work by Barnett and Peggy (Griffith University) in defining a phase operator in quantum optics received favourable mention in the discussion following a paper on this subject by Bendjaballah and le Pas de Secheval (CNRS Signals and Systems Laboratory).

Quantum stochastic processes were discussed by Holevo (Steklov Institute, Moscow) Accardi (Tor Vergata Rome), Belavkin (MIEEM, Moscow) and Ojima (Kyoto University). Barchielli (University of Milan) illustrated the application of quantum stochastic calculus to direct and heterodyne detection systems.

Quantum State Control: Squeezed States

The use of non-classical "squeezed states" for optical communication was well presented by Yuen and Teich in separate reviews. Although generation of "number-squeezed" and "quadrature-squeezed" light with intensity noise below the shot-noise limit (SQL) is now fully demonstrated and understood, application to shot-noise limited communication and measurement systems is still at an early stage. Teich mentioned the semiconductor diode number squeezing demonstrations by Yamamoto and colleagues at the NTT Basic Research Labs in Tokyo and by the quantum optics groups at the Royal Signals and Radar Establishment (Malvern) and the University of Plymouth. The RSRE group have been actively exploring non-classical light applications using non-degenerate parametric down-conversion ("photon-splitters") to generate strongly correlated twin photon beams. Heidmann (École Normale Supérieure, Paris) reported the largest number squeezing yet observed (80%) with an optical parametric oscillator.

The well known lack of robustness of squeezed light against attenuation and amplification was emphasised by several speakers. Hirota (Tamagawa University) and others discussed theoretical and practical aspects of the controversial "received quantum state control" communication system proposed to overcome the problem of transmission loss in coherent squeezed state communication. The RQSC system, which would utilise non-linear devices such as the bistable beam splitter mentioned by Collett and Walls (University of Auckland) at the 1989 quantum optics conference in Hamilton, stimulated much discussion. Yuen, who in 1976 first introduced the "two-photon" ic 'squeezed' states suggested photon preamplifiers and
regenerators as practical means of realizing the advantages of quantum state control (squeezed states) in lossy communication channels.

Quantum Optics Systems and Devices

Aside from the proposed RQSC system, little new material relating to systems and devices was presented. Osaki and Inagaki (Keio University) described a method of amplitude modulation for an on-off keyed squeezed light transmitter. Bun (Keio University) and Sasaki (Tamagawa University) outlined a squeezed state demodulator. Heidmann (ENS, Paris) described their optical parametric oscillator comprising a non-linear crystal in a cavity and suggested the implementation of bright squeezed light sources using monolithic OPO technology. They also gave a well received semiclassical description of a non-linear (Kerr effect) quadrature squeezing. They emphasised their view that quantum optics should be vigorously subjected to physical testing and interpretation (quoting in conversation a comment by the late John Bell on the dangers of uncritical acceptance of "impossibility theorems" such as the well known von Neumann theorem on hidden variables in quantum theory). Phoenix (British Telecom) described a new continuum mode analysis of light propagation and detection in optical fibre on behalf of coauthors Loudon (University of Essex) and Blow (British Telecom).

The strong support by British Telecom for optical communications was evident from this and other presentations. On the final day of the meeting Brillet (Université d’Orsay) gave a non-specialist account of the principles of gravity wave detection. He described the French-Italian Virgo and other gravity wave antennas planned to begin operation in 1996. Ohayon (Société Anonyme de Telecommunications) described another future implementation of a system at the quantum limit for coherent light: a satellite-born Doppler wind lidar. The audience was quick to point out that, unlike the gravity interferometer, quantum magic in the form of squeezed light did not offer any potential advantages in a high loss hetero-dyne system in which local oscillator quantum noise was suppressed in a balanced receiver.

Overall, the Workshop was probably successful in that it brought together a rather different group with quantum communications interests from those who attend the usual quantum optics and quantum electronics meetings. The Proceedings will be published by Springer-Verlag in early 1991.

Paul J Edwards
University of Canberra

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**FIX on PHYSICS**

The editorial board requires short illustrated articles for publication in our education supplement *FIX ON PHYSICS*. Articles, hints, ideas for experiments and discussion of material relevant to TEACHERS AND STUDENTS OF YEAR 11-12 PHYSICS are sought. Please send all contributions to the Honorary Editor (see address on Contents page).
This month’s cover features the shadow of a tree projected onto one end of the main physics building at The University of Adelaide; but the reader would be quite right in assuming that there must be some other reason for printing such an apparently-mundane photograph on the cover. Take another look.

Got it? If not, here’s where to look: say, at the densest parts of the shadow where it strikes the wall. In that region the light coming through the few pinhole gaps between or through the leaves gives rise to a myriad of identical crescent shaped images. The reason is that the photograph was taken on the morning of January 16th, during the partial solar eclipse visible from most of southern Australia, the crescents in fact being images of the part of the Sun not obscured by the Moon. At the time it was quite amazing to note the scarcity of people aware of what was going on, despite the very noticeable drop in the temperature and brightness of the ambient light; and of those who did recognize the event, how they tried to view the phenomenon (lamentably, many looking directly at the Sun), with pieces of cardboard and screens and mirrors, and sundry other techniques. 'Not up there!' one wanted to shout, 'just look at your feet!'. For no more sophisticated equipment was needed than a tree (although this might not work with a deciduous tree in winter), the pinholes between the leaves acting as excellent pinhole cameras. For a better example (not so sneaky as on the cover) see the photograph on this page, again taken outside of the physics building at The University of Adelaide.

There is, perhaps, more that can be learned from this on the pedagogic front. Charles Babbage relates the following story, involving his close friend John Herschel, in his book *Reflections on the Decline of Science in England* (1830):

* Now at the Anglo-Australian Observatory, Coonabarabran, NSW
An object is frequently not seen from not knowing how to see it, rather than any defect of the organ of vision (Herschel said) 'I will prepare the apparatus, and put you in a position that [the Fraunhofer solar absorption lines] shall be visible, and you shall look for them and not find them; after which, while you remain in the same position, I will instruct you how to see them, and you shall see them, and not merely wonder that you did not see them before, but you will find it impossible to look at the spectrum without seeing them.'

Is this not just what physics (or any other) education is all about?

Herschel was a fine scientist, although since his death it is usually his father Sir William Herschel (the discoverer of the planet Uranus in 1781) who is more often noted upon. Sir John Herschel pioneered many areas of what we would now call physics, working, for instance, with Michael Faraday; it was J.F.W. Herschel who introduced the terms 'positive' and 'negative' in photography. He published a book which I feel should be recommended reading for all beginning research students, no matter what their subject, and which was entitled 'An elementary discourse on the study of natural philosophy.'

Here is a sentence from it which I believe sums up what we would now view as the difference between the 'professional' and the 'amateur' approaches to science:

'We must never forget that it is principles, and not phenomena - the interpretation, not the mere knowledge of facts - which are the aims of the natural philosopher.'

In Adelaide there is a gravestone which begins: 'Sacred to the Memory of B. Herschell [sic] Babbage...'. This juxtaposition of names is not coincidental, but that is another story. Nowadays Babbage and Herschel would most likely be run off any university campus at which they registered as students. Whilst undergraduates at Cambridge they formed a group called the Analytical Society, which was vociferously opposed to the outdated methods of mathematics teaching in place in that university at that time (the second decade of the nineteenth century), with Newton still ruling supreme a century after his death. Their third collaborator was George Peacock, who later arranged for Charles Darwin to go on the voyage of the Beagle, and achieved high office as a cleric. More than just stating their opposition to the stagnant circumstances, they did something positive to improve the situation. As its watchword the Analytical Society pledged to 'Do away with the dog-ism of the University and replace it with the pure de-ism of the Continental notation', referring to the rival Newtonian and Leibnizian notations for the calculus, and the group was a major instrument in bringing about a revolution in teaching and studying methods.

Babbage did not sit his final exams since he did not care to come second (to Herschel): how does this compare to the modern-day quibbling over the fine grades within Honours divisions? Let me finish with something that I read in The Weekend Australian some time back. It is concerned with the author John Le Carré who addressed his old school (Sherborne) in these terms:

'You’re taught here to conform; I tell you that it is the conformists who have done most damage throughout history, not the individualists. You owe it to your world to give it the benefit of your individual genius'.

