The Australian Physicist

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SEMINAR

THE IMPORTANCE OF CORRECT TEMPERATURE MEASUREMENT IN INDUSTRY

Date: Tuesday 1 August 1978
Time: 9 am - 1 pm
Place: Lecture Theatre, National Measurement
Laboratory, Bradfield Road, Lindfield NSW

An informal half-day seminar, to which industrial
management is invited, is being held to provide a forum
in which management can state existing problems in
fields relating to temperature measurement and indicate
areas in which they consider NML should provide
assistance. The present capabilities of NML in the field
of temperature measurement will be stated and inspected.

Speakers: Mr. C. D. Ashton-Martin, (Consulting
Engineer in Industrial Heating Equipment,
Sydney).
Dr. G. Green, (Australiun Iron & Steel
Pty. Ltd., Port Kembla).
Mr. W. R. G. Kemp (National Measurement
Laboratory, Sydney).
Mr. R. Llewellyn, (State Electricity
Commission of Victoria, Melbourne).

Information of this seminar can be obtained from Mr.
T. P. Jones, NML, PO Box 218, Lindfield NSW 2070
(telephone 467 6765).

Correction

In the article "Physics Publication in Perspective"
by D. E. Boyd in the April issue the following major
error occurred:
Top of page 40, Col. 1, line 5 'with' should read
'without'.
President's Column

Recently Hartley, King, Carras and Dallimore have reported on High Technology Industry in Australia\textsuperscript{1}. Their paper is an excellent summary of the depressing state of Industrial Research and Development in this country. They advance well argued reasons why we should have high technology industries, not the least of which is the fact that these are required for the intellectual life of the country.

Most of the arguments call for planning. The desirability of planning in technological areas in Australia has been debated for some years with little progress.

One of the major reasons for our present state is that we confuse science and technology. The words are often used together in phrases like “Science and Technology policy”, “Science and Technology Council”, “Academy of Technological Sciences”.

The use of these terms obscures the fact that science and technology are very different.

Planning science is dangerous and akin to planning the development of music, art and literature. It would, rightly, be regarded as absurd to do this.

The case of technology is very different. Here, questions of economy, social desirability, legal aspects, political factors are as important as the science we attempt to apply. In this area it is essential that we have a policy. It will be very much easier to resolve the question of planning if we make this distinction.


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one hundred and twenty two

This is the number of recommendations made by the Inquiry created to review the objectives, structure and programs of the CSIRO. The Prime Minister earlier in the month referred to it as the Birch Report but the noise and echoes of any report seem to depend on the manner and timing of its firing. Among the 122 recommendations a great number have found favour with the Government and there will be general agreement on many of the directions to be taken, but the Government has shifted away from what would seem to have been one of the prime recommendations of the Inquiry committee.

The creation of six Institutes from the Divisions based on commonality of interest is to be implemented but the Directors of the Institute are not to be ex-officio members of the Executive. Their role as far as the Executive is concerned is to be advisory only. Indeed a little further on the Executive is to receive its major source of advice from an Advisory Council. This in turn will receive its advice from State Committees etc. of the getting and receiving of advice there is to be no end.

This decision of the Government was made after ‘fully considering all aspects of this matter including advice received from ASTEC on the issue . . .’ Such a decision may well be the right one – only time will tell – but ASTEC can hardly be thought of as a disinterested party and there would be much more merit in the establishment of a Parliamentary and Scientific Committee (proposed by Ann Moyal in “Search”, Jan/Feb. 1978 and the subject of a letter by R. A. Joseph in the April issue of this journal) for consideration of issues such as CSIRO management. If ‘the main role of CSIRO is to be scientific and technological research in support of Australian industry, community interest and other perceived national objects and obligations’ it seems unwise to divorce some ‘very senior scientists’ from an Executive which is to be the recipient of the advice and opinion gathered from many levels of scientific, industrial and social groups around Australia.

Perhaps members of the AIP and CSIRO will write to this journal giving their views on some of these questions and others which arise from the new CSIRO initiatives and re-organisation.

Bill Boundy
SIR.

Having read the report "High Technology Industry in Australia" published in the March issue, I have felt it necessary to make some comment. This comment has become rather lengthy and still does not include much that could be said but will, I hope, show that some of the views expressed in the report are not shared by all physicists.

An initial comment concerns the membership of the working party which does not appear to include any industry member — surely this is a shortcoming when dealing with the subject of high technology industry. If indeed this report is to be incorporated in a policy statement from the Institute of Physics then it would seem essential to incorporate the views of physicists from industry.

The authors adhere to the fallacy that there is unidirectional flow from research to production. It would be difficult to be further from the truth for the processes of research, development, production and application are all closely interlocked with many and varied feedback loops. It is probable that much of the research in academic centres and in CSIRO is still-born for just this lack of understanding of the process of innovation.

Further, they suggest that Australia should move away from resource-based industries and concentrate on defined tertiary industries. On the other hand, in a competitive world it is necessary for us to concentrate on those areas where we have or can create an advantage and this leads to consideration of resource-based industries on the one hand and those requiring a highly skilled and educated workforce and probably high capital investment on the other. Perhaps these latter specifications coincide with the definition of high technology industry but that term is rather vague and not in itself sufficiently precise. Hopefully it is possible for us to select some specific industries in which we now have and can maintain "centres of competence" which will ensure us of world standing. It should be noted that "centres of competence" involve vastly more than research.

In discussing expenditure on research and development as depicted in SCORE the report in question credits the Business Enterprise Sector with $22M as its total contribution. This figure is in error by an amount of $200M. The figures in SCORE show that R & D expenditure by Business Enterprise was $228M as compared to a contribution of $222M, thus the real Government contribution to R & D in industry amounted to only $6M. Not a very significant incentive.

Reference is made in the report to the OECD ranking of expenditure and sources of funds of member countries on R & D and four charts are discussed. In these Australia occupies respectively 9th, 8th, 10th and 11th place of the 20 countries listed. The authors would have us believe that 9th is unsatisfactory, 8th is "comparable or better than most OECD countries", while 10th and 11th "indicate that the contribution from the business enterprise source in Australia falls well below other countries with which we wish to be compared". In the chart where Australia occupies 11th place the neighbour in 10th place is U.S.A.!

At the very best the authors' interpretation of these charts must be regarded as suspect and biased. International comparisons such as this are always difficult and should be regarded only as indicative of general trends. All that can be said is that Australia lies in the mid-range of OECD countries in expenditure of R & D. Whether or not this is the optimum cannot be decided by comparison with other countries but must be related to national objectives.

