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Registered for posting as a periodical—Category C
Applications are invited for the above positions, vacant on 3rd February 1975. Consideration will be given to appointments under either of the following categories:

1. A graduate possessing a good honours degree and wishing to proceed to research for a higher degree. A successful applicant will be required to undertake the equivalent of 12 hours teaching, including laboratory demonstrating and tutorial marking each week throughout the year and will be expected to undertake research in a field of interest to the department.

2. A graduate possessing a higher degree wishing to combine teaching with research in one of the fields of interest to the department. Duties will involve supervision of under-graduate laboratory classes, and/or conducting tutorial sessions and may include some lecturing. The position will involve approximately half-time on teaching and half-time on research throughout the year.

FIELDS OF RESEARCH INTEREST:
Ionization in gaseous plasmas, pulsed gas and tunable dye lasers, experimental and theoretical solid-state physics, chemical physics, musical acoustics, ionospheric-magnetospheric physics, geomagnetism, solar-terrestrial relations, solar energy and thermoelectric studies.

SALARY:
Teaching Fellow $5,985-$7,285.

Conditions of employment provide assistance with travel and removal expenses.

Further information may be obtained from the staff officer, with whom applications, together with a recent photograph, and the names and addresses of three referees close on 31st October 1974.

ARMIDALE N.S.W. 2351.
CAN THE AIP DO SOMETHING ABOUT POSTDOCTORAL EMPLOYMENT?

Academic staff — particularly physicists — in Australian Universities can hardly avoid feeling somewhat guilty that they were themselves born to be 'post-docs' in happier times when Fellowships, and later permanent employment, were readily available and attainable by most on graduation. Perhaps the most depressing aspect of the present chronic job shortage lies in the need for present-day graduates to make scores of applications, often with little hope of success. Post-doctoral fellowships are fewer, though still available, but many have wisely chosen rather to take permanent employment in non-research positions. Consequently some really able researchers may never have a chance to try their initiative in their chosen field. This is surely bad for future academic standards.

Recognising these problems, the American Institute of Physics, hereafter designated AIP (US), has mounted a quite elaborate job placement service in which intending employees register their qualifications and interests for wide distribution among appropriate would-be employers. This note is an attempt to interest AIP members in the mechanics of this service, and its possible extension for the benefit of graduates in Australia.

The AIP (US) system, called "Doctoral Employment Information Service" (DEIS), makes available application forms in which a candidate documents in detail his personal details, academic career, past employment and names of referees. From such records, a computer-aided list is compiled into "Resource Volumes" which are made available, for nominal (non-obligatory) fees (currently US$25 per specialist field), to a wide range of employing institutions. Applicants need not be AIP (US) members, though obviously the existence of the scheme must to some extent encourage such membership.

Provided AIP (US) approval could be obtained there appears to be no reason why application forms for DEIS could not be made available to job applicants in Australia, although as it stands the scheme is little known here and would need some local advertisement.

Certainly it would be an improvement to see more of our PhD's placed in US jobs that match their qualifications. The AIP (US) could also be requested to make the "Resource Volumes" available to Australian employers. It seems reasonable that the AIP might interest itself as an agent in encouraging PhD-granting institutions to advertise the scheme, and arranging the supply of the Resource Volumes to Australian Universities, Colleges and Government agencies which are interested in employing PhD's.

The suggestions outlined above are intentionally phrased in tentative terms and undoubtedly could be improved by interested members' suggestions. It seems there would be nothing to be lost by Australian participation in the scheme — the employment position in USA is sufficiently bleak to rule out any appreciable brain drain — and a quite likely result might be an increased interest in AIP membership, as well as a boost of morale among our much-beleaguered PhD students.

TACHYONS AND BRADYONS

Are tachyons produced by cosmic rays?

There has been considerable interest lately among Australian physicists in the topic of faster than light (tachyon) speeds. R.W. Clay and P.C. Crouch (Physics Department, University of Adelaide) recently reported the results of experiments on cosmic ray air showers which provide possible evidence for the production of tachyons — particles travelling with velocities greater than that of light [Nature 248, 28-30 1974].

At the Adelaide congress in May Clay described the apparatus used. Their experiment consisted of the detection of showers with energies of the order of $10^{14}$ eV and a search for non-random events in the period just before the arrival of the shower front at the detectors. Cosmic rays interact with nuclei in the upper atmosphere at a typical altitude of 20 km. The resulting shower travels towards the earth with a velocity very close to c so that the transit time is typically 60 μs. If tachyons are produced in the initial interaction, they could reach the ground with any lesser travel time, i.e. up to 60 μs before the arrival time of the main shower front.

Clay and Crouch used a digital transient recorder to sample the output from a plastic scintillator at 1/2 μs intervals; and to retain the latest 256 such measurements. When an air shower was detected (using additional plastic scintillators in a 30 m square array) the previous 128 μs of transient information was recorded on a chart recorder.

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Inspection of events occurring before approximately 1300 air showers showed departures from a random distribution in time for the largest pulse observed in the 128 μs before the air shower arrival. Equipment tests of various kinds failed to account for the departure which a chi-squared test showed had less than 0.1% probability of occurring for a random distribution.

This experimental result may be interpreted as possible evidence for tachyons although, of course, many questions arise and much more experimental information is required to clarify the possibility.

**How does a tachyon interact?**

C.A. Hurst pointed out some difficulties in incorporating tachyons into the framework of relativistic particle theory.

"The only certain thing about tachyons is that they go faster than light and that is as solid a piece of information as the statement that a unicorn has one horn. Any further properties like charge, mass, spin or statistics are without any basis of solid theory and so the search for tachyons has to rely on somehow determining that ν > c has been observed.

"One way in which it would be hoped to show this would be to show the presence of Cerenkov radiation emitted in vacuo, by analogy with the case of a bradyon (subluminal particle) moving in a medium with velocity v > c/n, where n is the index of refraction. The crude theory of the latter integrates Maxwell's equations for the electromagnetic field in the presence of a point charge moving with constant velocity and show that if the above condition is satisfied then radiation is emitted. Of course under such circumstances the velocity will change because of the radiation reaction, but to a first approximation it is not unreasonable to assume that the velocity is constant. The corresponding argument for tachyons then consists merely in putting n = 1 and carrying the argument through as before. But this is not really a consistent thing to do because the classical theory of Cerenkov radiation is only an approximation to what is actually happening. In the presence of a medium a charged particle will undergo numerous scatterings with the consequent possibility of the emission of bremsstrahlung and the total effort of all this is as if it was radiating whilst moving with constant velocity superluminal in the medium.

"The analogy with the tachyon is obvious, but a careful calculation has not yet been carried out. In accordance with the principle that uncaused motions are not acceptable, the tachyon in empty space should travel with constant velocity. The simplest four-vector equations of motion which can be written down do admit a solution with constant velocity, but it is not yet obvious whether such equations are consistent with Maxwell's equations.

"Of course it would be better to go over the quantum theory in order to do it properly, for even the case of classical Cerenkov radiation only receives its proper justification when treated by the methods of phenomenological quantum electrodynamics. But attempts to construct even a consistent free field theory of tachyons have not produced a generally accepted solution. The problem is that the annihilation of a tachyon in one frame of reference would appear as the creation of an antitachyon in another frame so that if the vacuum is defined as a state in which no tachyons can be annihilated with respect to one frame, it will appear as a state in which no antitachyons can be created in another frame and such a state is difficult to accept for bosons. If one tries, as Feinberg did, to regard tachyons as fermions, even when their spin is zero, then although the vacuum can be well defined it will no longer be Lorentz invariant, and this failure of Lorentz invariance appears as a divergence. In this attempt and others, only tachyons for which the momentum had a minimum magnitude |p| > mc were admitted, and although this led to propagation with superluminal velocities its relativistic invariance was suspect. If, on the other hand, |p| = 0 was all that is required (which would imply the existence of imaginary energies), although an invariant theory could be constructed, it no longer admitted superluminal propagation. So far, only the simplest case of a spin zero field has been considered as this is much simpler than higher spins. The latter are required to be infinite component objects so there is nothing corresponding to a tachyon Dirac particle or vector meson. Any attempt to carry, for example, the Dirac equations over to imaginary mass leads to a non-unitary theory and therefore a breakdown in the conservation of probability. So with these difficulties appearing at such an early stage in the construction of a field theory, it is unlikely that an answer to the question whether Cerenkov radiation is emitted can be dealt with by quantum mechanics for quite a long time."