'You shouldn’t have said that, you know,' the headmaster remonstrated.

Let us not adopt the attitude of the headmaster. Who knows how many Herschels and Babbages are out there waiting to be allowed the chance to develop?
J.D. Cashion  Department of Physics, Monash University

In practical cases, the addition of spin to the linear motion parameters of a projectile occurs very commonly and it is very difficult to avoid completely in most cases. However, its deliberate use is usually done with one or both of two main aims in mind. The first aim is to stabilise the motion of the projectile through the conservation of angular momentum, particularly in the presence of wind. The spin axis can either be parallel to the trajectory (eg. torpedo punt kick, javelin, rifle bullet, dart, etc) or perpendicular to it (eg. drop punt kick, golf ball, tennis ball, etc. with a horizontal spin axis or a skipping stone or discus with a vertical spin axis).

The second aim is to cause the trajectory to deviate from the conventional parabola through the interaction of the spinning surface of the ball with the air (Magnus effect). This can give an improved trajectory in terms of distance or accuracy (eg. golf) or else help defeat an opponent with the faster shot achievable with topspin (eg. tennis, table tennis), deceive them with the changed flight (eg. baseball, cricket, tennis, table tennis) or enable the ball to reach a particular point via a trajectory which is out of the opponent's reach (eg soccer, tennis).

Like so many scientific discoveries, the theory of the Magnus effect was developed in answer to a military problem in this case the desire of Prussian artillery staff to understand why their projectiles (rotating spheres) deviated in flight. Magnus first published his analysis of the effect of spin in 1853 but in fact the effect was correctly interpreted by the English artillery engineer, Benjamin Robins, over 100 years earlier but his analysis was disputed by Euler whose view prevailed.

The force due to the Magnus effect acts in the direction perpendicular to both the velocity and the spin axis of the projectile so that it is clear that there is no sideways force if the spin axis is parallel to the velocity vector. The Magnus effect (or Robins effect) can be quite easily understood from the accompanying diagram. Figure (a) shows the streamlines symmetrically displaced around a non-rotating ball or cylinder moving with velocity V. However, if we give the ball an angular velocity \( \omega \), which is shown here as a backspin, then the tangential velocity, \( r \omega \), will act to increase the velocity of the air on the top, reduce it at the bottom and the stagnation points move down from their 180 deg separation as shown in the second diagram. Applying Bernoulli's equation (which is quantitatively valid only for a long cylinder in the present context) allows us to associate a lower pressure with the higher velocity and hence an upward force is produced. To a first approximation, this force is linear with the ratio \( r \omega V \).

Microscopically, a thin boundary layer of air rotates with the ball and there is a transition region over which this effect reduces. I have often

Figure (a)

Figure (b)
puzzled why the interaction of this rotating layer on the bottom of the ball, which hits the streamlines at the largest relative velocity, does not cause an increased drag on this side and hence a force opposite in direction to that given by the Bernoulli argument. It is true that this can be the dominant interaction at low values of \( r/s \), with turbulent flow on the bottom side and laminar flow on the top, but this condition is probably hard to detect in the sporting context beyond the feeling "I didn't hit that one properly, did I?".

The Magnus effect can be easily demonstrated in the classroom. A simple method (for well behaved classes!) is to use a table tennis bat and ball to show the different trajectories with topspin, backspin and sidespin. These are best viewed across the front of the class for the first two and hit towards the audience for the sidespin case. A second simple demonstration is to take a cylinder of paper or cardboard and wrap one or two pieces of cotton around it several times. Holding the free end(s) of the cotton, allow the roll to fall and watch the deflection of the trajectory as shown by the non-vertical state of the cotton as it unwinds.

There have been two excellent analyses of the trajectories of rotating balls, the first by Davies' on golf balls and the second by Stěpánek on the topspin lob in tennis. The analyses are very similar and they provide excellent examples for the better students to carry out a numerical integration of the differential equations on a minicomputer by successive calculation of the parameters of the ball after equal time increments.

A suitable set of equations from Davies' paper (a similar set can be obtained from Chapter 12 of Daish's) is:

\[
\frac{d^2x}{d\theta^2} = \frac{\partial M}{\partial \sin \theta} \cos \theta - \frac{1}{M} \frac{dM}{d\theta} \sin \theta \]
\[
\frac{d^2y}{d\theta^2} = -g - \frac{\partial M}{\partial \sin \theta} \cos \theta + \frac{1}{M} \frac{dM}{d\theta} \cos \theta
\]

where \( \theta \) is the angle of the trajectory to the horizontal, and the lift, \( L \), is given by

\[
L = 9.2 \times 10^{-4} V \left[ 1 - \exp\left(-1.6 \times 10^{-2} \omega \exp(-0.11) \right) \right]
\]

and the drag, \( D \), is given by

\[
D = 2.6 \times 10^{-5} V \left[ 1 + 6840 \omega \exp(-0.11) \right]
\]

Note that this assumes a 10% loss in spin rate per second where the spin rate, \( \omega \), is in rev/s. Typical numbers are: \( V = 25 - 70 \text{ m/s} \) (90 - 250 km/h), \( m = 0.046 \text{ kg} \), and a consistent set of values for the angle of elevation and spin rates for the various clubs are given in the table. Note that these values may be varied by opening or closing the club face.

<table>
<thead>
<tr>
<th>No.</th>
<th>Angle (deg)</th>
<th>Spin (rev/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Woods</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8.5</td>
<td>31.</td>
</tr>
<tr>
<td>2</td>
<td>10.0</td>
<td>38.</td>
</tr>
<tr>
<td>3</td>
<td>12.5</td>
<td>45.</td>
</tr>
<tr>
<td>4</td>
<td>14.5</td>
<td>52.</td>
</tr>
<tr>
<td>5</td>
<td>15.0</td>
<td>54.</td>
</tr>
<tr>
<td><strong>Irons</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>15.5</td>
<td>56.</td>
</tr>
<tr>
<td>2</td>
<td>16.0</td>
<td>59.</td>
</tr>
<tr>
<td>3</td>
<td>18.0</td>
<td>65.</td>
</tr>
<tr>
<td>4</td>
<td>21.0</td>
<td>75.</td>
</tr>
<tr>
<td>5</td>
<td>23.5</td>
<td>83.</td>
</tr>
<tr>
<td>6</td>
<td>27.0</td>
<td>96.</td>
</tr>
<tr>
<td>7</td>
<td>30.0</td>
<td>106.</td>
</tr>
<tr>
<td>8</td>
<td>32.0</td>
<td>114.</td>
</tr>
<tr>
<td>9</td>
<td>34.5</td>
<td>122.</td>
</tr>
<tr>
<td>W</td>
<td>40.0</td>
<td>145.</td>
</tr>
</tbody>
</table>

Practical considerations for golfers from these figures are that the spin is imparted by the grooves on the club head and will be reduced if you don't clean the head and also that the radially U-shaped grooves produce more spin than V-shaped grooves. This difference increases when hitting from long grass where the grass intervenes in the club head to ball contact causing the "flyer from the rough." Secondly, solid balls typically have 10 - 15% less spin than wind balls and a slightly longer total travel, although probably less of it is in the air resulting in less control. It should also be pointed out that the dimples on a golf ball are essential for getting the best boundary layer of air around the ball. A smooth ball will have a greatly reduced range because itcarries along more air with it. To give a feel for the numbers, immediately after impact, the lift force is typically approximately 0.1 lb or more and the drag is about 0.8 lb, so the ball travels in an approximately straight and not a parabolic trajectory.

All these considerations assume that the spin axis is horizontal, which is not the case if the golfer's swing is such that the club is not travelling straight towards the hole at the point of impact or if the centre of mass of the club head does not pass through the initial centre of mass of the ball thus causing the club head to twist. These result in the spin axis being tilted and hence a Magnus effect component giving the well-known hook or slice and forcing the unfortunate golfer to explore out-of-the-way parts of the course.