In the article being discussed here and in many other comments on Australian R & D it is suggested that we are too reliant on imported technology and that we should do a great deal more R & D here. Yet consideration of figures published for OECD countries shows that this is not necessarily so. Our population is about 2.1% of total OECD population and our R & D expenditure is 1.5% of the corresponding OECD expenditure. We must therefore expect that the overwhelming majority of technology used in this country will be imported. Even the doubling of our R & D expenditure, which may indeed be desirable, would not greatly change the ratio of imported to locally generated technology. Special emphasis should be given to items of particular significance to Australia for which the relevant technology cannot be bought. There is a major defect, more significant than the dollar expenditure, to be overcome in the R & D scene in Australia relating to the almost total spending of Government funds in Government laboratories. This inhibits the development of industrial research and development and prevents the flow of technology to industry. Some proportion of Government research will always have to be carried out in-house but if 60 to 70% of Government R & D funding were progressively transferred to industry a very much stronger and more effective R & D structure would result. In this way the R & D expenditure would be much more closely related to the organisation which can both define the R & D required and see that the results are applied as products or processes.

The authors also raise the subject of CSIRO or other Government agency becoming manufacturers when industry does not take up some development. This lack of enthusiasm on the part of industry is usually well founded and may be due to lack of market (inadequate market survey before R & D started) or to a market so small as to be unable to support manufacture. This is complicated by the fact that despite the small market the national benefit might be large. In this case development and manufacture should be done under contract by an established manufacturer not by an industrially naive Government agency.

One final point must be made in relation to patents, licences and their exploitation. If a Government laboratory such as CSIRO has developed a process or a product
on the basis of a national benefit then the return to the nation on that investment comes via improved user products and processes, employment, export earnings, improved environment etc. These produce both direct and indirect benefits which far exceed any royalties recoverable from an instrument manufacturer who may not himself reap any benefits from the product. Surely it is the function of Government Laboratories to carry out R & D on products of benefit to the nation and not to be regarded as profit centres based on royalty payments.

One general impression gained from the report is that the authors believe that the conduct of "proper research" as distinct from "specific problem oriented research" will in some way produce and maintain a high technology industry which is itself the solution to all Australia's problems.

It all sounds very much like the philosophy of the 1950's that pure research is a "good thing" and will always bring its own rewards. Unfortunately the "proper research" referred to by the authors is often better described as "curiosity research" and sometimes even as "hobbyism". This is hardly appropriate for the present time.

G. de V. Gipps, Ph.D., F.Inst.P., F.A.I.P.
Philips Industries Holdings Ltd., N.S.W.

SIR,
I was delighted to see extensive use being made of Project SCORE data in the report of the W.A. Branch Working Party on High Technology in Australia (Physicist, March 1978, p. 27). I would like to draw attention however to a misapplication of Project SCORE data within the report.

The report argues that as approximately 80% of R & D expenditure in the Transport and Fabricated Metal Product industries was spent on Experimental Development, and that as these two industries were responsible for nearly half the total R & D expenditure by Business Enterprise it appears "reasonable to conclude that the majority of R & D expenditure by the Business Enterprise sector cannot be classified as high technology". The conclusion may very well be true, but it does not follow from the Project SCORE data quoted.

Experimental Development, along with Basic Research and Applied Research, constitute a classification of R & D effort whose purpose is to give some idea of how close the R & D effort is to producing an innovation. This classification does not include the level of technology at all. In fact, the proportion of Business Enterprise R & D expenditure on Experimental Development is lower in Australia (60% over all industries) than it is in the United States (78%)².

The report also mentions that Australia is not participating in the most recent OECD surveys of R & D. I would like to explain that we skipped the 1975 survey (after participating in the 1973 survey using 1973/74 data) in order to facilitate timely participation in the 1977 (using 1976-77 data) and subsequent surveys. Although three years elapsed between the two most recent surveys, Project SCORE will be biennial from now on.

I have been requested by my Department to stress that the above remarks refer only to the references to Project SCORE data in the report, and do not imply any Department of Science view of its general philosophy, recommendations or conclusions.

Ian Maclean
Scientific Investigations and Information Section,
Department of Science


2. The U.S. figure refers to current expenditure only. The U.S. survey does not classify capital expenditure on R & D by Basic Research, Applied Research and Experimental Development.

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**Response from Varian**

SIR,

Your April edition carried a letter from D. B. M. Hartley which discussed an advertisement run by the Republic of Ireland. This advertisement implies, erroneously, that Varian is manufacturing atomic absorption spectrophotometers in the Republic.

All atomic absorption spectrophotometers sold by Varian are manufactured in Melbourne. It is true that we assemble two accessories at a Varian plant in Ireland, and we do that primarily to obtain tariff concessions into EEC countries which, in total, comprise a major part of our market. However, like our spectrophotometers, these products are totally researched and designed in Australia.

Varian Techtron, from its Australian base, is a major world supplier of atomic absorption instrumentation, selling to 130 countries. Its production processes include such sophisticated techniques as the ruling and replication of diffraction gratings and the production of hollow cathode spectral lamps. It is a totally Australian managed company and has a very real commitment to remain in Australia, despite the many advantages enjoyed by overseas based competitors.

We are grateful for Dr. Hartley's concern, and are happy to assure him that the design and production of atomic absorption (and UV-visible) instrumentation in Australia is alive and doing well.

Maxwell F. Spiller
Energy from oceans

The U.S. Energy Research and Development Administration (ERDA) will work with the Pirelli Company of Italy researching ways to use temperature changes in the oceans to produce energy.

The energy scheme envisages the production of electricity, from thermal energy, on floating platforms in the Atlantic. Pirelli has been given the task of designing cables to run underwater and transport the energy, at an average depth of 2000m, to the coast over 100 km away.

Installation of the first platform is scheduled for 1985. The cable network alone is estimated to cost $US50 million at today's prices. [Engineers Australia, February 10, 1978]

Declaration on Physics Education

"The Council of the European Physical Society meeting in Helsinki, and advised by its Education Committee, wishes to express its concern about the reduction which is occurring in the time and effort devoted to physics in secondary schools and in some European countries.

A sound knowledge of physics and mathematics is the basis for an education in both the natural sciences and technology. Knowledge and understanding of the physical world are essential components of modern culture. A continuation of the present tendency to neglect the learning of physics may therefore have a profound impact on the future of our civilization."

The above statement appears in Europhysics News, April 1978. In his address of welcome to the Council the President of the Finnish Physical Society, Vesa Fuuskanen made reference to the problem of maintaining a high scientific level in a small country. It is obvious that in such a country the effort which can be expended is not sufficient to maintain a high level of competence in all fields. In each country a selection must be made of those fields where physical and historical circumstances allow the greatest return to be made, relying on contacts with the outside world for current awareness of progress in other fields.

The Physics and Education Advisory Committee had been in conference over two days prior to the Council meeting. At present the committee is collecting and preparing data from 18 different European countries. For example, a survey of the views of 3000 physics teachers in the German Federal Republic has been conducted.

Attention is also being focused on teaching at university level and studies are in hand on the proper balance between research and instruction.

An editorial board was nominated for the new journal on education in physics which is to be launched by the EPS in collaboration with the U.K. Institute of Physics.