**Could tachyons exist unnoticed?**

D.C. Peaslee considers that tachyons could possibly already play a role in high energy physics.

"First note that in inelastic (e.p) collisions, we are already dealing with neutral vector tachyons:

\[(\nu, \bar{\nu}) \quad \nu^2 - q^2 < 0 = m^2 \quad \gamma \]

The virtual gamma has an effective negative m^2. If neutral vector tachyons exist with mass m^2 = \mu^2, then the process in diagram should show resonance effects at \nu^2 - q^2 = \nu^2. These haven't shown up so far, but they should destroy 'scaling' in inelastic (e.p) reactions.

"The range at present is only to exclude 0 \leq \mu \leq 3 \text{ GeV} / c so that tachyons are in the same situation as quarks and weak interaction (W) mesons: their masses are greater than about 5 \text{ GeV} / c^2.

Second, one can entertain the possibility that quarks are tachyons. There appear to be no particular dynamical difficulties in making baryons and bosons out of this kind of quark by the usual scheme N = qqq and B = q\bar{q}, since the quarks are virtual here."
"If real quarks are released, then their tachyon properties may make them very difficult to detect – charged tachyons go to zero energy in less than 1 mm, by Cerenkov radiation into vacuum. Neutral tachyons will be hard to single out in a high energy collision.

"Suppose that tachyon-quarks are in fact produced in a high energy collision releasing many particles. The release of unobserved quarks will result in three apparent non-conservations:

(a) Momentum-Energy

If the energies \(E_i\) and momenta \(p_i\) of all non-tachyons in the reaction are known, the missing mass will be negative:

\[
(\Sigma E_i)^2 - (\Sigma p_i)^2 = (\text{mm})^2 < 0
\]

This will be practically impossible to observe because of other unobserved, neutral ordinary particles like \(\pi\) in a high energy collision.

(b) Spin

If \(N = qqq\) in a high energy collision and all the q’s are lost, there will be a net loss of a half unit of spin, i.e. a nucleon disappears. This will also be very hard to detect.

(c) Charge

If some of the quarks produced and lost are charged, there will be a net charge imbalance. This is possible observable e.g. \(p + p\) giving an odd prong number."

Would physics be changed much by tachyons?

We should also note that the simple property of travelling faster than light is reasonably remarkable in its own right.

It has been reiterated recently [G.A. Benford, D.L. Book, W.A. Newcomb, “The Tachyonic Anti-telephone”, Phys. Rev. D. 2, pp. 263-265 1970.] that controlled creation of tachyons and detection of them at a distance can be used for signalling at greater than light speeds.

If the Lorentz transformation is a valid description of the relationship of two coordinate systems in unaccelerated relative (sub light speed) motion, then there is a coordinate system where the tachyon signal travels backward in time. It is more complex, but straightforward to construct a signal leap. Information passes along each leg to a later point in time for the frame containing emitter and detector. Total time to traverse the loop is negative.

In view of the consequences (see May issue of Scientific American) the detection of tachyons as described would lead to questions about the necessity of the Lorentz transformation.

It is safe, however, to predict that at least no simpler alternative will replace the special theory of relativity. The theory only became respectable over the dead bodies of a generation of able physicists. To date there are no known departures from exact numerical accuracy of the predictions. Fundamental requirements of the theory include equality of the measured speed of electromagnetic waves and that obtained by substituting other natural constants in Maxwell's equations. Any discrepancy is of the order of a few parts in \(10^6\).

Similarly the equivalence of mass and energy holds to a few parts in \(10^6\), as does the connection of mass and velocity and the null result for the 'velocity relative to ether' measured by Michelson and Morley. The time distortion associated with relative motion has been measured to a few per cent. Tachyon signalling, if confirmed, portends a careful examination of each of these limits as part of a considerable upheaval in physics.

Treatment of tachyon signals needs only consideration of speed and the existence of some interaction with ordinary matter. If a tachyon particle could be assigned such properties as energy and momentum, it would be on the basis of conservation laws operating when it interacts. A Lorentz (subluminal) transformation of the momentum vector can then be derived from first principles and shows that a tachyon is associated with a characteristic momentum \(p_\infty\). In the class of inertial frames where the speed is infinite, the energy is zero. The characteristic momentum is directed along the line of flight. Any Lorentz transformation with a velocity change normal to the line of flight leaves the momentum unchanged. Transformation to other frames where the speed is less than infinite increases the momentum and associates a non zero kinetic energy. Momentum and energy both approach infinity at light speed. A tachyon travelling backwards in time is associated with negative kinetic energy. The momentum transferred by the tachyon is continuously variable, even as the direction of the time arrow is reversed.

Numerous energetically possible reactions are forbidden by momentum considerations. The addition to the reaction of a suitable cluster of zero energy tachyons can remove any such difficulty. With a restriction to the emission of one tachyon of non negative energy in the centre of mass system there is usually a limit on the allowed value of the intrinsic momentum. Thus for a photon to decay in flight into an electron pair and a tachyon, the lower limit on the intrinsic tachyon momentum is given by

\[
p_\infty c > 2 m_0 c^2
\]

A photon of energy \(\nu c\) could be deflected in its path with the emission of a tachyon. There is in this case an upper limit to the permitted tachyon intrinsic momentum \(p_\infty c < 2 \nu c\). On a macroscopic level the 'momentum-like' tachyon is a better rocket exhaust than 'energy-like' gases now used, or even the photons that have been proposed.

The results of further experiments should be a clarification of the experimental picture. In the event of confirmation of the existence of tachyon signals some landmarks in the progress of physical thinking would appear to be imminent.

-D.W. Lang
STUDENTS STATISTICS IN PHYSICS IN THE COLLEGES OF ADVANCED EDUCATION

J.R. de Laeter
Western Australian Institute of Technology

C.N. Watson-Munro [1974], in an article entitled "Numbers of Physics Students", tabulated the number of third and fourth year physics students at Australian Universities from 1963 to 1973. He concluded that overall, third year enrolments had changed little over the past decade, whereas fourth year honours enrolments had dropped by 20 per cent.

An important factor in assessing the number of physics graduates in Australia is the contribution of the Colleges of Advanced Education. Although a number of such institutions have existed for many years, the CAEs have really only become a unified system since the first Commonwealth Advisory Committee on Advanced Education Report was published [CAACE, 1969]. In recent years many new CAEs have been established, some of which are involved in the training of physicists. The First Report of the Employment Survey [1972] tabulated the numbers of physics graduates or diplomates in CAEs for the years 1965-1971, and estimates for the years 1972-1975. It was pointed out that the numbers of physics students were difficult to ascertain, because many of the CAEs were in a state of transition at the time the survey statistics were compiled. The nomenclature of the awards conferred on physics graduates in the CAEs was also in a state of chaos at that time, since almost every institution had its own set of awards, and the same title was often used for a completely different level of study at different institutions.