Experiments on the tennis topspin lob\(^1\) with the Czechoslovak Davis Cup player Pavlo Sizil showed that the maximum spin rate was approximately 60 rev/s so high-speed photographs were taken with ball parameters in the range 13 - 54 rev/s and 13.6 - 28 m/s. These allowed the fitting of empirical relations for the lift coefficient, \( C_L \)

\[
C_L = \left[ 2.022 + 0.981 (\omega V)^{0.11} \right]^4
\]

and for the drag coefficient \( C_D \)

\[
C_D = 0.508 + 22.503 + 4.196 (\omega V)^{0.29} + 1.156 (\omega V)^{0.39}
\]

Fortunately for the ease of analysis, no reproducible dependence of either of the coefficients on Reynold's number could be determined. A spin bowler in cricket may spin the ball in several different ways. Usually one is interested in maximum turn after hitting the pitch and this dictates that the spin axis should be parallel to the trajectory and the ball is commonly, but not exclusively, held with the fingers across the seam to maximise the probability of the ball landing on the seam. Bending the wrist at right angles before spinning the ball out with the fingers produces a topspinner which hopefully will sneak under the ball after bouncing. However, the ball may also be released with the spin axis pointing in almost any direction, thus giving a combination of sideways movement through the air followed by turn after bouncing as is well explained by Mehtra and Wood.\(^1\) The easiest way of obtaining this orientation is to release the ball a little earlier than the top of the arm movement, a delivery often described by the commentators as 'giving the ball a little more air'. This aspect of the two causes of movement is not appreciated by most spin bowlers or coaches and as a one-time spin bowler, I wish that it had been explained to me a long time ago.

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**REFERENCES**

THE FUTURE USE OF COMPUTERS IN SECONDARY PHYSICS EDUCATION

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Macquarie University

Over twenty years ago when I trained to teach in secondary schools my pedagogy instructor insisted that we introduce our topic by asking appropriate questions. Following this concept, the context of this article can be set if we start by considering some of the questions that need to be faced before any comprehensive plan for the use of computers in secondary education can evolve.

The first set of questions concern possible changes in educational philosophy.

• To what extent is it envisaged that classroom teachers might be replaced by computer aided instruction?

• Will computers be used to teach and introduce educational material or will the pupils be encouraged to use computers as convenient tools to express their mastery of educational objectives?

• Where computers are used, can we be sure that they are in fact the most suitable means of achieving the particular ends?

• Should we plan for a restricted or whole scale use of computers for all students at all levels?

A second set of questions centre around the practical problems of installing and using computers.

• What will be the cost of introducing computers in schools and can these be justified in the face of competing demands?

• Will governments make a sincere effort to find the required funds or will the funding be on a 'too little, too late' basis?

• How long will it take for a particular choice of computer or software to become obsolete?

• Perhaps worse still, how long will it be before a particular system is thought to be obsolete?

• How well will a computer survive in the rugged classroom environment?

• Will funding be available for computer maintenance?

• Will computers continue to be offered in more powerful configurations, more cheaply?

These questions centre around the general problems of computers in education. However my particular concern is with the teaching of physics in senior secondary classrooms. No matter how computers are introduced to secondary schools, a final question remains.

• Will computers provide particular tools for teaching physics that might not be required in other subjects? I will deal with this question after we have settled a scenario for what can, or might, happen with the introduction of computers in schools.

The Introduction of Computers in High Schools

My opening questions seem so uncompromising that many readers will assume that I am pessimistic about the use of computers in schools. I am however, well aware of the fact that computers arrived in schools a decade ago. It is my purpose to consider how we can best develop and exploit the technology.

Hammond pointed out that the Commonwealth has spent 18.3 M$ on computer education in Australia, between 1983 and 1986, with the funding then continuing on a state-wide basis. In a recent article in the New Scientist a similar figure of NZ 23 M$ is given for funding computer education in New Zealand for the next triennium. Both reports show some concern for the need to improve teacher training at the same time.

In the state of New South Wales, there are over 50,000 candidates for Higher School Certificate every year. This implies that there are well over 100,000 students studying at the Year 11 or 12 level. If all these students were to have limited access to computers, in say their mathematics classes, then this might be achieved by investing $100,000 in each of 100 large high schools through an initial grant of $10 M$ direct to the high schools of NSW. This would provide approximately 50 basic computers and software in each school. When one adds on the difficulties of supplying smaller schools, time tabling to allow access, maintenance of equipment and in-service training of teachers, it can be seen that the funding of computers for senior high school students was and is quite inadequate. It is a credit to our high schools that they have generally managed to meet and improve on this target for student access. When the glamorous reports of the use of computers in schools are studied it seems clear that these invariably come from privileged private schools. The state schools are joining the race but only in selected schools and with generous supplies from computer companies.

When we look back at the first set of questions it should be clear that it may be some time before we have the luxury of considering just how computers are best used in education. At present we face a desperate need just to get systems up and running so that most students can get a fair chance at becoming familiar with using computers. This desperate race leads to the second set of questions on system choice and maintenance. Many of the problems so far, including that of in-service teacher training, could be solved in the following manner. First a decision must be taken to adopt a certain standard of hardware, say MS-DOS compatible with a network option. (This decision can be reviewed towards the end of the lifetime of the concurrent generation of computers which hopefully might stretch beyond five years.) Following this decision each State education department should then set up a centre to develop and supply software appropriate to the particular syllabuses and objectives. Such a centre will naturally become an important resource for in-service training as well as being capable of monitoring and supplying software updates. It may also be necessary for this centre to provide a service in hardware maintenance, as the classroom will prove to be a tough computer environment if only because of the expected heavy use.

At this point it is likely that people will feel prejudiced against setting up yet another bureaucratic organisation, especially in the face of what promises to be permanent under-funding; nevertheless the NSW Education Department already has a Services Directorate of appropriate scale, principally involved with video production and library support. If experienced support and advice in computing is not freely available to all teachers, their already demanding task will become so much more onerous. In a free enterprise system some schools and some teachers will excel, possibly at the expense of continuing high standards in other areas of their profession. It is also likely that education systems will fall prey to outside commercial interests, a possibility which NSW Department of Education strives to avoid (Board of Senior School Studies). As a political issue computers do not belong to the PM: Baratt; it is high time that Commonwealth and State governments become more serious about giving their future citizens a better exposure to information technology. Even the free enterprise system requires participants with some degree of financial freedom.

The Role of Computing in the Physics Curriculum

Most physicists are only too well aware of the importance of mathematics in their subjects. It seems almost axiomatic that a good physicist should also be a competent applied mathematician. Drawing from my own experience of teaching at >
University level and acting as a syllabus consultant for a senior school's physics syllabus, I have come to the conclusion that the fundamental mathematical skills that are required for a student beginning their university studies are:

- a sense of quantity,
- the ability to relate abstract symbols to real entities and
- spatial perception such as that required to interpret graphs.

In making this list I have excluded the concepts of calculus. The usual pattern is that students first meet calculus in the early part of the physics syllabus, then later they study calculus in the mathematics syllabus. At this point they knew that they had studied the topic before but no one was going to go back to study what they were already supposed to know. This sequence is not easy to break and probably does little damage unless the students also lack the more fundamental skills outlined above. It is at this point that computer aided instruction can be used as a means of reminding, reinforcing or reteaching earlier concepts. Perhaps readers should be reminded at this point that when we discuss the secondary school physics syllabus, we are not just talking about training for physics, we are also considering the initial training for engineers and many other technologists.

There are few, if any intrinsic properties of a physics syllabus that demand the use of a computer in preference to any other subject. There is, however, a real danger that, if elementary computer studies are offered at a vulnerable point in a students education, these studies will be wholeheartedly embraced as an easier option to harder paths. I think that this possibility may explain why only 5% of computing students at Macquarie University show any interest in the design of logical circuits and computer hardware. This subject could be rated alongside physics in degree of difficulty.

Most science and technology syllabuses at the secondary level demand and require numerical ability. This is best fostered by the fluent use of calculators rather than computers. Calculators which are more expensive are available for the price of a textbook and can be used as an aid to study for many subjects at an appropriate level. My opinion is that an exploration of real data and quantities using a calculator and graph paper is, an essential precursor to learning to write programs and to use packages that process data. Accurate data is essential and the development of the skills of evaluation and analysis in the classroom and the inclusion of appropriate questions in examinations. The primary stages of the development of these skills would be hindered by providing black boxes that accept input numbers and provide output numbers. Furthermore, problems concerning accuracy, precision and significance need to be carefully explored and considered, rather than being solved by an unthinking machine. Another current issue that needs particular attention in the NSW physics course is the provision of sufficient practical experiences and the consequent collection of realistic and appropriate data. In terms of priorities the supply of computers for the physics classes should wait until these classes have adequate sets of experimental apparatus.