Whilst it may be apparent to physicists that a physics education is a sine qua non of a modern cultured man, concern was expressed by speakers from several countries that education authorities were drifting away from the principle and in some cases adopting policies which militated against a proper teaching of the basic fundamental laws that govern all matter, whether live or inert. It was said that physicists needed to speak up for physics for if they did not it would be assumed that there was tacit agreement with the tendency that seemed to be under way. [Europhysics News, Vol. 9, No 4, 1978]

From the 1977 CAP Congress

Physics in Canada includes an article on "High School Preparation for University Physics" by M. W. Johns of McMaster University. He comments on the much greater problems encountered in planning a symposium on physics education than when planning one on a "hard" subject like nuclear fission. The latter topic possess an obvious chronology marked by successive discoveries, the former does not.

Although the social sciences have taught us a great deal about the human mind, it is not at all clear that this knowledge really helps much when it gets down to the intensely personal relationships in which effective teaching is carried out. It is not clear that we today are doing a better job of teaching than did Aristotle.

Professor Johns mentions the conflict between the view of purpose of the university as held by the university itself and the view held by the general public.

In the thirties students in non-professional university courses at last realized that their degree would probably be of little value in the world of earning a living. Many parents even sent their daughters to the university when conventional wisdom indicated that this was a useless practice. The demands of the second world war and the social revolution which followed changed the universities overnight. For 20 years any graduate could choose between two or three jobs. University education was equated to earning power. The situation has now changed again.

There seems little agreement at present as to what provides a proper curriculum in physics for an undergraduate course – the situation in the high schools is even less clear. It is obviously impossible to do all things for all people. The universities blame the high school teachers – these, the primary teachers and the latter resort to blaming the parents who spoiled the children before they ever came to school.

In stating his expectations of graduating high school physics students Professor Johns includes:
(a) eagerness to learn,
(b) some knowledge of logical thought processes,
(c) some exposure to mathematical and physical subject matter, most importantly mechanics, and
(d) some knowledge of the real world phenomena discussed in terms of physics.

Finally he expects an entering university student to be sufficiently mature so that he knows why he is going to the university, how to concentrate on the work on hand, whether or not it is exciting and be able to dissociate the material being studied from his personal feelings concerning the instructor.

Finally Professor Martin concludes with a plea for more opportunities for university and high school teachers of physics to interact and he hopes that the Educational Committee of the CAP might help here.

[Physics in Canada, Vol. 34, No. 1, 1978].
Recent Advances in Photoelectron Spectroscopy

R. Leckey, Physics Department, La Trobe University, Victoria.

Photoelectron spectroscopy, in its modern form, is now ten years old. Originally applied to the study of electronic transitions in atoms and molecules at x-ray energies by the Uppsala group, it rapidly became clear that the technique could also be applied to the study of surfaces due to the short escape depth of the photo excited electrons. For most of the past ten years the topic has been artificially divided into two areas due to the availability of suitable photon sources (UPS, $\hbar \omega \lesssim 1500 \text{ eV}$) but the increasing use of synchrotron and storage ring sources has begun to break down this barrier. Similarly, the recent introduction of angularly resolved studies of solids has begun to reveal the true power of the photo-emission technique, i.e. the ability not only to reveal the density of occupied electronic states but now also to provide a detailed map of the E(k) band structure.

The present paper is intended to provide a broad overview of the recent development of photoelectron spectroscopy and to illustrate the present capabilities of the technique.

Photoelectron spectroscopy involves the study of the interaction of relatively low energy photons ($1 \text{ eV} \lesssim \hbar \omega \lesssim 2 \text{ keV}$) with matter by means of the energy analysis of the photoionized electrons.

Practical requirements include: a high intensity photon source, a high luminosity electron energy analyser/detector and an ultra-high vacuum (UHV) environment. Traditional photon sources include the resonance lines of inert gas glow discharges (He I, 21.21 eV; He II, 40.81 eV) for ultraviolet photoelectron spectroscopy, UPS, and the characteristic Al Kα and Mg Kα x-rays at 1240 eV and 1483 eV respectively for XPS. More recently use has been made of the synchrotron radiation generated by storage rings which provides a continuously tunable source spanning the UPS and XPS regimes with the additional advantage of being almost totally polarized. The high intensity available from such sources may be estimated from Fig.1, but presently available storage ring facilities suffer from the fact that they were not primarily designed for use as light sources and consequently the existing massive shielding implies a large distance from beam to experiment. Additional problems relate to the efficiency of available monochromators and to the build-up of an absorbing film of carbon on all reflecting surfaces. As a result of these constraint, storage ring sources are restricted to photon energies $\lesssim 280 \text{ eV}$ for photoelectron spectroscopy. The need for UHV arises from the short escape depth of electrons in most solids. For example, the inelastic scattering mean-free-path of electrons of energy in the range $10 \text{ eV} - 1 \text{ keV}$ in metals is less than 10Å, hence the need for atomically clean surfaces.

The energy distribution of electrons photoemitted without loss of energy from a solid by photons of energy $\hbar \omega$ may be conveniently written as [Shirley et al., 1978]

![Fig. 1 Spectral radiation from the Stanford storage ring, from Shirley et al. 1978.](image-url)
\[ N(E_{\text{h\nu}}) \propto \sum_{\mathbf{k}_i} |\phi_i(\mathbf{r})\rangle \langle A \cdot \mathbf{p} \rangle |\phi_i(\mathbf{r})\rangle |^2. \]

\[ \delta (E_f(\mathbf{k}_f) - E_g(\mathbf{k}_i) - \hbar \nu) \delta (E-E_g(\mathbf{k}_i)). \]

where the subscripts \( i, f \) refer to the initial and final states of the system (solid and photoelectron), \( A \) is the vector potential of the incident radiation, \( \mathbf{p} \) the momentum operator and \( \mathbf{G} \) a reciprocal lattice vector. The energy conservation \( \delta \) function is clearly universal but the \( \delta \) function implying momentum conservation is written here in a form suitable only for polycrystalline materials or for experiments which are angle integrating. We will see later how this must be modified in angularly resolved photo-emission.

Since the final state in the XPS regime is well removed in energy from the Fermi energy, it is often assumed that no structure remains in the density of final states, nor is the dipole matrix element expected to vary significantly over the width of a conduction band at such final energies. Neither of these assumptions may be made in the UPS regime and it is informative to use synchrotron radiation to monitor the transition from UPS to XPS. Figure 2 has been taken from the work by Shirley et al. [1978] on polycrystalline Ag, from which it may be seen that the relative 5d band intensity goes through a distinct Cooper minimum around \( \hbar \nu = 120 \text{ eV} \) leading to a reversal of the relative heights of the 3/2, 5/2-derived peaks in the spectra over the interval 100 eV < \( \hbar \nu < 150 \text{ eV} \), due to the rapidly decreasing cross-section for photoexcitation in this region.

We have yet to consider the extra information available. Assuming that the angular acceptance of the instrument is reduced to ± 2° and that the analyser may be placed so as to sample a selection of polar (\( \theta \)) or azimuthal (\( \phi \)) angles of electron emission from an oriented single crystal sample, we need to know if we may hope to extract the E(k) band structure of the initial state from the experimental spectra.