The situation with respect to the nomenclature of awards in the Australian CAEs has recently been clarified [CAACE, 1972], and there are now three awards that can be made at the undergraduate level and two at the postgraduate level. One of the undergraduate courses requires two years of full-time tertiary study and is called an Associate Diploma (UG3 category). The other two undergraduate courses require three years of full-time tertiary study and are known as Diploma (UG2 category) or Bachelor degree (UG1 category) courses. The length, breadth and depth of study of the major and supplementary subjects in the bachelor's programme is expected to require intellectual effort at normal degree standard over the whole progression of the course. Although a degree course in advanced education may include some vocationally oriented skills, an emphasis on the acquisition of these skills would normally be associated with a Diploma course. Most of the major CAEs now offer bachelor degrees in physics which fulfill the academic requirements for graduate membership of the Australian Institute of Physics.

Table 1 lists the number of three year trained graduates in physics from 1968-1973. The 1974 entry represents the number of students enrolled in the final year of the respective courses, and is therefore likely to be in excess of the number of students who graduate in 1974. The figures indicate that the total number of physics graduates has remained constant from 1968 to 1972, but that in 1973 and 1974 there has been nearly a two fold increase. This is in contrast to the university statistics where there has been little change over the same period of time. This is undoubtedly due to the growth in the CAEs, although it is unlikely that the numbers of three year trained graduates will increase markedly in the future. It should also be noted that the 85 graduates in the CAEs in 1973 represents approximately one fifth of the number of third year physics students in universities in the same year, although it is not clear what proportion of the university students actually graduated.

The CAEs also provide post graduate training up to the Master's level. Three institutions are already offering a Master's programme, and it is probable that courses in another two of the major CAEs will be accredited in the near future. The Western Australian Institute of Technology currently has 27 students enrolled in their M.App.Sc. course, which offers options in 'Physical Methods of Analysis' and 'Physics Education'. Royal Melbourne Institute of Technology has 7 students enrolled in their Applied Physics Master's degree, while New South Wales Institute of Technology have enrolled their first student in a Materials Physics Master's programme. The course at the Queensland Institute of Technology will be specifically in the field of medical physics.

It is likely that the post graduate courses offered by the CAEs will be structured so as to enable students to be trained in a specific field which is of relevance to the Australian situation. Many of them may be offered on a part-time basis, and contain a proportion of course work in addition to thesis material. They will provide an opportunity for those who have graduated in physics some time ago to embark on post graduate work in areas which are of relevance to their needs and interests.

It is also of interest to note that many of the CAEs also offer Associate Diplomas, either in Applied Physics or in Radiography. For example 25 students completed Associate Diplomas in Applied Physics at RMIT, in 1973, whereas approximately 150 Diagnostic and Therapeutic Radiography students graduate each year from QIT, RMIT, SAIT, and WAIT. Thus the undergraduate programme in the CAEs is much more diverse than in the universities, which have concentrated primarily on the training of three year degree students. It is also
Table 1

Number of Bachelor Degree and Diploma Graduates in Physics in CAEs

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† Enrolment figures.

likely that the CAEs will become more involved in providing physics courses for science teachers in the future, in addition to their traditional role of producing applied physicists.

The statistical information presented in Table 1 demonstrates that the CAEs currently represent a significant component of the supply of Australian physicists at the undergraduate level, and it is likely that they will produce an increasing proportion of students at the post graduate level. In addition to their service teaching function, the CAE Physics Departments are also involved in the training of radiotherapists and applied physics technical staff at the sub-degree level. I believe this latter role to be one of the most important areas with which physics in the CAEs must be identified in the future, in order to produce a balanced output of physics oriented manpower for our national needs. I would like to thank the Heads of Departments in the CAEs for supplying me with the information on which this article is based.

References


REFLECTIONS ON THE ADELAIDE CONGRESS

The first National Congress of the AIP, held in Adelaide in May 1974, was an undoubted success. In the words of one person "I think that this National Congress has created a national institute of physics in Australia where before there was only a collection of state branches". It must have taken courage just to initiate the idea of a national meeting of physicists in Australia and more courage to persist with it. I would therefore like to congratulate the South Australian branch of the AIP, and especially its Chairman, Bill Boundy, on making the Congress such a success.

It was highly appropriate to have the Congress at Adelaide since there were the double celebrations of
the fiftieth anniversary of Sir Marc Oliphant's first degree at Adelaide University and the hundredth anniversary of Adelaide University. The exhibition representing the latter was excellently arranged. It was open on the Thursday morning and was skillfully arranged so that up to two hours were needed to inspect the well chosen exhibits. The earlier exhibits, especially, of Lamb and Bragg inclined the thoughtful visitor to contemplation; how many of the newer universities will be able to say as much in their turn? Dr Stan Tomlin is to be congratulated in his choice and arrangement of the exhibits.

In the list of 214 delegates to the Congress, 67 per cent. came from the Universities, 16 per cent. from Colleges of Advanced Education, 14 per cent. from Government laboratories and 3 per cent. from industry. 154 names appeared on the list of speakers at the sessions. The handbook containing the titles and abstracts of the talks was published as a supplement to the Australian Physicist (April 1974). This, though probably expensive, was an appropriate idea.

The organizers chose what may be called the classic outline of a congress, namely long invited papers to the whole Congress followed by short specialist papers in parallel sessions. Having thought about various other possibilities I think that the choice made was most appropriate for our conditions in Australia of fairly widely distributed centres of laboratories, and it was also appropriate for this initial Congress.

The themes for the specialist sessions suited the Adelaide environment and were also suitable for a national survey and altogether the program was both lively and informative.

I have recently been conscious of the changing patterns of the branch activities of the AIP, the former role, in Victoria at any rate, of providing a monthly meeting with a specialist speaker seems to have changed. There are many seminars and colloquia in universities, CAFs and industrial laboratories; what attraction is there for physicists to come out for another speaker in the evening? I think that one of the new roles for the state branches might well be to provide organizational skills for promoting small symposia on current fields of interest with a few speakers chosen to survey the fields. Certainly the state branch would have to organize the national congress. I am also not clear about the AIP Summer Schools because, although they have been valuable in the past, one very important job to be done at the moment and in the future is to interact with high schools. A lot of effort is going into thinking about secondary science; should the AIP assist in this or is this purely the function of the tertiary teaching institutions? I am conscious that I am now raising questions which I heard discussed at the National Congress in Adelaide and I look forward to NSF in 1976 to hear possible solutions.

If I may offer personal advice to the next organizers, I would like three things considered. Firstly, there should be plenty of time for discussion after both the invited talks and those in the sessions. It is of the essence of a meeting of scientists to have time for discussion both formal and informal. Secondly, my own preference for the Congress dinner (an essential part of the cohesion of a Congress) is to have it at a University Hall. Most physicists are academics at heart and the Hall atmosphere with its familiar blend of academic tradition and conversational freedom seems to me to be more suitable than a hotel. I also like to move around during a dinner; one of the most effective conference dinners I have attended was at Brasenose College, Oxford, where the six-course meal, admittedly extravagant, was interspersed by a fresh setting arrangement after every second course. This may be an ideal that I keep in front of me only as a blessed memory but an approximation to it will find sympathetic response. Thirdly, I would like to think that the various Groups of the AIP may be associated with a future National Congress either as organizers of a session or by having their own Group Conference before or after the main Congress.

—H.C. Bolton

Australia has come of age in physics. For reasons of physics alone the Adelaide Congress was right for 1974 and circumstances both global and national helped it. This is not to say that the Adelaide meeting was truly representative of Physics in Australia today. Indeed many people were conspicuous by their absence. The reasons for this non-representative nature of the congress were many.