Graphical analysis includes data presentation but conceptually it progresses to include curve fitting as well as the basic concepts of differentiation and integration. Both these topics are suitable for discussion and learning, providing the student experiences the initial motivation. The best fit of a straight line to data can be calculated using formula derived by calculus or iterated by plotting about the centroid. Either approach should show the significance of the root mean square of deviations, and interpolations and extrapolations can be discussed in terms of the correlation coefficient. In a similar spirit of mathematical discovery, the slopes of, and areas under curves can be explored for various finite differences. These results can then be compared with those calculated using the formulae of calculus. As this type of discovery with its accompanying tabulation takes place, the usefulness of advancing first to a programmable calculator and then to a more comprehensive computer becomes appreciated. At the same time the inherent problems of data analysis are also clearly indicated. If computers or even programmable calculators assist in these areas of discovery then they have found a unique use in the science classroom.

Data collection and experimental control have now become a commonplace use for computers in practice. I would be delighted if such systems were available for physics classes. However, in the light of what we have already considered, this level of sophistication cannot claim top priority on the list of essential prerequisites especially for the physics classroom. If, or when, these systems become freely available they should be adopted, as the collection of data is never less important than the analysis, and hopefully, the synthesis and further creative planning that should follow this activity.

References


Olympiad offers exciting opportunities for students

Many teachers and students are unaware of the involvement of Australia in the International Olympiad programs and of the increasing success of Australia in these competitions. In recent copies of The Australian Physicist we have published reports of the rankings and reproduced the question papers. It will be obvious that the final competition is only for gifted individuals in the areas of Physics, Chemistry and Mathematics. Many people will be unaware however, of the advantages which can follow from involvement in the selection process.

The initial advertisements for nomination to be included in the group from which selection is made are distributed to schools at about the same time as the notices advertising the National Science Summer School held each January in Canberra. Indeed Dr. Jory, who organises the National Summer Science School, also organises the Olympiad team and travels with the team to the nominated venue. The selection procedure involves participation in a central school in Canberra at which students are given trial questions and laboratory exercises as well as an intensive instruction program in Physics. Students who are successful in selection for the team will be roughly at or above the level of a first year University student, when they leave for the Olympiad itself.

Universities and various schools have now realised the benefits of training for the Olympiads and a number of Universities in particular now offer extension courses in Physics, aimed at preparing students for the selection process. While five students ultimately will be selected for the team, the training groups by now would total 100 students or more and are expected to increase further over the next few years.

Students involved in the selection process are exposed to a real challenge and obtain a significant advantage in their understanding of Physics through the extra courses and tutorials to which they are exposed. Students selected in the team itself can be admitted later to tertiary institutions with exemptions from some first year coursework. This allows them to expand their studies in later year options.

Information on the Olympiad program is available from Dr. Jory, University of Canberra (phone 06-249 2777 or 06-249 2602). Students with a real aptitude for Physics and Mathematics should be encouraged to apply for the program.
'Improvement in the dissemination of information and in the sounding of opinions will reduce the time wasted in committees and both directly and indirectly increase the probability of their meetings,' say Prof. EJM Campbell and Prof. Michael Gent of McMaster University's school of medicine in an article first published in the British Medical Journal (1976, 2, 1551-1552) and reprinted in the McMaster Courier of 8 May 1990. The article, 'On the probability of a committee meeting,' is reproduced here with permission.

In the beginning, when we were few, we would meet often in various formal and informal guises. The difference between a conversation and a committee was marginal. Now we are numerous. We have adopted a constitution and bylaws and set up a structure of standing committees which seems to work quite well. Nevertheless, ad hoc matters are always arising to which the normal response is to convene a committee to ensure broad representation and participation. As the school gets larger these ad hoc committees get larger and more difficult to convene, so they are arranged further in advance and after normal hours. These responses - planning ahead and working harder - seem laudable, but we are doubtful. The analysis described below not only lends respectability to our doubts but is so sobering that we think it worth sharing those similarly afflicted.

**Varying Probabilities**

We considered the probability of an ad hoc committee meeting, assuming that the members of such a committee have a working week - that is, are 'on the premises' - of 40, 45 and 50 hours in each of which 20, 25 or 30 hours are committed. We further assumed that the committee and uncommitted hours are randomly and independently distributed throughout the working week in units of one hour. We then calculated the probability that an ad hoc committee of n people, where n varied from 2 to 8, could be brought together for a one-hour meeting in a given week (see table).*

A high probability indicates that such a committee can probably be called without any member failing to meet other commitments. A low probability implies that it will be difficult to bring the committee members together. This will demand a lot of 'administrative energy' from the system, not only in unfulfilled other commitments by its members but also in secretarial time spent scheduling the committee and rescheduling the other work of the members. In other words, the lower the probability, the greater the cost.

Let us look at a few specific examples from this table. For a working week of 40 hours with people committed for 30 of

<table>
<thead>
<tr>
<th>Working week (hours)</th>
<th>n</th>
<th>No of hours already committed</th>
<th>Probability</th>
<th>n</th>
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| 4                    | 0.4443                     | 4            | 0.8651 | 4  | 0.9963      | 4  | 0.9963 |
| 5                    | 0.1724                     | 5            | 0.5651 | 5  | 0.9378      | 5  | 0.9378 |
| 6                    | 0.0603                     | 6            | 0.3010 | 6  | 0.7654      | 6  | 0.7654 |
| 7                    | 0.0204                     | 7            | 0.1450 | 7  | 0.5400      | 7  | 0.5400 |
| 8                    | 0.0068                     | 8            | 0.0667 | 8  | 0.3443      | 8  | 0.3443 |

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| 3                    | 0.9815                     | 3            | 0.9999 | 3  | 1.0000      | 3  | 1.0000 |
| 4                    | 0.7558                     | 4            | 0.9772 | 4  | 0.9999      | 4  | 0.9999 |
| 5                    | 0.4142                     | 5            | 0.8229 | 5  | 0.9918      | 5  | 0.9918 |
| 6                    | 0.1885                     | 6            | 0.5623 | 6  | 0.9304      | 6  | 0.9304 |
| 7                    | 0.0793                     | 7            | 0.3316 | 7  | 0.7821      | 7  | 0.7821 |
| 8                    | 0.0324                     | 8            | 0.1801 | 8  | 0.5881      | 8  | 0.5881 |

* This table was derived from some basic concepts in probability theory using a programme specially written for our HP 3000 computer.
FOR GREATER EFFECTIVENESS - VISIT THE BAR BEFORE GOING HOME IN THE EVENINGS

those hours there is less than a 50% chance of a committee of three meeting without extra cost (working week 40; hours committed 30; n=3; P=0.4919). Adding one more member to this committee outweighs the benefit of working five hours longer per week (45; 30; n=4; P=0.4443). Even in an organisation in which each member keeps 20 hours uncommitted, increasing the size of the committee by one outweighs the effect of working 10 hours longer (compare top right (40:20) with bottom left (50:30)). A committee of eight has only a 50% chance of meeting without extra cost if composed of people working a 50-hour week of which only 20 hours are committed - a highly desirable but unrealistic state of affairs.

• have lunch together;
• visit the bar before going home in the evenings.

We submit that the improvement in the dissemination of information and in the sounding of opinions will reduce the time wasted in committees and both directly and indirectly increase the probability of their meeting.’

**Implications**

Many of the implications are obvious but some are not, and quantitatively most are sobering.

Obviously the smaller the committee the better, but not that much better.

Obviously the longer one works the better, but note how little better.

Obviously the more one plans one's time (the more hours committed) the worse for the system: in a sense, the more 'efficient' one is, the less 'effective' - available - one becomes.

Should it be felt that the purpose of one or more of these ad hoc committees has become a regular matter, the suggestion will be made that somebody should be employed to handle it. Unless the individual has no other responsibility - that is, none of his time is otherwise committed - either the problem is compounded, because n is increased, or he must replace the committee.

**So What?**

In addition to the qualitatively obvious, but quantitatively surprising implications, we would make the following assertions and suggestions.

1. Responsibility should be given to individuals. Even if a committee is needed, the chairman should do as much as possible by himself.