To see that this may be possible provided that certain conditions are met, we now examine a simple model proposed recently by Shevchik [1977]. In this model, the initial states are assumed to form a band of tight-binding states

\[ \psi_i(\mathbf{k}_i) = \sum_{\mathbf{R}_j} e^{i \mathbf{k}_i \cdot \mathbf{R}_j} \phi_{ij}(\mathbf{r} - \mathbf{R}_j) \]

where the \( \phi_{ij} \) are atomic orbitals centered on \( \mathbf{R}_j \). The final state is approximated as a single plane wave of momentum \( \mathbf{k}_f \) leading to an expression for the transition probability between \( \psi_i \) and \( \psi_f \) which factorizes into an atomic dipole matrix element \( a_{ij}(\mathbf{k}_f) \) and a sum over lattice sites. Thus

\[ P_i(\mathbf{k}_f) = a_{ij}(\mathbf{k}_f) \langle \psi_i | \sum_{\mathbf{R}_m} e^{i \mathbf{k}_f \cdot (\mathbf{R}_m - \mathbf{R}_i)} \psi_f \rangle \]

with \( a_{ij}(\mathbf{k}_f) = \langle \mathbf{k}_f | \mathbf{A} \cdot \mathbf{p} \rangle |\phi_i(\mathbf{r})\rangle |^2 \).

Incorporating thermal disorder via the Debye treatment modifies \( P_i(\mathbf{k}_f) \) to the form:

Fig. 2 (a) Photoelectron energy distribution from Ag for a selection of photon energies. Spectra have been arbitrarily normalized.
where the first term corresponds to thermal diffuse scattering (indirect transitions) and the second to direct (k conserving) transitions. The Debye-Waller factor $M = (k_f - k_i)^2 \Delta r^2$, with $\Delta r^2$ being the mean square thermal displacement from $R_b$, measures the relative strength of direct/indirect processes. In photoemission, unlike x-ray diffraction, $|k_f| \neq |k_i|$ and consequently indirect transitions dominate the spectrum if either $|k_f| >> |k_i|$ or if the temperature is high. For copper, Shevchik estimates that for $\hbar \nu = 40$ eV, 15% of all transitions are indirect, whereas at $\hbar \nu = 1500$ eV, the figure increases to 95% indirect. For the determination of $E(k)$ from photoelectron spectroscopy, the inference is thus that a relatively low (UPS regime) photon energy is necessary.

Although we have used a single plane wave as the final state for the purposes of the above argument, this has been shown quite conclusively by a number of workers to be inadequate for a complete theoretical description of the photoemission process [Shevchik and Liebowitz, 1977]. As shown by Pendry [1976] and by Mahan [1970], an adequate final state wave function is given by the use of a time-reversed LEED function which acknowledges the strong attenuation of the beam within the solid and its free electron nature far from the surface. LEED states are eigenstates of $k_f$, the component of electron wave vector parallel to the surface, but because of the broken symmetry due to the presence of the surface, are not eigenstates of $k_\perp$. We have thus a conservation rule for $k_\perp$ but not necessarily one for $k_\parallel$. The interpretation of an angular photoemission experiment then is presently based on the conservation of $k_\perp$ and the use of nearly free electron formulae to describe electron refraction at the surface. Thus:

$k_\parallel^2 = k_\perp^2 - k_f^2$

where $E_f(k_f) = \hbar^2 k_f^2 / 2m$. The photoelectron energy within the solid $E_f$ is matched to that outside the surface $E$ by means of an inner potential $W$ and the use of an effective mass $m^*$. At present some uncertainty in $m^*$ and $W$ exists and there is evidence that surface refraction can exceed the free electron estimate by as much as 30% in some cases [Williams et al., 1978]. Despite these problems it is clear from a rearrangement of the above formulae that

![Fig. 2 (b) Variation with photon energy of the relative d-band intensity of Cu, Ag and Au, showing a pronounced copper minimum for the Ag 4d band.](image)

![Fig. 3 Photoelectron energy distribution curves from the (100) plane of PbS, as a function of polar angle $\theta$ for $\hbar \nu = 21.2$ eV. Angle integrated spectra are also shown for comparison.](image)
once the external energy $E$ and polar angle of emission $	heta$ are measured, the internal $k_p$ is known via

$$|k_p| = \frac{\hbar}{2mE} \sin \theta$$

Fig. 4 Dispersion of $E$ with $k_{\parallel}$ for the conduction band of PbS from the results of Fig. 3. The theoretical curves have been calculated by Grandke, et al. as outlined in the text.

Fig. 5 The Brillouin zone of PbS showing one dimensional rods in the [100] direction responsible for structure in Fig. 3.

Grandke and Ley[1977] have studied photoemission from the (100) plane of PbS, their detector moving in the (010) plane such $k_\parallel$ lies in the (001) direction and $k_\perp$ in the (100) direction. Fig. 3 shows their results and Fig. 4 plots the dispersion of $E$ in terms of $k_p$. They argue that conservation of $k_\perp$ plays no part in the photoemission process and consequently that each spectrum represents a one-dimensional density of states
calculated along a rod in k-space parallel to \( k_\perp \) (Fig. 5). Peaks in their energy distribution curves therefore correspond to critical points (\( \partial E/\partial k = 0 \)) in this one-dimensional density of states which then enables identification of \( k_\perp \) by comparison between Fig. 4 parts (a) and (b).

The absence of certain branches of the theoretical band structure in Grandke and Ley's results implies considerable pre-selection by means of the photoionization cross-section. The most complete theory of photoemission yet published is due to Pendry [1976] and its application to Cu (001) by Pendry and Titterton [1977] is illustrated in Fig. 6. This calculation, based on a multiple scattering formalism in which the surface potential step, surface effects in both initial and final states and life-time corrections are included in an essentially exact one-electron solution for the Chodorow potential may be seen to provide good agreement at \( h\nu = 21.2 \) eV for a variety of polar angles \( \theta \) with the experimental data of Lloyd et al. [1976]. To obtain this agreement, however, Pendry and Titterton found it necessary to allow for a residual selection rule on \( k_\perp \), finding that \( k_\perp \) was typically uncertain to about ¼ of the Brillouin zone. This restriction on \( k_\perp \) is of obvious importance to the interpretation of future photoemission data and clearly needs further elaboration.

Despite the above comments and uncertainties, it is clear that angular photoemission studies are poised to provide detailed band structure information of a complexity not possible by any other technique.

In a review of this length it is clearly necessary to be overly selective. In this regard I have not included many areas of current interest which are very actively pursued at present. Of these I might mention (a) the use of polarized photon sources to study magnetic effects, (b) the exploitation of storage ring sources in the so-called constant-initial-state spectroscopy. (By adjusting both \( E \) and \( h\nu \) it is possible to map out the density of empty) final states by selecting a constant initial state energy, (c) the ever increasing use of traditional UPS/XPS techniques to study a vast array of problems including those of catalysis, surface absorption, alloy band structures and many more. In conclusion I think it fair to say that the technique of photoelectron spectroscopy is maturing rapidly but has certainly yet to stop growing.