Firstly, there was simultaneously in Canberra the Fifth National Convention of the Royal Chemical Institute to which many physicists went for specific sessions in the area of chemical physics. Also there was a meeting involving the Biophysics group of the AIP in Sydney the same week. In addition, not all university vacations overlapped the week of the Congress, preventing many attendances. Also, the program committee for the Congress had deliberately limited the fields of physics to be catered for by taking into account such facts as (a) meteorological physics had been catered for by a meeting of the International Association of Meteorology and Atmospheric Physics in Melbourne in January 1974, (b) Radio Astronomy had had an international treat on the Gold Coast of Queensland the previous September, and (c) a nuclear physics conference was held in Canberra in February.

So the Congress was limited to the following nine areas of physics: Atomic and Molecular Physics, Plasma and Discharge Physics, Upper Atmosphere and Magnetosphere, Geophysics, Physics in Society and in Industry, Nuclear and Particle Physics, Cosmic Rays, Plasma and Discharge Physics, Solid State Physics and Optics.

In format the Congress program looked like a normal international meeting with both contributed and review papers. The standard of contributed papers was, in the field of the present author (upper atmosphere and magnetosphere), of a standard acceptable at the top
international meetings. Comments from other persons lead me to believe that the papers were generally of a standard acceptable at the larger international meetings.

An important aspect of the meeting was the participation of post-graduate students, many of whom were 'bussed' for the first time by presenting their work to a substantial and critical audience of active workers in their field. This is an important step in the process of development of a professional physicist.

The fact that regular Australian national meetings have not taken place in the last fifteen years appears, in the experience of the writer, to be due to a number of factors. Chief among these is the fact that science is international. Both for professional reasons and reasons of kudos, active workers have wanted to interact with their colleagues in the highest international forums available, and these have usually been overseas. Restrictions of time and energy (largely determined by our antipodean situation) then militated against local meetings. Next, the Australian Institute of Physics, to which the bulk of physicists belong, has been heavily 'state-minded' in the conduct of its business, and until recently travel costs for meetings even interstate have not been within the budget capacity of most physicists or their institutions. Thirdly, the Australian Academy of Science which maintains formal links with international scientific organisations has not ventured into the field of national meetings as such, but has supported local meetings as venues for some international bodies of rather specialist kinds. Fourthly, ANZAAS has tended to be used (rather ineffectively) by some members of the physics community as an outlet for material which should properly be presented at a National Congress of Physics or an international meeting. Fifthly, the spate of distinguished international visitors to Australia in recent times has, perhaps, satiated some appetites in a way that meetings might not.

With the emergence of a proper and substantial national physics forum available to the great majority of physicists in Australia there should be a rethinking of physicists' participation in ANZAAS. There should be a return to the original concept of that body, at least in as much as physics is involved -- viz. the bringing of the disciplines to what are essentially lay audiences -- a most important task requiring skills which are not necessarily fostered at physics congresses.

At the same time the AIP may have to rethink its function and then its structure to cope with this most important development. There may have to be a shift of responsibilities, or an acceptance of new ones by the federal council. I think that eventually the responsibility for running the National Congress of Physics should be a direct federal responsibility, so that an Australia-wide committee of physicists would decide such things as programmes and invited speakers, and the state would act in the capacity of local hosts.

The Physics community of Australia should congratulate the South Australian branch of the AIP for organizing the successful 1974 Congress.

-K. D. Cole.

LETTERS

Postgraduate Training

SIR:-- The letter of T.M. Sabine in the April issue of the Australian Physicist leads me to offer two more comments.

First, Dr Sabine's claim that "we are producing too many people in what could be broadly called nuclear physics" does not tally with his later statement that "...the thesis topic should be chosen so that the student acquires the more general skills. In this case the detailed topic does not matter".

I would contend that no research area gives opportunity to learn "the more general skills" better than nuclear physics.

Second, Dr Sabine's injection of "nuclear physics" into the discussion is an obvious reference to physics at the University of Melbourne. I wish to observe publicly that the aim in this School of Physics is to train physicists, and not nuclear physicists, high energy physicists, solid state physicists or theoretical physicists. That some measure of success has been achieved in this aim is indicated by the wide range of skills required in positions to which Melbourne physics Ph.D.'s have gone. And, in recent years, the majority of Melbourne's physics Ph.D.'s have successfully made the transition from the area of their thesis topic to other areas of research. Further details concerning this are available from the School of Physics if required.

- B.M. Spicer
  School of Physics
  University of Melbourne

SIR:-- May I reassure Professor Spicer that I love my alma mater and am not specifically attacking the University of Melbourne.

I am not certain of the correctness of his statement that nuclear physics is a good field in which to learn general skills. I have visions of students spending vast amounts of time measuring particle tracks on films and then running these measurements through huge computer programs, in the process becoming expert programmers but not much else.

When next in Melbourne I will accept Professor Spicer's invitation and read some nuclear physics PhD theses.

-T.M. Sabine,
  NSWIT,
  Sydney, NSW

The Australian Physicist, October 1974 203
STUDENT CONTRIBUTION

RADICAL APPROACHES TO LEARNING PHYSICS: SOME EXPERIENCES OF FIRST YEAR UNIVERSITY STUDENTS

Graeme Henderson, Brian Martin, John Skaller, and Carol van Beurden
University of Sydney

Introduction

The learning potential of first year physics students is largely untapped. Some first year physics students have important contributions to make in determining the structure of their courses. Do you agree with these statements? They are two conclusions reached as a result of activities in the Sydney University School of Physics in 1973. The two most important of these activities form the subject of this article. First, a group of first year students successfully participated in a course based on reading and studying published physics research papers. Second, some of the same group of students designed their own experimental physics course and upon its provisional acceptance by the School of Physics ably demonstrated its many advantages. We describe these happenings and discuss some of their implications.

The Research Study Course

In second term 1973 two separate groups of seven first year students each began a course based on reading and discussing a coherent series of research papers, called the Research Study Course. The topic of the papers in the course, “The use of trace substances in studying stratospheric dynamics”, was an area of the research work being done by the instructor, postgraduate student Brian Martin. The course was based directly upon the teaching/learning method developed by Herman T. Epstein and described in his short book, A Strategy for Education [Oxford University Press, 1970]. To our knowledge the method had never been applied to physics previously. The course was advertised as being voluntary and non-credit, and furthermore the participants were asked to pay for xeroxing costs.

The classes were conducted primarily through student discussion and questioning. A student would ask a question or make a statement, which might be taken up or challenged by another student or presented by the instructor to someone else. The instructor’s main duties were to answer technical points, to encourage balanced student participation, and to keep attention focussed on the paper at hand (that is, to keep digressions to a reasonable length). Some of the aspects of the papers which were discussed were factual details, the types of questions raised in the paper and the way in which the questions were asked, the way data was collected, the relevance of the data, the justifications for the method of collection of the data, the principal hypothesis presented, alternative hypotheses, and the validity of the arguments used to support a given hypothesis. An important area of discussion was methodology – the validity of the way in which the scientist attacked a certain problem, the justification for choosing one particular approach over various alternatives.

At all times the primary focus was on the actual work done by the researcher. Informational content was discussed only as it was required to understand the stated activities of the researcher.

After reading a given paper but before the discussion, many of the students did not feel that they understood the paper very well. It was the function of the group discussion to raise common problems and clear up areas of difficulty, and most importantly to emphasize aspects of the paper whose significance had not been fully appreciated. The discussions were helpful in aiding student understanding and comprehension of the papers for two particular reasons. First, because the instructor had done research in the area of the papers, he was able to explain with confidence the kind of fine points that often trouble students but which by necessity are slurred over in conventional presentations. Second, the students could efficiently help each other because, being at much the same level of understanding of the subject matter, they were able to understand each other’s problems, difficulties, and ways of thinking. Often the students would remark that the paper made much more sense to them after the group discussions.

Even though the students were informed that they should ask the instructor elementary questions, at
first they were hesitant to talk and perhaps appear foolish or ignorant in front of their peers. Also most of the students were not used to stating their views openly. These difficulties disappeared naturally as the course progressed, and eventually all but a few reticent students capably offered useful contributions to the discussion.