2. Committees should meet only to deliberate, not to disseminate or communicate.

3. Committees may disseminate or communicate, but to do this they do not need to meet.

4. By far the most powerful item in the table is 'n': the practical implication is obvious.

5. The next most powerful item is the number of uncommitted hours, which were assumed to be randomly distributed. Herein is the second best hope of improvement: constrain the committed hours and protect the uncommitted time by habits which as well as increasing effectiveness, if not efficiency, are also more civilised than those currently observed. Thus:
   • do not have coffee at your desk - go to the cafeteria, the common room, the ward, or the laboratory, and at the same time as other people;
   • attend rounds, clinical conferences, and seminars; arrive a few minutes early and hang around afterwards;

**I'm on a committee**

Oh give me your pity!
I'm on a committee,
Which means that from morning to night
We attend and amend,
And contend and defend,
Without a conclusion in sight.

We confer and concur,
We defer and demur,
And reiterate all of our thoughts.

We revise the agenda
With frequent addenda,
And consider a load of reports.

We compose and propose,
We suppose and oppose,
And the points of procedure are fun;

But though various notions
Are brought up as motions,
There's terribly little gets done.

We resolve and absolve,
But we never dissolve,
Since it's out of the question for us
To bring our committee
To end like this dirty
Which stops with a period - thus.

Leslie Lipson

Source: Reproduced, with permission, from Epidemiology Monitor, June 1983

**Citation rates have become a sport**

a gold medal for 'citation classic' and lesser awards for being able to list enough mentions to secure tenure or advancement or to keep the unit's head above water for another year. We hear little of the holders of the wooden spoon ... How often are papers, in different disciplines, uncited in the four years after publication? In this curious race physics wins (only 36.7% uncited), medicine comes fifth at 46.4%, between the geosciences and mathematics, and the booby prize goes to the arts and humanities, where only 2.0% of papers got a mention ... Happily, nobody really knows what any of these numbers mean.


62 Australian & New Zealand Physicists Volume 28, Number 4, April 1991
**Solid State Group Submission to the Strategic Planning Committee**

At the recent Wagga Conference it was decided that the Solid State Group should make a submission to the Strategic Planning Committee established under the sponsorship of the National Committee for Physics. The submission will describe current physics research programs under broad headings identifying the strengths. It will also describe facilities and infrastructure needed to significantly improve the research.

In the tables opposite, broad research areas and proposed new facilities are listed with the names of those who will write the submission for that area or facility. It is expected that they will seek opinions widely. It is open for anyone to contact these people or to make a submission directly to the Committee.

A small group will be set up on ARNnet as soon as possible to allow comments, suggestions and requests for information to be transferred between interested parties. This works by mailing your contribution to an address which you will be given once you register. Your contribution will then be automatically sent to all members of the mailing list.

To register, send a request for registration with your ARNnet address to:

SOLID-REQUEST @ latrobe.edu.au

It is proposed to submit the resulting submission both to the Planning Committee and to the Australian Physicist for publication.

| Neutron Source | Dr S Kennedy  
| 30MW Reactor, 10^6 n/s/cm^2  
| 30K Cold Source | Dr I Davis  
| | AINSE |
| Photon Source UV | Dr R Leckey  
| | LaTrobe University |
| Pulsed ESR Spectrometer | Prof I Pilbrow  
| | Monash University |
| Supercomputing Facilities | Dr T Choy  
| | Monash University |
| Mössbauer Spectroscopy | A Prof J Cashion  
| | Monash University |
| MBE facility | A Prof T Tansley  
| | Macquarie University |
| Sample and Crystal Growth Oxides, polymers Sample Preparation | Volunteer required |
| High Resolution Microanalysis | Dr D Cockayne  
| | Sydney University |
| μ Raman Spectroscopy | Dr T Finlayson  
| | Monash University |
| High Temperature Superconductors | Dr Nick Savvides  
| | CSIRO Applied Physics |
| Semiconductors | Prof J Williams  
| | ANU, Dr G Pain  
| | Telecom Research Labs  
| | Dr R Elliman  
| | ANU |
| III-V |  
| II-VI |  
| IV |  
| Opto-electronics/non-linear optics | Prof Paul Rossiter  
| | Monash University |
| Many Body Physics | Dr T Choy  
| | Monash University |
| Solid Electrolytes | Dr T Hughes  
| | CSIRO Mat Sci & Tech |
| Magnetism | Dr S Collocott  
| | CSIRO Applied Physics |
| Thin Films and Surfaces | Volunteer required |
| Surface Characterisation Facilities XPS, AES, SIMS, STM, AFM, RBS SAXS, spectroscopic ellipsometry | Dr R Netterfield  
| | CSIRO Applied Physics |
| Hardness and Adhesion | Volunteer required |

*Australian & New Zealand Physicist Volume 28, Number 4, April 1991*
Professor Norman Ramsay Visits New Zealand

Nobel Prize-winning physicist Professor Norman Ramsay (centre) met a former Harvard student when he visited the University of Auckland in November last year. Professor Dan Walls (left) was a student at Harvard 25 years ago when he first met Professor Ramsay who has been Higgins Professor of Physics there since 1947. They are pictured with Professor Alan Poletti during Professor Ramsay's visit.

Last year Professor Ramsay shared the Nobel Prize in physics for the development of atomic precision spectroscopy which led to the atomic clock. Delivering his Nobel lecture to Physics Department staff and students, Professor Ramsay said the application of his research to the atomic clock came about almost by accident, demonstrating the unpredictable uses to which fundamental scientific discoveries are often put. The super accurate atomic clock, subject to only one second of error in 1000 centuries, is used in radio astronomy, space navigation, for measuring pulsars (very compact stars that emit radiation in pulses), and testing the special and general theories of relativity. Professor Ramsay's experimental work has ranged from molecular beams to particle physics and has concentrated on precise measurements of the electric and magnetic properties of nucleons, nuclei, atoms and molecules. His current research addresses time reversal symmetry.

Besides meeting fellow physicists to describe and discuss his work, 75-year-old Professor Ramsay was in New Zealand to walk the Milford Track. In 1989 he spent 23 days crossing the Himalayas on foot.

---

Einstein Prize to NZIP President

The NZ Physics community extends its warmest congratulations to Professor Dan Walls of the University of Auckland for sharing the 1990 Einstein Prize for Laser Science. He shared the award, which comprised a commemorative plaque and US$1000, with Professor Carlton Caves of the University of Southern California. The prize, which was instituted two years ago by the organisers of the International Conference on Lasers and Applications, was awarded at San Diego in December.

The award recognises Dan's outstanding contributions to theoretical quantum optics. His theories for testing the fundamental photon nature of radiation and producing 'squeezed' light were subsequently confirmed from experiments that he also assisted in designing with his experimental collaborators. He is presently excited about the potential applications of squeezed light, which has been successfully produced in optical fibres, to telecommunication systems, computer chip technology and for cooling atoms. He currently heads a vigorous young theoretical group at Auckland continuing research into the theory of squeezed light which he pioneered some ten years ago.
Chairman
Dr B.M. Hartley
Radiation Health Section
Queen Elizabeth II Medical Centre
18 Verdun Street
Hollywood WA 6009
Tel (09) 389 2261
Fax (09) 381 1423

Secretary
Dr R.A. Anderson
Dept of Physics
The University of Western Australia
 Nedlands WA 6009
Tel (09) 380 2738
Fax (09) 380 1014

Treasurer
Dr R.R. Burman
Dept of Physics
The University of Western Australia
 Nedlands WA 6009
Tel (09) 380 2728
Fax (09) 380 1014

Branch Correspondent
Associate Professor R.S. Crisp
Dept of Physics
The University of Western Australia
 Nedlands WA 6009
Tel (09) 380 2737
Fax (09) 380 1014

The Annual General Meeting of the Victorian Branch of the AIP was held on 22nd November, 1990 at the School of Physics, University of Melbourne. The official business of the meeting finished in a record time of less than 10 minutes due to the combined efforts of Professors Klein and Smith, present and past Presidents of the AIP. Between themselves they proposed and seconded most motions of the meeting, often even before the Chairman had a chance to complete reading them. Perhaps both the honourable Professors were doing their best to save the members the agony of lengthy AGM formalities.