References
The Ethical Dilemmas of the Physical Sciences

Patsy Hallen, Lecturer in Philosophy, Murdoch University, WA

This article has been based on a talk given to the W.A. Institute of Physics.

Gone are the good old days. No longer do the public hold optimistic views of science as the cure-all for social ills. No longer do scientists hold unguarded views of science as a panacea for humankind. For the first time in the history of science some high priests of science are themselves losing faith in the power of science to benefit humankind (Steneck, 1974). In a letter to Max Born in 1955, Einstein wrote: “In the present circumstances, the only profession I would choose would be one where earning a living had nothing to do with the search for knowledge”. Today, new knowledge opens Pandora’s box.

In speaking of the physicist’s part in the making of the atomic bomb, Robert Oppenheimer wrote in 1948 in The Bulletin of the Atomic Scientists: “In some sort of crude sense in which no vulgarity, no humor, no overstatement can quite extinguish, the physicists have known sin; and this is a knowledge which they cannot lose”. The bombing of Nagasaki and Hiroshima weighed heavily on the conscience of the makers of the bomb (Eslea, 1973). The image of science is very recently tarnished by its involvement in war.

Whatever the causes – be they philosophic or economic – there is a modern disenchantment with science. For whatever reason – be it the mistaken belief that the real frontier of science lies in biology or be it the poor current employment prospects for physicists or anything else – the enrolment numbers are down for the physical science in Australia and America. One reason is the romantic reaction of people like Theodore Roszak who represent the hippy, flower-power sub-culture. He claims that the scientific mentality is intrinsically alienating. If you want to nurture the environment do not enrol in environmental science. If you want to build a truly human world which is receptive to creativity and responsive to love, do not enrol in any science. For all science is life-destroying. Roszak’s thesis is an astonishing one – a blatant over-reaction. In my opinion to reject science and technology is to make a serious mistake – for I see science and technology as great vehicles of liberation – but Roszak’s following is surprisingly large and if one looks at him closely one can see the over-reaction. This, it is true, is an over-reaction to some well-founded complaints about the use of science and technology as vehicles of destruction, pollution and domination (Eslea, 1973), but it is misleading to point the finger at science, the tool, rather than at the users of the tool. Thus Roszak’s thesis, though wrong, alerts us to the ethical issues involved in science. What are some of the ethical dilemmas of the physical sciences and how should we deal with them?

Scientific work does not include normative issues even in the physical sciences, though the moral questions involved in the biomedical sciences – euthanasia, in vitro fertilization, iatroscopy, human experimentation, genetic engineering – are more obvious.

There are three levels of ethical dilemmas which a physicist must face – the ‘before’ dilemmas which surround the choice as to what research to undertake (secret research, research for military concerns, research funded by the military, research that will ‘pay’ or research to alleviate suffering); the ‘during’ dilemmas encountered within the research itself (moral problems concerning standards, fudging results, exploitation of students; and the ‘after’ dilemmas concerning the use of research results. Let us take one level at a time.

Just 30 years ago, government funding for science was practically unheard of in the United States. But in 1969, in the physical and biological sciences in the USA, 90% of the support for research was federal; and defence accounted for more than 60% of this (Brown, 1974).

Unlike the USA, the situation is different in Australia with most university research being funded by the ARGC. Government and defence involvement in research projects is comparatively minimal in Australia. We are unlikely to see in Australia anything like that famous University of Utah fire which revealed a secret laboratory on campus engaged in producing deadly diseases for the government arsenal. Still, ethical decisions about what kind of research to undertake must be taken. Would you, as a scientist, engage in secret research on weapons production, funded by the military? Would you, as an industrial scientist, work for Dow Chemical in fabricating a super-adhesive form of napalm? It is easier to ask these questions than to answer them. It is easier to answer them if you are a philosopher, rather than a worker for Dow Chemical and have a spouse and children to support.

This area of choice, it must be remembered, is limited. In the United States, out of 600,000 persons engaged in scientific research, not more than 5,000 were allowed to choose their research subject (Brown, 1974). So it is imperative to have a political rider concerning the structure of decision-making and democratization. Since over 90% of all scientists and technologists that have ever lived are alive today, determination of the extent of the control of the research and the extent of democratization needed are large but crucial tasks.

The solution to this level of ethical dilemmas should not fall simply on the shoulders of the individual scientist who does have a choice. Such a burden needs structural support and so should be shared by scientific institutes and societies. Examples of such participation can be found. The Society of Scientists and Engineers for Social and Political Action recently drew up the following pledge which was circulated internationally: “I pledge that I will not participate in war research or weapons...”
production. I further pledge to counsel my students and urge my colleagues to do the same”.

Physicists have a good record in this respect. At the end of World War II the Federation of Atomic Scientists was born and with it their journal Bulletin of the Atomic Scientists (now named Science and Public Affairs). It was dominated by physicists who were involved in the building of the atomic bomb and who felt the need to try and shape science policy, to help determine to some degree the kinds of choices with which individual scientists would be faced. They fought for the civilian control of atomic energy; they have worked toward world-wide arms control and participated in the debate over anti-ballistic missile weapons systems.

The point then is that we need a share of the social control of science — some say in what research programmes are to be funded. This point is complicated by the fact that it is difficult to predict how one’s research is to be used. Witness Arthur Galston’s work on triiodobenzoic acid and soybean protein which he undertook to aid the under-nutrition and malnutrition of the world’s people. Ironically his work was used to develop a defoliant in Vietnam, a war he morally opposed. Even though results can be unpredictable and possibly badly used this does not mean that the individual scientist, or the scientific community, or the public should wipe its hands of attempts to influence science policy or should overlook the ethical dimensions of research choice.

What about those moral dilemmas encountered during the research? R. S. Cohen postulates that it is an ethical act to be scientific. He argues that there is an internal ethic within science which derives directly from its own activity (Wartofsky, 1969). The ethic of science is the democratic ethic of a co-operative republic. Science has aspects of inter-independence. There are no elections for the leaders of science, yet implicitly the scientific community agrees to rules and acknowledges leaders while reserving the right to revolt and to reject anything lacking sufficient evidence.

But Cohen’s portrayal of science as a model of democratic living is an ideal only. Independence can be expensive and hard won and, as Ravetz points out, these democratic values can be exhibited in science only if certain necessary conditions prevail in the scientific community: excellent leadership and good morale. Otherwise science’s “organized scepticism” (not to believe anything without sufficient evidence) and its “communalism” (sharing of property) its “democratic ethic” breaks down. In the publish or perish syndrome the sense of sharing tends to be absent and the sense of intellectual property becomes acute. Ravetz also points to the increasing interpenetration of science and industry, and he notes that in such a situation, the safety of the product will more readily be sacrificed to the commercial prospects of the product (Ravetz, 1971).