The level of understanding demonstrated by the students showed two sides. First, areas of ignorance or basic misunderstanding were uncovered. In most conventional courses the students are afraid to appear ignorant before teachers or peers, while the same time normal methods of assessment usually only test recall or a surface level of understanding. Therefore areas of ignorance and misunderstanding can often persist undiagnosed for a long time. It is the advantage of the discussion format of the Research Study Course that to some extent the students were freed from their normal inhibitions, so that key shortcomings in knowledge and understanding could be quickly overcome. The students were highly motivated in this task, as it was prerequisite to a satisfactory understanding of the research papers.

While on one side demonstrating areas of lack of understanding, on the other side the students showed a remarkable talent in seeing into the heart of a paper, in asking the most important questions. The chance to develop and practise this ability in comprehension and critical evaluation appears to depend vitally on the reading of original research papers. In conventional courses using textbooks and lecture notes the emphasis is necessarily on knowledge and applications. Usually not until personal research work is begun is the student given the chance to develop his ability to comprehend and evaluate scientific work. But as demonstrated by the Research Study Course, this process can be begun much earlier, and at the same time used to motivate the learning of required background knowledge and applications.

The series of research papers has been called coherent: each paper reported work which in some way followed on from or built on work reported in the previous papers. Towards the end of each discussion the students would be asked to infer, if possible, from the previous papers the next research effort that logically or practically should occur in the field. Usually numerous suggestions were offered, and at least one of these startlingly forecast the subject of the next paper. Furthermore, other suggestions were known by the instructor to have been the basis for other research efforts. Thus the students showed the ability to follow the thought processes of a scientist as presented in a research paper, and to think for themselves using these thought patterns as a guide.

Perhaps the most important achievement of the Research Study Course was the enthusiasm for learning which it engendered and sustained in the students. For a student, even one interested in physics, voluntarily to pay for a copy of a paper and then come in at 5 p.m. after classes to discuss what is to most first years an uninteresting subject (stratospheric physics) says a lot about motivation. Where did it come from? Mostly the motivation came from the excitement of trying to discover what a researcher is trying to do and how he is going about it, of following the mental path blazed by a scientist.

Some of the enthusiasm flowing from the course led to related individual and group activities. Some students did extra reading and looked up pertinent references. To aid in this work, through student initiative the group was able to obtain passes to the research library and be instructed on how to find research articles. After the completion of the course a long seminar was held to explain the course to Physics School staff, with the attendance of almost every student who had been in the course. Indeed, one problem that arose for about half the group might be called over-motivation, since time spent on physics resulted in some lack of attention to other subjects.

What are the criteria for success in a course like the Research Study Course? We may answer by describing what a student learns. He learns how scientists think and reason when working on a particular problem. He learns how the efforts of successive scientific workers can contribute to scientific knowledge, and about some of the pitfalls along the path to this knowledge. He learns a considerable amount of factual material related to the papers studied. Finally he learns that he is capable of understanding the important aspects of published scientific material, of analysing and criticising scientific work, and of validly thinking for himself about scientific matters. As a result of his learning the student becomes more confident in his study of physics. The course is successful if the student learns these things voluntarily, if his interest in science is increased by his studies. The Research Study Course was a success for most of its participants when judged according to these criteria by the students, the instructor, and the numerous visitors to the discussions.

The Trial Experimental Physics Course

During one of the Research Study Course discussions one of the students mentioned how unsatisfactory their laboratory work was. This comment struck a resonant chord, and a lively discussion ensued. After another such discussion at the next meeting, the group members decided to meet and plan an alternative to the first year physics laboratory course. Although no one in the group at that stage believed there was much chance that an alternative would be accepted by the Physics School as a real option, the planning of an 'ideal' experimental course for themselves was thought to be a useful exercise in itself.

In designing their course, the students were guided by two principal aims. First, the student should have the opportunity to learn through direct experience the working of the experimental method: for example, how one asks a scientific question, how one designs an experiment to answer a specific question, how one conducts, analyses, and draws conclusions from an
experiment, and how one can learn from failure at any stage of an experiment. The opportunity to learn these things is basically the freedom to do as one likes in the laboratory (within the practical limitations which apply to every researcher), with no pressure for results or penalty for failure.

The second principal aim was that the students should have the chance to develop an understanding of the relationship of experimental physics and its techniques to theoretical physics and to the attainment of scientific knowledge: broadly, to place experimental physics in the context of our culture. This goal suggests a study of philosophy and methodology of science and of experimental method, and how these relate to the actual experiences of a researcher in the laboratory.

The students in designing their course were in general (if implicit) agreement about the aims just described. However there was considerable disagreement about how to design the course to achieve the aims, each student having his or her own individual set of ideas and opinions. The small amount of staff and postgraduate help in the planning mostly consisted of emphasizing the need for specific agreed-upon proposals. The one central idea accepted by everyone was that the course should be flexible and accommodate individual initiative and study preferences.

We now outline the sections of the proposed course, together with the suggested number of hours during the term to be spent in each area.

(1) Research Study Course (nine hours). This would be like the course described earlier but on a different topic.

(2) Visits to laboratories (six hours). The laboratories visited would ideally be related to the topic of the Research Study Course or to experimental work being done by the students.

(3) Statistics (four hours). The material studied should be applicable to data obtained in the student experiments, as well as facilitating an understanding of the role of measurement, accuracy and precision in the attainment of scientific knowledge.

(4) Computing (eight hours). This would be a course in simple programming for use in statistical analysis and the design of mathematical models.

(5) Philosophy of science (two hours). This would involve studying from a philosophical point of view the ways in which a physicist looks at a scientific problem.

(6) Experimental work (six hours). This work would be done individually, in groups, or by assisting a postgraduate student in his research. A resource list was requested to help the students in deciding on and planning their experiments. It was suggested that many students would wish to spend extra time working at their experiments. Also planned were optional reports on the work carried out, and seminars at which results and experiences could be communicated to the other students in the group.

(7) Report (one hour). This would be an appraisal of all aspects of the trial course from the individual student's point of view.

Surprisingly to the students, acceptance of the course plan followed quickly after its submission to Dr. Brian McInnes, Director of First Year Physics.

Let us now consider the course as executed in terms of the planned course.

(1) Research Study Course. A series of papers on shock waves in plasmas were studied under the supervision of Dr. Brian James. There were some differences between this course and the earlier one covering stratospheric dynamics. First, the students were experienced in the method and so discussion developed more easily and freely. Second, some of the subject material had been covered in lectures. Third, Brian James purposely allowed the conversation to stray from the paper at hand and dwell on basic understanding of subject matter. It was found that material covered in lectures often was just not understood by students at an elementary level. Discussion in the Research Study Course allowed this to come out and for fundamental questions to be cleared up, in the process of relating the relevant concepts to the research paper at hand.

(2) Visits to laboratories. Due mainly to lack of time, the only visit was to the plasma physics laboratories at Sydney University. This was quite fruitful, since the Research Study Course had prepared the students for understanding the apparatus and for the asking of intelligent questions.

(3,4) Statistics and computing become especially worthy of note to the physics student when serving as tools for experimental work: running computer programs related to an experiment, and making statistical tests of data obtained. However the lectures on computing and statistics were not very successful. We feel this was mainly due to the lecture format used, and the fact that the students did not know or agree on what material should be covered. Especially in computing, the students had widely varying backgrounds and requirements. The lecturers advertised their availability for consultation but little advantage was taken of this by the students. Nevertheless, we feel that staff support would most beneficially be in the form of persons available for consultation. By removing the time and pressure of the formal lectures and emphasizing the availability of a consultant, and perhaps by organizing student self-help sessions, more interest and learning might be achieved.