After the formalities of the AGM, Mrs Boas presented the 1990 Walter Boas Medal to Professors Opat and Klein for their outstanding work on Neutron Optics and its application to study fundamentals of Physics. Our congratulations to the recipients for this achievement. Both Professors Opat and Klein gave most stimulating and informative talks on this subject highlighting their contributions and achievements in the field.

After the meeting the members and guests were treated to tea, coffee and biscuits rather than the usual wine, cheese and sundries which had been a hallmark of our AGM's. It was regrettable that at the major occasion of both AGM and Boas medal presentation, a more elaborate refreshment, even a repetition of last years, couldn't be organised. Perhaps at the 1991 AGM we might have a bit more luck.

Office bearers of the Victorian Branch were elected at the AGM.

Chairman
Associate Professor J. Cashion
Vice Chairman
Dr. P. Dyson
Hon. Secretary
Dr. R. McLean
Treasurer
Dr. D. Arnott
Committee
Dr. F. Armitage, Dr. A. Choudhiri, Dr. E. Essex, Prof. P. Hannaford, Ms. V. Hansper, Dr. M. Manton, Mr. G. Moorhead, Dr. K. Nugent, Prof. G. Opat, Dr. R. O'Sullivan, Dr. Z. Padynyi, Dr. A. Roberts, Dr. A. Wilson.

M. Chaudri

Professor Opat, Dr. Boas, Mrs. Boas and Professor Klein after the presentation
Electron Guns and Electron and Ion Optics

Custom design and construction of low to intermediate energy (1.0 eV - 5.0 keV) electron guns and charged-particle optics is now available in Australia.

Australian Scientific Instruments, a division of ANUTECH P/L are agents for GUN CONTROL electron and ion optics and can offer a custom design service to suit the individual needs of the research and development community. The custom nature of the service extends to both the energy range and beam quality aspects of the optics and to the physical dimensions required by the user.

For more information please contact:
Peter Wallner
ANUTECH Pty Ltd
GPO Box 4 Canberra ACT 2001
Phone (06) 249 4708
Fax (06) 237 1473

Automated Alignment for Optical Fibres and Integrated Optics

Photon Control has introduced NanoTrak, an automatic alignment system for single mode fibres and integrated optical devices.

NanoTrak uses an adaptation of a tried and tested radar technique known as 'conical scanning', whereby a servo-controlled system maintains the position of a source on a target. In the case of NanoTrack, the vertical and horizontal axes of a Photon Control piezoelectric positioner are used to drive the optical source in circular path, resulting in a modulation of the power coupled through the system to be aligned. Phase sensitive circuitry then provides correction signals to the two axes to maintain alignment at the nanometre level.

NanoTrak is designed so that the amplitude of the scan is reduced from 3 microns to 20 nanometres when coupled power is at a maximum. This is sufficiently high to maintain alignment but low enough to ensure that the resultant modulation does not interfere with device characterisation.

NanoTrak may be used with Photon Control's existing range of MicroBlock, DM2 and INFOLD positioners, or with the new NanoBlock ultra-precise micropositioner.

Please contact Coherent Scientific for more information.

New Specified Wavelength for 'Spectrum' Mixed Gas Ion Laser

Coherent U.S. has announced that the Innova-70 'Spectrum' mixed gas (argon/krypton) ion laser will now have a 300 mW specification at 457.9 nm.

This very versatile laser now has power specifications for 8 laser lines range from 457.9 nm to 752.5 nm, as well as multiline visible and multiline U.V.

Complete details of the specifications are:

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<td>30 mW</td>
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<tr>
<td>Multiline UV</td>
<td>50 mW</td>
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For further information, please contact Coherent Scientific.

Low Cost Ring Dye Lasers

Coherent U.S. has advised that it still has parts to build a further 4 model 699-21 actively stabilised ring dye lasers. The 699 series dye laser were superseded last year by the 899 series of Ti:S/Dye ring lasers.

The 699-21 lasers are being offered for sale at approximately 75% of the price of an equivalent 899.

For further information, please contact:
Norman Jones or Paul Wardill at Coherent Scientific Pty Ltd
138 Greenhill Road
Unley, South Australia 5061
Phone (08) 271 4755
Fax (08) 271 1202

CLEO/QELS-91

The eleventh annual Conference on Lasers and Electro-Optics (CLEO) and the 1991 Conference on Quantum Electronics and Laser Science (QELS) will be held concurrently in Baltimore in the period May 12-17th 1991.

As usual, an international exhibition of lasers and related optical equipment will be held in association with CLEO/QELS. The exhibition will be open on May 14, 15 and 16.

Since the CLEO meeting is the major annual event in the international scientific laser business, many manufacturers choose this venue to announce and display major new product releases.

This year, for example, we expect to see important advances in the mode-locked Ti:Sapphire and diode pumped laser areas.

LET'S GET PHYSICAL, GRAPHICALLY SPEAKING

We need striking, visual graphics which are physics related to illustrate the Physicist.

The illustrations do not need to be of artwork quality . . . we can redraw them or touch them up.

Please send your contributions to:
Production Manager
Australian & New Zealand Physicist
Impress Studios
41 Kemp Street
The Junction
NSW 2299 Australia
A Symposium on Propagation Effects in Communications

to be held in conjunction with AUSSAT, CSIRO, OTC, and Telecom Research Laboratories

on Wednesday 5 June 1991 at

CSIRO Division of Radiophysics, Marsfield, NSW

The Program will be:

1.20 Opening
1.30 'Propagation through the rain' Robert Crane
2.30 Discussion
3.00 Refreshment Break
3.20 'Site diversity in tropical regions' Peter Arlett
3.50 'HF propagation in the ionosphere' David Cole
4.30 'Propagation in ducting conditions' DSTO
5.00 Refreshment break
5.30 'Rain attenuation reduction techniques' Robert Crane
6.30 Discussion
7.00 Finish
7.30 Dinner

Cost: IEEE members: $80 if pre-paid by 1 May 1991 or $100 thereafter.

Others: $100 if pre-paid by 1 May 1991 or $120 thereafter.

Students: half-price.

See advert on page 52 for contact details.
New Maps of Pleasure

Much hyperspace has slipped past the warp-drive in the thirty years since Kingsley Amis presented his New Maps of Hell in which he surveyed the written sci-fi genre as it appeared to him prior to the 1960s. It is only to be expected that the Space Age would shift the emphasis of science fiction somewhat - after all, the astonishing discoveries of the Voyager missions have stripped the planets of many mysteries and replaced them with many more. Not so much has changed in the hunting grounds beyond the solar system, where the imagination is much less fettered by fact.

The electronic revolution has also wrought its changes. Dick Tracy's wrist radio/computer is at hand (sorry about that). Sci-fi concepts such as phase reversing sound eaters are now a reality. So science fiction must move on, or cease to need the word 'science'.

These changes, together with those of a more social significance, are explored by British physicists Robert Lambourne and Michael Shalvis, and Australian historian/philosopher Michael Shortland, in 'Close Encounters? Science and Science Fiction'. Besides updating Kingsley Amis, the trio Lambourne, Shalvis and Shortland (LS&S) include sci-fi films within their ambit. Throughout their 167 pages of illustrated text, LS&S spend a good deal of effort examining the science of sci-fi and the various ways sci-fi authors explore the relationships between science and politics, social systems (not forgetting religion), and the military. They succeeded in raising my awareness of many elements of the genre that I had not fully thought about, and have given me many titles to track down because I now want to read them.

Inevitably I was disappointed by some of their omissions. No mention of some authors who, in my view, have set sci-fi moving in new directions, such as Douglas Adams of Hitch-hikers Guide to the Galaxy and light but different Philip Jose Farmer. Harry Harrison, who stirred humour into sci-fi with his Stainless Steel Rat character, is noted for a plaque from space theme (shades of Heye and Wickramasinghe) and another novel on the peril of overpopulation. Only passing mention of Eric Frank Russel, whose Sinister Barrier, along with Jules Verne, turned me on to sci-fi. The religious myths of C.S. Lewis are well covered but there is no assessment of the impact of L.Ron Hubbard, who founded a religion, or Cordwainer Smith with his quasi-religious sci-fi myths. Otherwise most of the better known sci-fi authors are included. Neither LS&S nor Amis mention the only sci-fi volume to ever earn a Nobel Prize for Literature: Hermann Hesse's Das Glasperlenspiel, which is a boring book anyway.