The third and largest area of ethical dilemmas relates to the extent that physicists are responsible for their research, or for scientific questions which affect the public and upon which they are experts. This cluster of ethical dilemmas raises the more general question: what is the social responsibility of the scientist for research results and what form should it take? Galileo promptly and lucratively sold his telescope as a war instrument to the Venetian Senate. Leonardo da Vinci destroyed the flame-thower which he had invented because he feared that it would do too great a harm to mankind. To what extent should the scientist as a scientist be ethically responsible for how his or her research results are used?

In my opinion a scientist has a special moral responsibility distinct from a responsibility as a citizen. First, a scientist has a responsibility to provide advice to the public on such matters that relate to an area of expertise. Such politically neutral advice is becoming increasingly important in an era where people are no longer so ready to delegate authority to the experts. Authorities, who worked on the Fox report, specifically recommended that even on questions with complex technical aspects such as uranium mining, it is the public who must decide.

Certainly the involvement of scientists is growing and some fine examples can be found. The Institute of Physics running an Open Essay Competition for the most helpful contribution to a public understanding of uranium is one example.

The Scientists Institute for Public Information in the United States was formed in response to this need to provide advice to the public. The Institute believes that a well-informed public is the best safeguard against scientific abuses by government, and certainly the moratorium on genetic engineering called by the citizens of Boston bears witness to the truth of this belief. There is also in America the Society for Social Responsibility Science which aims to educate scientists to their social responsibilities and to their responsibility for communicating their opinions on technical matters which affect the public — proclaiming the benefits, warning of risks and indicating the grey areas of quandaries.

But there is a second side to the social responsibility of scientists. Scientists need not just be potential information sources for the public. They also need to be a political force. Galbraith speaks of the need for the scientific estate to emerge as a political force (Easley, 1973). Despite the tarnished image of scientists, their political clout is considerable, for they still hold a place of prestige in the community.

Certainly since 1945, this has been happening. In 1958 a petition drafted by Linus Pauling and signed by 9,000 scientists asked for a ban on all nuclear tests as a first step to general disarmament and was presented to the United Nations. Physicists score highly in this area of political involvement, and this is revealed by Easley’s figures breaking down faculty protestors to the Vietnam War into their respective disciplines. (Figures obtained by dividing the percentage of academics in the discipline by the percentage of academics in general who protested).

<table>
<thead>
<tr>
<th>Field</th>
<th>Percentage of Academics Protesting</th>
</tr>
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<tbody>
<tr>
<td>Physics</td>
<td>2.53</td>
</tr>
<tr>
<td>Social Science</td>
<td>2.51</td>
</tr>
<tr>
<td>Medicine</td>
<td>1.37</td>
</tr>
<tr>
<td>Humanities</td>
<td>1.27</td>
</tr>
<tr>
<td>Mathematics</td>
<td>1.27</td>
</tr>
<tr>
<td>Biology</td>
<td>0.85</td>
</tr>
<tr>
<td>Chemistry</td>
<td>0.54</td>
</tr>
<tr>
<td>Education</td>
<td>0.18</td>
</tr>
<tr>
<td>Business</td>
<td>0.10</td>
</tr>
</tbody>
</table>

There was political action taken by scientists across America in 1969. It was initiated by a research strike at M.I.T. — to take a day off and look at the directions of science — and the idea was taken up by 30 other American Universities, including Cornell, Columbia,
Yale, Stanford and Berkeley. Again, the Scientists and Engineers for Social and Political Action were politically active in the anti Ballistic Missile (ABM) system debate. In an unprecedented action, over 200 physicists walked to The White House in 1969, picketed it and presented a petition to the then President Nixon which reads: “Mr President, We as scientists and citizens urgently seek the withdrawal of plans to build and employ the Safeguard ABM system. Our concern springs from two basic sources: (1) As scientists, we are wholly unconvincing that any presently proposed ABM system can defend against a determined missile attack. (2) As citizens, we deplore the beginning of a particularly dangerous, yet ultimately futile round of nuclear arms escalation when our expanding domestic crisis demands a relaxation of the national resources”.

So some individuals and some groups have assumed social and political responsibility as scientists. Others have been more wary. When a Chapter of the American Society of Micro-biologists (ASM) attempted to disband that Society’s Advisory Committee to the military, many members based their objections to the move on the grounds that it contained implicit statements of an “ethical” nature which were outside the rightful province of a professional scientific society. In a letter to Science, one member of the ASM said that “morality is a sometime thing” and that “to take a moral stance... is perhaps the last refuge of a scoundrel”. The point is that the ASM were already morally involved!

Others are a bit more callous. One engineer quoted by Marcuse said: “My real love is minimum weight structures... but I am willing to work on minimum cost structures on how to kill the Russians better because the organization survives by doing research that’s saleable” (Marcuse, 1964).

As Toulmin says: “The walls of the scientific monastery are down and the cold winds of moral ambiguity are blowing through its rooms” (Steneck, 1974).

For the scientist there is an ethical imperative. In the same sense that Socrates said: “The unexamined life is not worth living”, so the scientific ethic should declare: Unexamined science is not worth doing. Scientists have not just an epistemic responsibility to truth but an ethical responsibility to consider on moral grounds the kind of research in which they engage within science and to take responsibility for the decisions of great scale and urgency which science necessitates. But it is not just the scientists who have this responsibility; so do the public and so do philosophers. As Jacques Monod said in 1971: “One of the most urgent duties of scientists and philosophers is to contribute to a reunification of their fields”. For, after all, science and philosophy were born together in ancient Greece, and were indistinguishably up until the 18th century. Philosophers must seek to make their discipline once again life-relevant and rather than obscuring the obvious, address moral questions of practical importance and link up again with an old ally: Science.

It is for this reason, then, that I have had the gumption to address you. Perhaps I have stimulated some thought. Perhaps I have sometimes been right. This is not too difficult for, as G. K. Chesterton remarked: “A person must know a great deal to be always wrong”.

References
Easlea, R. (1973), Liberation and the Aim of Science
Marcuse, H. (1964), One Dimensional Man
Ravetz, J. R. (1971), Scientific Knowledge and Its Social Problem
Rozsak, T. (1960), Ethical Values in the Age of Science
Steneck, M. (ed.) (1974), Science and Society

Backsets of Periodicals
Dr. Colin Kerr Grant has available some long runs of physics journals which may be of interest to members of AIP or to Libraries and Institutions.

Among the periodicals available are the following:

Science Abstracts (Section A) from Vol 1 to Vol. 52 but with Vol. 10, half Vol. 11 and Vols. 21-23 missing; Also Physics Abstracts Vol. 65-72.
The Geophysical Journal almost complete.
Geophysical Prospecting, complete except for one part.

Journal of C.S.I.R. Vols. 1-20 with one part missing; and in addition runs of:
Monthly Notices of the Royal Astronomical Society
The Observatory,
Quarterly Journal of the Royal Astronomical Society,
Journal of Geophysical Research, (solid-earth only),
Australian Journal of Physics,
Physics Bulletin,
Geophysics etc.