(5) Philosophy of science. It is important for the student entering a lifetime study of science to realize that there are different views of science,
and that a scientist's perception of his own view of reality may not be accurate. In this respect the three lectures on the philosophy of science were useful, in that the students were able to apply this philosophy to the scientific approaches they found in their lectures—not only in physics, but in applied mathematics and psychology as well. However its application to the philosophy of science lectures themselves suggests that discussion among the group would have been more fruitful in presenting the philosophy of science from more than one approach, rather than simply the lecturer's view.

(6) Experimental work. Although only six hours minimum were specified for the whole term for this area, most students ended up doing at least three hours per week. Each student had the opportunity to choose an experimental project, to try various methods of investigation, to run up against various dead ends, to evaluate equipment in terms of its possibilities for an experiment, and to make conclusions that were not anticipated from the beginning. To the student the experimental work gave the chance to do an experiment on one's own, rather than the necessity to follow instructions or to guess what someone else would like to see done.

It may be of interest to note some of the experiments done by the students. In one case a pair of students used equipment which served for a set of exercises in the Physics I Laboratory on the special distributions of black body radiation, but developed their own approach. Other groups of students worked in the following areas not related to the normal first year laboratory: the motion of a gyroscope, for example the variations in precession period with spin speed; the properties of a microwave absorption band as a function of the temperature of the absorbing medium; and the transmission of stereo sound via a polarised laser beam. In some of the experiments the students reached a successful conclusion to their work, in others progress was not particularly marked. In most cases the students encountered both failure and success in choosing a valid project, determining its feasibility, and working towards understanding of a physical phenomenon. Because of this, the students felt that they had learned a great deal about experimental physics.

Unfortunately there developed a subtle pressure from the staff on the students to spend time on experimental work in laboratory. Some students willingly spent large amounts of time on their experiments, but others would have preferred that more time be free for study in other aspects of the course. Near the end of term the students were unexpectedly asked to submit reports on their experimental projects. Although some students would willingly have prepared a report, to have the requirements imposed at such short notice appeared to be a manifestation of the underlying pressure to spend time on experimental work. Of course from the staff point of view work in a laboratory may seem the only valid way to learn experimental physics—it certainly this is reflected in the existing course. But the student group had felt otherwise, and expressly designed the course to permit an approach to the understanding of experimental physics from a number of aspects.

(7) Report. Three students submitted reports on the Trial Course as a whole. Numerous suggestions were offered in these reports, and specifically comments about implementation of the course for more students in later first year classes.

The course both as planned and executed required a lot of student work. However all of the students fulfilled the minimum requirements of the plan and most did a significant amount of extra work: a total effort of eight hours per week on the Trial Course was not unusual. This compares with three hours per week that would have been spent in the Physics I Laboratory course; the theory covered in three lectures per week was in addition to each of these courses. In spite of the time spent by the students, one of the main problems in each aspect of the course was lack of time to follow up what was started or touched on. The reason for this problem is the large amount of time needed to study four subjects (the more formal course work) which leaves little time for private research. Naturally the effect of this problem varies from person to person. Some students will make time, or take time (at the expense of studying examinable material) for study of non-examinable subject matter. Others feel caught up in the formal courses to such a degree that they are afraid to do outside work, or feel guilty if they do. This problem of time was present in each component of the course.

The students were directly involved in much of the detailed planning and organizing of the course as it progressed, such as arranging lecture meeting times, discussing material that should be covered, and locating equipment. Some of the time spent in these sorts of activities may have been at the expense of other aspects of the course. On the other hand, the involvement of the students in organizing and running the course also fostered interaction of the students with many staff in a stimulating manner that would not have been normal in a smoothly running course.

In terms of content, a most important feature of the Trial Course was the breadth of material covered. Most of the specific areas, such as philosophy of science, statistics and computing, are normally covered as part of separate specialized conventional courses. But a given student might not be able to take each of these courses, especially since faculty requirements are sometimes rather restrictive. And even taking a course in a subject is not always desirable from the student's point of view, since the depth required or the emphasis made in the formal course might not suit his requirements. The advantage of the Trial Course here is its flexibility. The student is exposed to each subject area in the course, but does not have to follow up each topic to a predetermined depth. On the other hand if the area intrigues him, he has the option to study it in more depth on his own or to take a conventional course.
Another important aspect of the content of the course was the potential for integration of the subject areas covered. Although the areas were not formally integrated, the weekly study in areas such as the Research Study Course, the philosophy of science lectures and the experimental work emphasized the interlinking of theory and practice in experimental science.

The motivation for designing the Trial Course came from the students' overwhelming rejection of the Physics I Laboratory course which forms part of the first year syllabus. This rejection may seem surprising, since from the point of view of most staff and postgraduates of the present generation, the Sydney University Physics I Laboratory is one of the most modern, well-designed and enlightened one would be likely to see. For example, the experimental exercises, carefully designed using modern equipment, are "open-ended", in that there is more possible work available than any student can complete, and the procedural details are not spelled out cookbook-style. In fact, the stated aims which guided the designing of the Physics I Laboratory were much the same as those which led to the Trial Course. Here we do not attempt to diagnose in detail the reasons for the practical shortcomings of the conventional course. Rather we plan to describe some aspects of the average student's perception of the laboratory.

From the student point of view there is little if any perceived response to student desires. The laboratory course (indeed the University itself) seems from below monolithic and unresponsive, hence the unreality of the possibility of fruitfulness of student initiative. Mostly coming from rigid and authoritarian high school structures, students do not expect that opportunities for personal initiative exist, nor believe in them when they are presented. So although the official laboratory course potentially may be flexible in theory, it just does not seem so to the students, which is in many ways equivalent to it not being flexible at all.

So we may say that the failure of the Physics I Laboratory is not that students are not given choices. Rather it is that students are not encouraged to develop their ability to make their own choices, to use their initiative. That this does not occur in the laboratory is supported by simple observation. The task for teachers and course planners who seriously care to develop the critical abilities of physics students is that of designing a course structure which allows for a maximum of useful student contribution to that very structure.

These comments on student perception of the Physics I Laboratory throw some light on the success of the Trial Course. The very fact that it was designed by the students themselves greatly increased their motivation, and as a result their work improved in quality and quantity. If a course like the Trial Course were forced on another group of students, the same degree of success would be far less likely. The enthusiasm for work and learning which marked the Trial Course came not only from its scope and flexibility, but also from the fact that the students were to a significant degree in control of their own education.

Conclusion

At the beginning of this article we stated that the learning potential of first year physics students is largely untapped and that some first year students have important contributions to make in determining the structure of their courses. Let us consider these statements further in the light of the experiences we have described.

Normally first year students are not thought to be ready to read published research papers in physics, and in any case few people ever imagine that such an activity could be a useful way to promote learning. But experiences such as the Research Study Course indicate that students are capable of reading and ready to read research papers, and indeed eager to do so. And in this eagerness lie the reasons for the success of this teaching/learning method: the students are motivated to learn a mass of material, factual and conceptual, as a means to understanding the research papers. From an educational point of view, the method may be considered to stand conventional teaching on its head. Instead of first learning 'facts' so that later principles may be understood as correlating them, the activities of scientists are the main object of understanding; the students' desire to understand these activities motivates the learning of the necessary background facts and organising principles in a highly efficient manner.

Few educators demonstrate in practice a belief that first year university students can take any real control of their learning. Student suggestions and attitudes are sometimes noted with attention, but usually so that the educator may redesign the course for them. This attitude that the learning environment of the student must be completely structured for him leads to actions which can only appear to support that belief: given little or no responsibility for his education, the student never develops the ability to handle responsibility and often comes to believe he has no right to any responsibility. We believe this attitude is misguided.