Close Encounters will continue to provide me with new maps to regions of interest and pleasure in sci-fi which I might, left to myself, overlook. The only problem is lack of time to read as many as I want. Oh for a 35-hour day!

Close Encounters is published under the Adam Hilger imprint by the Institute of Physics Publishing Ltd, and it costs 12.95 pounds sterling in paperback.

Colin Keay
Book Reviews Editor

Reviews

The Early Universe
E.W. Kolb and M.S. Turner
Addison-Wesley, 1990
xvi + 547pp, US$48.50 (hardcover)

The Early Universe: Reprints
E.W. Kolb and M.S. Turner (Eds)
Addison-Wesley, 1988
xvi + 719pp, US$56.95 (hardcover)

The reprint volume, reviewed by Colin Keay in the November 1988 issue so whetted my appetite for the monograph that I answered Colin's invitation for reviewers. My expectations of the monograph have been amply fulfilled. Both volumes should be in every university library, and a university with far-flung astronomers will need more than one copy of the monograph. Both volumes will be particularly useful to graduate students in astronomy and particle theory.

I have included the reprint volume in this review because each volume complements the other. The reprint volume includes papers on topics not covered in the monograph and has less emphasis on topics covered in detail in the monograph. For instance the Universe of the monograph is homogeneous and isotropic on a large enough scale, but the 58 page review Anisotropic and inhomogeneous relativistic cosmologies of M.A.H. MacCallum redresses the balance in the reprint volume.

It is a sign of the strong interaction between particle physics and cosmology that Kolb and Turner both have appointments at the Fermi National Accelerator Laboratory as well as at the University of Chicago.

The first five chapters of the monograph give a modern treatment of traditional baryon cosmology, although even here particle physics makes its presence felt. For instance both the abundance of baryon and the observed decay width of the Z constrains the number of quark-lepton generations. The final six chapters deal with more speculative topics arising from particle physics and include spontaneous symmetry breaking and phase transitions, the various versions of inflation, dark matter including WIMPS - weakly interacting massive particles, cosmic strings, domain walls, magnetic monopoles, instantons, axions, spherelrons and pyrgons.

The weaknesses and some of the strengths of these two volumes are due to being in the series Frontiers in Physics which includes the concept of an informal monograph, of which The Early Universe is a fine example. At times the reader, especially the non-specialist, might wish for a more polished and more definitive treatment of some topics. For instance, in the treatment of axions, the non-specialist reader will have to do a little work to realize that the axion is a pseudoscalar. On the other hand the informal approach facilitates the treatment of topics which are still rapidly changing, and gives us some occasional whimsical writing. After pointing out that certain topological entities are axionic strings, the authors write 'The reader who stayed awake while reading chapter 7' (on cosmic strings) 'must have anticipated this fact'. I did stay awake in chapter 7, my favourite chapter, but I confess I did not anticipate this fact although it is obvious after being pointed out. One other quotation I must make is from the introduction to the quantum theory of the Universe. 'While today the single-Universe approximation seems to be quite adequate - when was the last time you saw a Universe created or destroyed?'

A comparison of the monograph can be made with The Early Universe by D.
G. Börner, reviewed in the January/February 1990 issue. I think that Börner provides the better introduction to particle physics for the neophyte, but the non-astrophysics would find the treatment by Kolb and Turner of the implications of particle physics for astrophysics the better of the two. For instance, Börner's introduction to axions is probably as clear as anyone has made this topic (but axion strings are not included). Kolb and Turner give a very comprehensive treatment of the astrophysical consequences of axions.

L.J. Tassie
Department of Theoretical Physics
Australian National University

Classical Dynamics and its Quantum Analogues (2nd ed)
David Park
Springer-Verlag, Berlin, 1990
ix + 333pp, Dm78 (hardcover)

David Park is a professor of physics at Williams College in Massachusetts. His first love is clearly classical dynamics, the eldest and most elegant branch of physics. The core of his book is an exposition of this topic, including most of the elements of a standard text such as Goldstein. Planetary motion is treated in some detail. The development is not so concise and lucid as that of Goldstein, but some nice snippets of history are included from time to time.

Intertwined with the classical dynamics is a discussion of quantum mechanics, along parallel lines. Some elementary knowledge of both fields is assumed. He discusses the transition from wave optics to ray optics, and from quantum to classical mechanics. There is no discussion here, however, of the deeper questions in quantum mechanics such as Bell's theorem or the EPR paradox.

There are some pieces on modern topics, not to be found in older textbooks. An important one concerns Poincaré surfaces, the KAM theorem, and chaos, which no modern text on classical mechanics can ignore. Others discuss Berry's phase, the Aharonov-Bohm effect, and (of local interest) the Klein-Ozat experiment demonstrating a sign change under 2π rotations for the wave function of spin 1/2 neutrons. More peculiar is the choice of some topics from general relativity, which require some rapid hand-waving since of course there is no time to develop the theory properly.

Altogether, I feel the book is rather too diffuse and discursive to be useful as a textbook, but it does contain some new perspectives which will make it a valuable library reference.

C.J. Hamer
School of Physics
University of New South Wales

Metal-Insulator Transitions (2nd ed)
Sir Nevill Mott
Taylor & Francis, London, 1990
x + 286pp, UK£39 (hardcover)

The first edition of this book was published in 1974. The number of chapters has now been increased from six to ten, although the total length, as judged from the size and number of pages, is much the same. Two new chapters, dealing with high temperature superconductors and liquid systems respectively, have been added, and Wigner and Verway transitions now rate a chapter to themselves, as do a number of 'curious' systems such as magnetism-bismuth films, tungsten bronzes and lanthanum strontium vanadate. Developments in solid state theory affecting our understanding of the Anderson and Mott-Hubbard transitions have been incorporated, and the reference list has been updated and extended significantly.

Mott does not identify a target readership, but in my view this book remains essential reading for any physicist or physical chemist beginning research in the metal-insulator transition field. One of Mott's strengths as an author is his ability to outline the essential physics of the problem at hand in a very concise yet satisfying manner, using only elementary mathematics and undergraduate level quantum mechanics. This modus operandi is continued in the two new chapters; I found the introduction and the section on metal-ammonia in the liquids chapter particularly helpful.

Priced at around $100, group leaders might consider buying two copies, one for the lab and one for the office!

R.J. Fleming
Physics Department
Monash University

Physics for a New Generation:
Prospects for High Energy Physics at New Accelerators

H.Latal & H.Mitter (Eds.)
Springer-Verlag, Berlin
Heidelberg, 1990
xi + 306pp, DM 97 (hardcover)

This book contains written versions of invited lectures presented at the 28th Internationale Universitätswochen für Kernphysik in Austria, March 1989. It offers an excellent summary of the frontier of elementary particle physics, and its anticipated progress, as at that time. Of the lecturers whose material makes up the book, three are theorists and three experimentalists. The first chapter provides an illuminating summary of the Standard Model (SM), defining it in terms of a minimal set of assumptions, which are clearly set out, making some statements on its predictions, and followed by short statements on the testing of these assumptions. The material of supersymmetry, and searches for supersymmetric (SUSY) particles, are topics taken up by a number of the lecturers, and appear to be one >
BOOK REVIEWS

The Superfluid Phases of Helium 3

Dieter Vollhardt and Peter Wölfle
Taylor and Francis, London, 1990
xxi + 619 pp, UK £75.00 (hardcover)

The less common isotope of helium, 3He, was discovered by Oliphant, Kinsey and Rutherford in 1933. Although the superfluidity (the ability of the fluid to flow without friction) of 3He had been studied since the late thirties it was only in 1972 that superfluidity was reported to occur in 3He below a temperature of one thousandth of a degree kelvin by Osheroff, Richardson and Lee.

The 3He atom is composed of an even number of fermions, two electrons, two protons and two neutrons and hence has the composite properties of a Bose particle. Its superfluidity at 2 kelvin is basically due to a Bose-Einstein condensation in which nearly every particle occupies the lowest quantum state. In contrast, the 4He atom, with one less neutron, is a composite fermion, so bulk 4He cannot undergo Bose-Einstein condensation but behaves as a system of interacting Fermi particles, very like the electrons in a metal. The superfluidity of 4He results from a pairing between atoms in a manner analogous to the pairing between particles of electrons that occurs in simple superconductors such as lead, tin or aluminium, although in the case of 4He the pairing is due to the weak attractive Van de Waals force.