Dr. Kerr Grant will send a complete list to anyone who is interested and such persons should write to him at the Department of Geology, University of Melbourne, Parkville, Victoria 3052.
A Novel Coincidence Experiment
J. Higinbotham, Department of Physics,
Schuster Laboratory The University, Manchester

Introduction
Radioactive isotopes are widely used in various medical diagnostic techniques and we decided to demonstrate a possible practical application of coincidence spectroscopy (Melissinos, 1966) to our students in the Advanced Physics Laboratory. By some means a radioactive isotope, which emits annihilation radiation, is supposed to have been injected into a cancerous tumour in a human head. The students are asked to locate the tumour and to determine its size using a standard coincidence circuit. Perhaps because of its apparent relevance our students have found this to be one of our most interesting experiments.

![Coincidence circuit diagram](image)

Fig. 1 Coincidence circuit. The symbols have the following significance.
HV — high voltage power supply
AMP — linear pulse amplifier
TSCA— timing single channel analyser
SC — scintillation counter
COIN — coincidence unit
S — source

Theory
The $^{11}$Na nucleus decays by $e^+$ decay. Each positron emitted in this process later slows down until almost at rest and annihilates with an electron,

$$e^+ + e^- \rightarrow \gamma + \gamma$$

In order to satisfy the requirements of conservation of energy and momentum, to a good approximation the two gamma rays produced are of equal energy and travel in opposite directions. Since the two gamma rays appear at the same time they can be readily detected by the coincidence circuit shown in Fig. 1 provided that the two counters are placed 180° apart and are in line with the $^{11}$Na source.

Experimental
The $^{11}$Na nuclei were produced in two glass marbles by irradiating them by bremsstrahlung radiation produced by a 30 MeV linear accelerator. The marbles were placed on perspex rods held in place by O-rings. The rods could be placed in different holes and set at heights varying over 110mm as shown in Fig. 2. The students were told that they were to locate a mock radioactive tumour, but were not given any further details. Using a Ge(Li) counter, 1024 channel pulse height analyser and x-y recorder, the $\gamma$ ray spectrum showed that the $\gamma$ rays emitted from the tumour were due almost entirely to $^{11}$Na. Next the arrangement shown in Fig. 3 was then used to map the location, size and shape of the tumour. The approximate location of the tumour was determined without any collimation. In order to measure the boundary of the tumour to an

Fig. 2 Method of positioning the radioactive marbles.

Fig. 3 Arrangement for determining the location of the tumour.

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Fig. 4 Typical result of locating the tumour. The boundary of the tumour corresponds to the counting rate being equal to half the maximum counting rate.

accuracy of $\sim 1$ mm, the lead blocks with 9 mm diameter holes were placed in front of the counters as shown in Fig. 3. The model head could be displaced horizontally and vertically and it could also be rotated through $360^\circ$. The location of the tumour was expressed in cylindrical units and a typical result is shown in Fig. 4.

Discussion
A careful measurement enabled the centre of each part of the tumour to be located within $\sim 1$ mm. The actual location was checked by observation through the lead collimators. Unfortunately, it was found necessary to place a lock on the head to prevent students locating the tumour visually. The novel nature of this experiment and the possibility of practical application aroused a keen interest in the students performing the experiment.

Acknowledgments
I wish to thank Mr. A. Valler for making available the original version of this experiment, Dr. H. W. Taylor for designing the present form of the experiment and Mr. Alex Campbell for constructing the apparatus.

Reference

Professor Street's movement West
Professor Robert Street has relinquished his position as Director of ANU's Research School of Physical Sciences to accept the position of Vice-Chancellor at the University of Western Australia.

Professor Street has an extraordinarily wide range of academic interests. He has said: "This is the way I would see physics in the future proceeding. It cannot be compartmentalized. It must take broad views. The possibility of bringing to bear on a wide range of problems new fields and new thinking is exciting. I think the real enemy of this entrenched attitude by compartmentalized thinkers".

This compartmentalized thinking, Professor Street believes, can be accentuated by large scientific installations, and the expensive facilities needed for much scientific experimentation.

Professor Street feels that there is now, more than in the past, a more critical approach to spending and resource allocation. He thinks that, on the whole, this is a good thing.

On his move he says, "I shall certainly miss laboratories and workshops - but then you can't have everything in life" [ANU Reporter, Vol. 9, No. 1, 1978].

Warning on European Science
If support for small-scale basic research in Europe continues to be squeezed as a result of larger proportions of dwindling budgets being devoted to large scale undertakings, the development of scientific research would be stifled at its point of origin. This warning is contained in the recently published third annual report of the European Science Foundation. Sir Brian Flowers, President of EFS, says that this danger is compounded by the shortage of posts at universities and research institutes for the appointment of young research workers.

The Royal Society has been concerned about the reduced level of support for university research and its effects on young scientists in the U.K. and has decided to use a number of its professorships and fellowships to support outstanding younger scientists. Similarly the EFS now proposes the creation of modest fellowship and workshop schemes to provide support for young researchers to travel and carry out research abroad and enable small groups of scholars to meet for short periods of time to discuss specific topics. [Physics Bulletin, March 1978].
Conferences and Courses

Groundwater Pollution, Perth, February 19-23, 1979
The Australian Water Resources Council is holding the conference and information may be obtained by writing to AWRC, Ground Water Pollution Conference, Department of National Development, P.O. Box 5, Canberra, ACT, 2600.

International Conference of Women Engineers and Scientists, France, September 4-8, 1978.
Information may be obtained from Patrya Symonds, Conference Department, IEA, 11 National Circuit, Barton, ACT, 2600.

Strength and Structure in Carbons and Graphites.
A meeting of the Joint Carbon and Graphite Group of the Institute of Physics and the Chemical Society, in collaboration with the Industrial Carbon and Graphite Group of the Society for Chemical Industry will be held at the University of Bath, from 4-6 April, 1979.

The purpose of the meeting is to focus attention on those structural factors which limit the strength and related mechanical properties of carbons and graphites in their different environments. Offers of papers with a 300 word abstract in camera-ready form suitable for Photo-litho reproduction should be sent by 30th September, 1978, to the Conference Secretary, Dr. B. McEnaney, School of Materials Science, University of Bath, Claverdon Down, Bath BA2 7AY.

Further details may be obtained from The Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.

Electrostatics 1979
The Static Electrification Group of the Institute of Physics is organizing a conference on Static Electrification at St. Catherines College, Oxford, from 17-20 April, 1979.

The programme will be divided into five sections: Applications, Hazards, Fluids, Solids, Measurement Techniques and Atmospheric Electricity. Contributions are invited and a preliminary title should be sent to Dr. J. F. Hughes, Department of Electrical Engineering, University of Southampton, 509 SNH by September 15, 1978.

For further information write to The Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.

Nuclear Structure and Elementary Particle Physics
A preliminary notice has been received indicating that an Institute of Physics Conference on the above topic will be held at the University of Birmingham from 28-30 March, 1979. More details will be available later.