The example of the Trial Course as an experience in student capabilities and initiative suggests that apparent student apathy and inability may be explained in terms of a lack of involvement in the designing of their courses. Some students can design a plan for their own education and show in the process considerable sensitivity to the problems involved in the enterprise. But the real importance of students having an active role in designing their education is the enthusiasm for work which this role engenders. Normally it is thought the students must be pushed into study by attendance at lectures, assignments, examinations, or other pressures; spontaneous extra work by students is though to be unusual and something to be 'absorbed' by making the course more difficult. From our experience with the Trial Course, we believe that given a group of students taking a course because they want to, a successful course will be marked by the fact that extra work is the rule.
rather than the exception. The Trial Course was spectacularly successful in this sense, not only because it was open-ended and flexible, but also because it was designed by the students themselves, and therefore especially suited to their particular needs.

To conclude, we believe the student is much underrated by those who administer his educational experiences. The few occasions on which students show their true potential belie the assumptions of the conventional approaches to teaching. Although we believe that the method of the Research Study Course and the structure of the Trial Course are in themselves of considerable significance, their real import lies in their demonstration of the hitherto unrealised or repressed capabilities of first year university students.

Acknowledgements
We thank Jos Beunen, George Vorlicek, and Dr. B.A. McInnes for reading portions of the manuscript. The success of the Trial Experimental Physics Course was made possible by the support of many people in the Sydney University School of Physics, and in particular of Dr. McInnes.

THE REGISTER

CHANGES IN MEMBERSHIP FROM 23 APRIL 1974 TO 2 JULY 1974

Fellowship
Transfer
Thomas, B.W. Western Australian Institute of Technology

Membership
(a) New Elections
Barber, M.H. University of New South Wales.
Chan, D. M–H. Department of Primary Industry, ACT.
Dewar, R.L. Australian National University, ACT.

(b) Transfers
Doughty, C.J. South Australian College of External Studies.
Willert, P.R. The Olympic Tyre & Rubber Co. Pty Ltd, Vic.

(c) Removals from Register under Clause 13 of Articles of Association
Bailey, J.E. (NSW) Crinean, G.B. (Vic.)
Fenton, R.S. (Vic.) Gordon, C.J. (NSW)
Gupta, R.K. (O/S) Hands, P.E. (WA)
Lokan, K.H. (O/S) Shamsi, S.K. (O/S)
Simons, R.G. (NSW) Webb, J.P. (Qld)

(d) Removals from Register, Address Unknown
LeMarne, A.E.

(e) Resignations
Belin, R.E. (Vic.) Towson, J.E. (NSW) (Mrs)

Graduateship
(a) New Elections
Antonopoulos, W.G. Department of Education, NSW.
Harridge, G.W. Monash University, Vic.
Rigutto, G. (Ms) Monash University, Vic.
Zybert, J.J. Monash University, Vic.
(
(b) Transfers
Campbell, M. (Mrs) Wollongong University College, NSW.
Coles, B.D. AFMECO Pty Ltd, SA.
Kennedy, G.D.M. Department of Education, NSW
Whyte, L.C.F. Australian National University, ACT.

(c) Removals from Register under Clause 13 of Articles of Association
Bhathal, R.S. (O/S) Borejdo, J. (O/S)
Dingle, R.E. (Vic.) Hagan, P.J. (O/S)
Harwood, K. (Vic.) Isaak, G.R. (O/S)
Kiewiet, C.W. (O/S) Miller, D.J. (NSW)
Nolan, S.J. (SA) Waite, P.J. (SA)
Wallace, W.J. (NSW) Wilson, V.C. (NSW)

(d) Removals from Register, Address Unknown
Falvelle, A.J. Fowler, D.K.
Molde, T.A.

(e) Resignations
Barker, P.S. (Vic.) Bolton, T.M. (O/S)
(Mrs) Holt, J.N. (Qld)
Brown, K. (NSW) Stewart, R.T. (NSW)

Students
(a) New Elections
Bartlett, W.P. (Vic.) Clark, P.R. (Qld)
Khanarian, G. (NSW) McKay, P.A. (Qld)
Porter, S.E. (Qld) (Miss)
Willmott, M.C. (Vic.) Soar, R.G. (Vic.)

(b) Removals from Register under Clause 13 of Articles of Association
Bradford, B.D. (WA) Carter, R.J. (Vic.)
Curtin, P.C. (Qld) Fletcher, G. (NSW)
Powell, D.L. (ACT) Sturzaker, L.R. (NSW)
Whitehouse, T.J. (Vic.) Zalcman, L.B. (Vic.)
BOOK REVIEWS


Reviewed by R.G. Hewitt, School of Physics, University of Sydney.

This book contains two sets of notes for lectures given in 1968 at the Latin American School of Physics in Mexico.

The first set by F. Levin surveys the theory of direct nuclear reactions and describes the successes and failures of the standard DWBA method and its extensions in fitting experimental data. It covers a wide range of topics including core excitation and knockout processes, spin dependent effects and stripping into unbound states. Because of this, the text is abbreviated and in many places difficult to read without a good background in nuclear reaction lore; many of the copious figures reproduced from research papers are not adequately described in the captions or text. The long list of references at the end of each of the sections should however be useful to people interested in doing research in this area (even though there has been a five year delay in publication of these notes).

The second set of notes (approximately one-fifth of the book) by H. Feshbach contains a quite readable account of a unified theory of direct and compound nuclear reactions. It includes discussions of energy averaging, the optical model, intermediate structure and isobaric analogue states and should be of interest to theoretical nuclear students.

Reviewed by H.F. Symons, National Measurement Laboratory, Chippendale NSW.

This book was originally published in Kiev in 1969 in Russian, and the present English translation in 1973. From the “Authors Preface” one gathers the impression that the purpose of the book is to stimulate the development of materials suitable for use in quantum paramagnetic amplifiers and other quantum devices, yet only the final chapter (27 pages out of the total 213 pages) is devoted specifically to this purpose.

In the rest of the book the authors give a conventional treatment of paramagnetism of transition – metal ions, crystal field theory, the behaviour of paramagnetic single crystals in electric and magnetic fields and describes the principles of the EPR method and its application to the study of paramagnetic crystals. Apparatus is not mentioned – the book is about theory. It concludes with the conventional set of tables but convention is finally upset by the total lack of any index.

I cannot assess what sort of niche this book finds in the Russian literature but it is very hard to find a place in the English literature for it: between “Paramagnetic Resonance in Solids” (Low 1960) and the “bible” (Abragam and Bleaney 1970) we have been blessed with a number of books which cover the ground of Sorin and Vlasova.


Reviewed by J.L. Goldberg, National Measurement Laboratory, Chippendale NSW. 2008, Australia.

The aim of the author of this book has been to demonstrate that linear system theory familiar to electrical engineers can be applied to optical systems so that the effect of a chain of optical devices on an input light signal may be directly calculated. The analogy of an optical chain to an electrical network is particularly appropriate in studying systems which are used, for example, in pattern and character recognition. The properties of the two-dimensional Fourier transform needed in this work have been derived in a non-rigorous way. Readers not acquainted with this Fourier approach to optics will find that well known principles of physical optics are described in an unfamiliar way. For example Huyghens principle is used to describe mathematically the light distribution on a planar surface P, due to a planar light source P, as “proportional to the spatial convolution of the light source distribution with the spatial impulse response”.

The author has generally fulfilled his aim but this reviewer questions several statements and conclusions. In one of these, the author states that “it should be clear to the reader that Parseval’s theorem implies the conservation of energy”. Firstly, the theorem that the author has proved is in fact Rayleigh’s theorem and the principle of the conservation of energy is neither implied in this theorem nor invoked in its derivation.