However, because the helium atoms cannot approach closer to one another than one atomic diameter each pair possesses a finite orbital angular momentum, and to make the pair wavefunction antisymmetric under exchange of atoms the nuclear spins must be in a spin-parallel (triplet) state, giving what is called p-wave pairing. The order parameter has 3X3 = 9 components, in contrast to simple superconductors where it has one. The nuclear spin of the pairs is able to couple to static and dynamic magnetic fields, and furthermore the non-zero orbital angular momentum of the pairs means that they can rotate about their centre of mass more easily in a plane parallel to the boundary of their container than perpendicular to it, producing an anisotropic boundary effects. All this gives rise to behaviour that is astonishingly complex and subtle.

Despite these difficulties a reasonably thorough theoretical understanding of the behaviour of superfluid 3He has been developed in the past fifteen years. This understanding is expounded in this monograph by two authors who have themselves made important contributions to the theory. The book starts with a general survey of the behaviour of superfluid 3He, gives an introduction to Fermi liquid theory and the theory of weak coupling superconductivity and then goes on to develop the sophisticated many-body theoretical techniques that are needed to describe this complex material. The mathematical theory of symmetry is used extensively to classify the many possible phases that might exist and their spatial textures. The book deals only with theory; a discussion of the clever experiments that were needed to discover and elucidate the behaviour of the superfluid is outside its scope.

The book appears to be comprehensive, up to date, and is likely to become a standard reference work on the subject. It is, too, magnificently well written. The authors succeed in explaining the physical basis of the theories simply and clearly. Their exposition is never a mere regurgitation of the original papers ('those copious, if muddy, sources' as J.M. Ziman terms them) but is illuminated by a sympathetic insight into the mind of the reader as she or he struggles to grasp the new and difficult ideas presented. Few people, except specialists, will want to read through the whole book, but several parts, such as the introductory survey and the introduction to broken symmetry can be read profitably by the general reader. The book should be in the library of every institution that conducts high level research in theoretical physics.

Since temperatures of one millikelvin are relatively unusual and superfluid 3He is a rare and expensive substance with no known applications, the authors are at pains to justify the amount of theoretical and experimental work that has been devoted to the subject. They point out that the techniques that have evolved to describe the complexities of superfluid 3He, as well as being a triumph of modern physical theory, may be applicable also to astrophysical objects, to heavy fermion superconductors and also to the much studied high temperature ceramic superconductors. The methods could also be applicable to the complex structured materials found in certain colloidal systems.

One interesting slant on scientific history emerges from the book. In the mid fifties Blatt, Butler and Schafroth, working at the University of Sydney, put forward a theory of the superconductivity of simple metals based on the idea of the Bose-Einstein condensation of charged bosons formed from paired electrons. Their theory did not attract wide support and was soon afterwards overwhelmed by the powerful and comprehensive theory of Bardeen, Cooper and Schrieffer who were later awarded a Nobel Prize for it. However the extensive work on superfluidity done since then, and described in this book, suggests that the two theories are in fact different ways of looking at the same thing, and that consequently the Australian workers may have received less credit than was their due.

Andrew Stewart
Department of Applied Mathematics
Australian National University

The Penguin Dictionary of Physics (2nd Ed)

V Illingworth (Ed)
Penguin (1990)
544pp A$17.99 (paper)

This new edition, an abridged version of the recently revised Longman's Dictionary of Physics, provides an up-to-date compendium of current Physics.
BOOK REVIEWS

Terminology used in Physics and a range of related scientific and technological fields.

The descriptions and definitions presented are generally clear, concise, and accurate and I found them eminently readable. The book provides good summaries not only of current terms but of many phenomena, theories, devices and instruments. In areas such as solid state physics where scientific advances in recent years have been considerable, I was delighted to find descriptions of current theories and devices including STM's and SQUID's. Although its size clearly precludes comprehensive treatment of all areas, geophysics and computing entries appear somewhat limited, but what is presented is at an adequate level for the informed, but non-specialist reader.

Efficient cross-referencing is employed throughout enabling one to follow up a topic in increasing depth. Minor omissions e.g. intersecting storage rings, do not detract from the high standard achieved overall. The presentation is such that I found it tempting to browse from one topic to another and I was rarely disappointed with the entries.

As a ready reference this book should appeal to both teachers and students of physics and to scientists and technologists working in research, industry and medical physics.

H.M. Kellyn
Department of Physics
Australian National University

New Books

Theory of Neutron Star
Magnetospheres, F. Curtis Michel
University of Chicago Press,
US$ 34.95 (paper)

Chaos/Xaoc: Soviet American Perspectives on Nonlinear Science,
D.K. Campbell
American Institute of Physics,
New York 1990. xvi + 496 pp
UK£ 21.75 (paper)

Journey to the End of the Universe,
C.R. Kitchin
Adam Hilger (IOP Publ), Bristol, 1990
ix + 198 pp. UK£14.95 (hardcover)

Laser Neting of Metals,
A.M. Prokhorov, V.I. Konov,
I. Ursu & I. Mihailescu
Adam Hilger (IOP Publ), Bristol, 1990
xii + 339 pp. UK£45 (hardcover)

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CONFERENCES & MEETINGS

1991

April 9
Opportunities in Carbon Technology
The Royal Australian Chemical Institute, Solid State Division
Dr. T. Turney, CSIRO Division, Materials Science and Technology,
Normanby Road, Clayton VIC 3168, Tel: (03) 542 2777, Fax: (03) 544 1128

April 29 - May 1
Advanced Materials - Opportunities and Developments Conference
First Call For Papers
The Conference Convenor, Institute of Metals and Materials Australasia Ltd.,
Suite 215, 191 Royal Parade, Parkville VIC 3052
Tel: (03) 347 2544 Fax: (03) 348 1208

June 5
Symposium on Propagation Effects in Communications, Sydney
To be held in conjunction with AUSSAT,CSIRO,OTC
and Telecom Research Laboratories
Dr Bruce MacA. Thomas or Carol D. Wilson
CSIRO Division of Radiophysics, Marsfield NSW
Tel: (02) 868 0264, Fax: (02) 868 0450

July 1 - 5
Gordon Godfrey Workshop on Strongly Correlated Electron Systems
Dr. D. Neilson, Physics, UNSW, Kensington NSW 2033
Tel: (02) 697 4564

July 15 - 19
Introduction to Optical Design Course
Continuing Education Office, Macquarie University, Tel: (02) 805 7470

July 23 - 24
Asian Physics Education Network - 200 Years Faraday’s Birthday Meeting
Registration: Professor Geoffery I. Opat, School of Physics,
The University of Melbourne, Parkville VIC 3052
Tel: (03) 344 5121, Fax: (03) 347 4783

August 7 - 16
PICXAM X-Ray and Surface Analysis Conference, Hawaii (including workshops)
Picxam ci- AXAA, PO Box 90, Parkville VIC 3052
Tel: Don Williams (03) 337 7211 or Brian O’Connor (03) 351 7192 or
Julius Bogi (02) 218 9530

Sep 29 - Oct 4
Australian Conference on Optics, Lasers & Spectroscopy – ACOLES ’91
Australian National University, G.P.O. Box 4, Canberra ACT 2601
Tel: 61-6-249 4244, Fax: 61-6-249 0029

Sep 30 - Oct 4
International Conference on Ion Sources (ICIS ‘91), Bensheim, W. Germany
B. Wolf, GSI, Postfach 110552, 6100 Darmstadt, W. Germany
Tel: 49-6151-359 320, Fax: 49-6151-359 785

1992

Jan 13 - 31
5th Physics Summer School: Atomic and Molecular Physics and
Quantum Optics, Canberra
B.A. Robson, Dept of Theoretical Physics, R.S. Phys.S.E., ANU, GPO Box 4,
Canberra ACT 2601, Tel: (06) 249 2971, Fax: (06) 249 4676

July 12 - 15
Twelfth International Workshop on Rare-Earth Magnets and their Applications -
Sponsored through the Department of Industry, Technology & Commerce by the
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