Solid State Physics
The 16th Annual Solid State Physics Conference organized by the Institute of Physics will be held at the University of Warwick from 3-5 January, 1979. More details will be available later.

Application of Machine-Aided Image Analysis
The Material and Testing Group of the IOP in association with Harwell Laboratory and sponsored by EPS will hold a Symposium on the above topic at Oxford from 4-6 September, 1978.

Tutorial Review papers will be given on: Basic Techniques, Pattern Recognition, Scene Analysis, Methodology and Implementation, Visual Perception. The contributed papers will present only recent, novel and outstanding work, as the conference is intended primarily for specialists. Further details may be obtained from The Meetings Officer, Institute of Physics, Belgrave Square, London, SW1X 8QX.

Alcohol Fuels
The Institute of Chemical Engineers (NSW Group) is organizing a three-day Conference on Alcohol Fuels to be held at the Sebel Townhouse, Kings Cross, Sydney from 9-11 August, 1978.

Papers are being invited. The Conference fee is $125 and includes preprints and meals. Further details from Dr. D. J. McCann, Department of Chemical Engineering, University of Sydney, NSW, 2006.

British Association for the Advancement of Science
The 1978 meeting will be held in Bath on 4-8 September. Information: Miss J. H. Dring, BAAS, 23 Saville Row, London W1X 1AB.


Computational Physics Conference (Atomic and Molecular Physics) 12-15 Sept 1978, Nottingham. Information: R. L. Hudson, Mathematics Department, University of Nottingham, University Park, Nottingham NG7 2RD.


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**Treasurer:** Mr R. E. Price  
**Committee Members:** Dr J. Cornish  
Mr N. Forrest

# NUCLEAR AND PARTICLE PHYSICS GROUP FOR 1978

**Chairman:** Professor J. O. Newton  
**Vice-Chairman:** Professor L. Peak  
**Immediate Past Chairman:** Dr R. B. Taylor  
**Hon. Secretary:** Dr J. T. Taylor  
**Treasurer:** Dr P. C. Tandy  
**Newsletter Editor:** Dr I. F. Bubba  
**Committee Members:** Professor A. Stamp  
Dr T. Ophel  
Dr J. R. Bird  
Dr R. F. Barrett  
Professor B. M. Spier  
Professor B. H. J. McKellar
President: Professor T. M. Sabine, FAIP
Vice-President: Professor H. C. Bolton, FAIP
Hon. Treasurer: Dr. C. J. Howard, MAIP
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NSW Dr. R. E. Collins
Q’land Dr. R. B. Gardiner
SA Dr. E. Murray
Tasmania Dr. J. E. Humble
Victoria Professor K. D. Cole
WA Dr. J. Black
Past President Dr. J. G. Campbell, FAIP

CHANGES IN MEMBERSHIP FROM DECEMBER 1977 UNTIL MAY 1978

FELLOW
New Elections
R. J. Bray (NSW) A. N. McKee (Tas)
M. J. Buckingham (WA) J. Unsworth (NSW)
R. O. Jones (O’seas) J. J. Deane (NSW)
Transfers
B. C. H. Wendlund (Vic) M. H. Repacholi (O’seas)
K. J. W. Lynn (WA) J. W. Ziliman (Vic)
S. J. Raycham (Vic)

MEMBER
New Elections
J. E. D. Barker (WA) C. W. Latey (Tas)
A. P. Campbell (NSW) A. D. Martin (NSW)
N. R. Heckenberg (Qld) J. R. Rankin (WA)
R. G. Heydon (NSW) D. F. Ward-Smith (Vic)
D. A. Jones (O’seas) B. J. Wilkinson (Vic)
R. J. W. Lake (NSW)
Transfers
A. Harrison (NSW) M. T. Prosser (WA)
R. E. McLaren (Qld) P. J. Rye (WA)
M. A. O’Keefe (O’seas) J. W. Connolly (NSW)
Reinstatements
M. A. Folkard (NSW)

GRADUATE
New Elections
B. A. Amir (O’seas) J. Hageyriakou (Vic)
I. A. Amari (NSW) R. P. Harrison (NSW)
T. P. Bevan (Tas) P. J. Higgins (Vic)
H. A. Buxton (Vic) C. H. Law (Vic)
M. A. Cavey (Vic) T. J. McKenna (ACT)
C. A. Cornwell (Vic) C. D. Matthes (NSW)
A. J. Dornans (Vic) G. J. Milstead (Vic)
M. C. Duldig (Tas) Z. Ninkov (Vic)
P. Golding (Vic)

Transfers
M. Brandt (NSW) S. P. Murby (Vic)
P. W. Gorman (Vic) A. P. Murray (Tas)
R. K. Graham (Qld) C. R. Paige (Qld)
P. A. Heuer (NSW) L. J. Rikus (Vic)
A. Langenegger (NSW) J. S. Sandt (NSW)
R. R. Moore (O’seas)

Reinstatements
F. Baglioni (WA) G. W. Thickbroom (WA)

ASSOCIATE
New Elections
J. Bombardieri (WA) J. M. Reid (SA)
E. L. Daly (Vic) M. R. Seery (NSW)
S. Elias (WA) B. R. Wolff (Qld)
S. T. Gibson (Qld)

Transfers
I. A. Papadopoulos (Vic) T. P. Rogers (Vic)

STUDENT
B. G. Ackland (Vic) M. E. Meneghelli (WA)
J. M. Cadogan (Vic) A. F. Parkinson (NSW)
S. A. Fysh (Vic) N. Whentley (WA)
V. B. Hill (Vic)

SUBSCRIBER
N. J. Forrester (WA) D. K. Gay (NSW)

ADDRESS UNKNOWN

Would any member knowing the current address of persons on the list below please inform the Honorary Registrar, c/- Science Centre, 35-43 Clarence St., Sydney 2000.

Name Membership Number Last Known Postcode
DR. J. C. BYRNE MAIP 1318 W.A. 6018
MR W. J. CHANG GAIP 2086 VIC 3168
MRS H. L. COMPORT GAIP 1774 VIC 3174
MR. T. A. CUMPSON ST. 754 ACT 2614
MR R. DAVIS MAIP 393 W.A. 6009
MR. D. W. FAULKNER GAIP 534 S.A. 5108
MR T. S. GRACE GAIP 1423 N.S.W 2351
MR S. G. LUSBY FAIP 164 QLD. 4007
MR A. J. OATES ST. 758 QLD. 4650
MR R. M. R. YARDELEY ST. 784 VIC 3185

The Institute regrets the inclusion in the last list of Unattached Members of Prof E. H. Carman, who was overseas on study leave.

J. G. COLLINS, Hon. Registrar
Australian Conference on Electron Spectroscopy
La Trobe University
Melbourne, Australia
22-25 August 1978
INFORMATION: Dr. R Leckey,
Physics Dept. La Trobe University,
Bundoora, Victoria 3083.