In another section, on holography, this reviewer has found it difficult to accept the author’s result for the optimum ratio of reference beam to object beam illuminance. The author’s theory indicates that this optimum ratio is in general unity. Calculations by other workers have indicated an optimum beam ratio greater than unity. This reviewer has also found this to be the case in most experimental situations in practical holography except in the case of a single point object.

The author might care to try experimental confirmation of his own result on much larger objects than the ones illustrated on page 322, to see if still holds.

This book cannot be whole heartedly recommended at the price of $A22.50.


Reviewed by N.H. Fletcher, Department of Physics, University of New England, Armidale, NSW.

In the words of the author’s preface “the purpose of this book is to provide the statistical mechanical base for the study of solids” but it is a book about crystalline solids rather than about statistical mechanics. The choice of topics is very much what one might expect for a first course in this subject — Einstein and Debye theories of specific heat, electron statistics in semiconductors, order-disorder transitions, diffusion theory (the author’s special interest) and so on — with appropriate background material and a good emphasis on fundamental principles.

It is disappointing to find little discussion of topics of more current interest which one might have expected in a book with this title. There is no mention of polymers, glasses, melting or other phase transitions and magnetic phenomena receive only two pages.

The level of treatment is about right for an honours course but stops short of what is needed in a research monograph. The brief bibliography refers mainly to other books. The high price and large overlap with standard texts on solid state physics limit the appeal of this otherwise useful book.
FROM STONEHENGE TO MODERN COSMOLOGY, Fred Hoyle, W.H. Freeman and Company, San Francisco, 1972. 96 pages, $4.45

Reviewed by J. V. Hindman, National Standards Commission.

The second Distinguished Visiting Lectureship of the Faculty of Natural Sciences and Mathematics at the State University of New York at Buffalo was awarded in 1971 to Fred Hoyle. A series of four lectures—Science and Society in Modern Times, Stonehenge, Recent Developments in Cosmology I, and Recent Developments in Cosmology II—are published in this entertaining little book.

In this series of lectures Fred Hoyle in typical fashion ranges over the whole gamut of human knowledge—Cambrian glaciation, quasars, blue green algae, the Yellowstone springs, Einstein, Hubble, Mach, Dirac—all are here plus a deal of speculation to build up a fascinating if at times shaky picture of the "World".

In his first lecture Professor Hoyle attributes a religious motive to the investigations of scientists of all ages in the sense that "the discovery of the deeper levels of significance in the structurally elegant and beautiful laws which govern the "world" is for the modern scientist the religious equivalent of eclipses of the Sun and Moon for stoneage man."

The second lecture traces the personal interest of the author in the explanation of the structure of Stonehenge I, mainly consisting of the Aubrey holes and the Heelstone, as a computer for the prediction of eclipses.

You don't have to believe it, but it is fascinating stuff.

The third and fourth lectures are devoted to the expansion of yet another basis for the mathematical treatment of cosmology, sparked largely by the discrepancies between red shifts measured for QSO's and apparently physically related normal stellar bodies, which is based on the assumption of a universal mass field from which individual particles derive their observed masses by their interaction with the field.

Reviews should be critical; it would be useful if some standard for expressing numbers like $2.5 \times 10^9$ were to be adopted. In this particular volume we have $2.5 \cdot 10^9$, $2 \cdot 10^9$, $3 \cdot 10^9$ etc. all on the one page.


Reviewed by J. L. Hughes, Australian National University, Canberra, ACT.

The fifty-sixth volume of the Proceedings of the P.N. Lebedev Physics Institute contains three articles each summarising research students' dissertations of work carried out in the period 1965-69. Despite the relatively long publication delay in what is one of the most rapidly advancing fields of science this volume is of wide interest to the laser community.

The first article by A.S. Markin presents data on the regulation of the temporal and spectral characteristics of solid state lasers using a bleachable dye, both for Q-switching and mode-locking of the many different cavity configurations. Although the work did not have the benefit of picosecond recording techniques available today, it does give a good background to the basic problems associated with bleachable dye switching of high power laser oscillators.

The second article by V.M. Stutskii deals with the use of Z-pinch discharges for the realisation of pulsed lasing action in Argon I, II (blue-green) and also in Argon III in the deep ultra violet, although no lasing action was achieved with the latter. The various stages associated with the pinch discharge are analysed and followed by experimental results using various electrode configurations. The possibility of operating A III in the deep U.V. is discussed in terms of the problems involved. It is concluded that lasing action in the deep U.V. will only be possible in the superradiant mode. No mention is made of travelling wave techniques in this respect.

The third article by I.N. Kryazhev systematically analyses the pulsed lasing action associated with electron transition in diatomic molecules, excited by the leading edge of a powerful current pulse in a gas. This work led to the observation of pulsed lasing action for electron transitions in $\text{H}_2$, $\text{D}_2$ and HD molecules and at 90 new emission lines of the first positive band system in $\text{N}_2$. Emphasis is placed on the power and energy capability of these lasers as well as on their efficiency.

Bearing in mind that the book deals with work carried out during the mid 1960s, it contains excellent background information for a wide cross-section of the laser community and provides another example of the solid scientific foundation of the Lebedev Institute.
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C S I R O

NATIONAL MEASUREMENT LABORATORY
CHIPPELDALE, N.S.W.

SCIENTIFIC SYSTEMS ANALYST

GENERAL: The National Measurement Laboratory is located in the grounds of the University of Sydney. It is responsible for the maintenance of the Australian standards for the measurement of physical quantities, and has an extensive program of related research. It is expected that the Laboratory will move to new buildings at Bradfield Park, West Lindfield, N.S.W., early in 1977. The laboratory has several mini-computers used for the rapid acquisition of data.

DUTIES: The appointee will be expected to write, in machine language, any software required for the acquisition and on-line processing of experimental information. He/she will also be required, in consultation with electronic engineers, to design the interfacing of these experimental systems and help in the development of new projects.

QUALIFICATIONS: A degree in engineering, science or mathematics or equivalent qualifications and appropriate experience.

SALARY: Appointment will be made within the salary ranges of Experimental Officer Class 2 or Class 3: $10,465-$13,491 p.a.

TENURE: This position is available for an indefinite period and Australian Government Superannuation benefits are available.

Applications stating full personal and professional details, the names of at least two referees and quoting reference number 750/552 should reach:
The Director,
National Measurement Laboratory, CSIRO,
University Grounds,
City Road,
CHIPPELDALE, N.S.W. 2008
by 15th November, 1974.
THE AUSTRALIAN NATIONAL UNIVERSITY
Research Scholarships
Research School of Earth Sciences

In 1973 the Department of Geophysics and Geochemistry was reconstituted to form the Research School of Earth Sciences, and Professor A. L. Hales was appointed as the first Director.

The University offers a limited number of scholarships to applicants of high scholastic calibre with a capacity for research, who hold, or expect to hold, a good honours degree (generally at least upper second class honours). Some of these scholarships are tenable in the Research School of Earth Sciences. Applications are sought from graduates with backgrounds in physics and mathematics and who are interested in pursuing a course for the degree of Doctor of Philosophy in the fields outlined below.

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- Experimental deformation of minerals and rocks under high pressure and temperature (including electron microscope study of deformation processes), with applications to flow within the solid Earth and to earthquake mechanics.

- Ancient and present-day variations of the Earth's magnetic field and their relationship to relative motions of continents and to the electrical conductivity and temperature within the Earth.

- Use of seismic data in the determination of the parameters characterizing the earthquake source and of the physical properties (especially density and velocity and attenuation of elastic waves) of the Earth's interior and their significance for geodynamic processes.

- Elastic and transport properties of minerals at elevated pressures and temperatures and, by comparison with observed properties of the Earth, elucidation of the composition of the solid mantle and liquid core.

Prospective students are invited to write informally to the Director regarding specific details of research projects in these or related fields.