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President’s Column

The April issue contained a short but thought-provoking article by Dr A.W. Pryor on ‘Applied Physics’. I enjoyed his conclusion to the effect that those administrators who exhort us to be imaginative and inventive should themselves be requested to go and invent a workable organisation. It’s fun to blame administrators (or politicians!) but success is most likely to stem from a good partnership between scientist and administrator.

One of Dr Pryor’s most interesting suggestions is that since the 1960’s science has ceased to lead technology and that indeed modern technology can look after itself. I have always found satisfaction — though perhaps I was misguided — in a bootstrap theory of science and technology — i.e. that each tends to advance by exploiting the advances in the other. The extent to which this has been true involves fascinating questions on the ‘ascent of man’. Whether or not it is now true, or is now seen to be true, could be crucial to the future of physics as we know it. Much of our teaching of physics and the attitude of society to physics is based on the assumption that it is fundamental to technology. It is important that we question this and, if necessary, change our approach to maintain the relevance of physics. On the other hand we should not forget that there is justifiably another side of physics as one of the highest manifestations of human endeavour (dare I suggest also as an art form) to gain an understanding of our universe. Indeed the word ‘physics’ stems from the Greek ‘physia’ indicating the endeavours of mankind to gain insight into the essential nature of all things. Quite apart from its use to advance technology, physics is an invaluable ingredient of human scholarship in its own right.

I note that this volume includes a letter and form on the Freeze Appeal. I urge you to consider this as a private initiative by Professor Runciman; the Institute encourages such initiatives on matters of interest to physicists. Views, for example, opposing the Freeze Appeal would be just as welcome.

edit Wilson

Editorial

It is good to see several letters in this issue, and other evidence of Members’ involvement. This month the Nuclear Freeze and the participation of women in physics are given prominence, book reviews have had to be held over until August.

Those interested in the role of women in physics should read the summary and recommendations of the report, *Girls and Physics*, by the joint Physics Education Committee of The Royal Society and The Institute of Physics, published in *Phys. Bull.* (1983) pp 180, 181. There are not many surprises, but it is evident that opportunities for discrimination are legion, and that it is easy to be blind to these factors. If I had to choose the point of greatest influence in forming male/female relationships and attitudes, I would unhappily choose the home. The question then becomes how to influence the family units of a nation. The Eastern Bloc seems to have a good start here!

Concerning the Freeze Appeal, I personally hope there will be a good response. If you do not wish to add your signature to the petition, perhaps you would care to let us know your views? Please note that in this instance, only signatures of physicists are required. I do not subscribe to the view that physicists are more culpable than others, but we do have a responsibility by virtue of our special capacity to understand the technical issues. In fact, merely because of our higher education and training we have a greater social responsibility.

The Victorian Government passed their “nuclear free” legislation while this issue was being prepared. In my view, much more thought should be given to this “ban everything” attitude. Nuclear power offers benefits in conservation of resources and in pollution reduction. We ban nuclear power while there are still major problems such as cigarettes and alcohol which result in obvious mass carnage all over the world. When you consider the nuclear arsenals already in existence (described elsewhere in this issue), what extra risk is imposed by the possibility of theft of fissile material?

Some people tend to oppose the introduction of nuclear power on the Mickawberish basis that “something new will turn up”, and the same argument has been leveled against the Gordon-below-Franklin scheme. Writing in Engineers Australia, John Owen of Hobart likened this to planning one’s life on the assumption that a “pools win” or similar win will all sooner or later eventuate. As a matter of fact, if one is sufficiently in debt, this is the only course open; it is necessary to develop the possible while it is possible.

Every new technology introduces an element of risk and uncertainty, and some have received violent opposition, usually because of a risk of unemployment. The risks usually decrease as an invention is developed and enters into general use.

The Department of Metallurgy at Birmingham University at the time of the Comet disasters of the early ’50’s. We were told that no aeroplane could be designed to withstand the worst extremes of atmospheric turbulence it was possible for a plane to encounter. Such a plane would be too heavy to leave the ground. Even at that time, flying was comparatively safe. It has become safer not so much because the planes are now stronger (although the Comet’s problem was a structural
LETTERS

Dear Sir,

It is not before time that the Institute has set up a Working Group on Nuclear Armament and Warfare. The AIP has the responsibility to provide a lead to the public on all matters where physics is involved, and this certainly includes nuclear physics.

Too many people, including some who should know better, refuse to distinguish between proper and improper, or moral and immoral, uses of nuclear physics. The distinction is continually being blurred and muddled for political and ideological reasons.

I hope that the AIP Working Group, after due and thorough consideration, will adopt the A.P.S. statement opposing nuclear war, nuclear weapons and nuclear explosives. Such a stand will not hinder endorsement of nuclear power generation and other non-military uses of nuclear energy and nuclear physics generally.

At a topical level, I would like to see the Working Party support the creation of Nuclear Weapon-free Zones and just as strenuously oppose the misguided creation of Nuclear-free Zones, which are now proliferating around our cities. Nuclear-free Zones confuse the issue and give activists all the excuse they need to block beneficial uses of nuclear energy.

A few members of the AIP are utterly opposed to nuclear power generation, but such views should not prevent the Working Party from drawing a clear distinction between nuclear power and nuclear weapons. The Canadian example shows quite clearly that the former can be successfully accomplished without the latter.

If the view is maintained that all nuclear technology is harmful and dangerous, then I would confidently predict that the AIP will split down the middle on the issue and remain divided. Should that happen, the Institute will become totally ineffective in condemning nuclear weapons and their use. And surely the vital issue is the prevention of nuclear war, which is the ultimate perversion of nuclear physics.

COLIN KEAY, F.A.I.P.
Associate Professor of Physics
University of Newcastle

A “Mock Sun” Seen In The Blue Mountains of N.S.W.

Dear Sir,

On May 7th, 1983 I saw an atmospheric phenomenon which I believe was a “mock sun” or parhelion.

It was a fine, still day with a fair amount of light cloud, some of it being cirrus. I was driving north and west from Katoomba to Mount Victoria, in the Blue Mountains of N.S.W., a little after 4 p.m., when I noticed a brightly-coloured patch in the sky ahead of me, at the same height as the sun, but well to the right of it. It was at the right hand end of a long, fairly dark grey cloud which had a fringed edge at that end, and the colours followed the shape of the fringed edge, a yellow band merging into a red one (sunset tones, but long before sunset, and no other colour elsewhere in the sky). Immediated to the right of the coloured bands was a very bright, diffuse light, like the sun shining through clouds. The apparition continued for 15 or 20 minutes after I first noticed it, but the intensity of the colours began to fade after about 10 minutes.

Later that evening I spoke to somebody living at Wentworth Falls, a bit east of Katoomba, and she told me that she had seen, at about 4 p.m., a “second sun” shining through cloud, but in her case it was at the centre of the cloud and there were no colours.

I identified the apparition from the only reference book I had to hand: a “mock sun”, but in the two records in that book there was no mention of colours, I am indebted now to Professor H. C. Bolton for an explanation and further references, and have since found a good qualitative account of the formation of such parhelia in an old textbook. They are produced by refraction through the prisms formed by ice crystals which, falling under gravity in still air, are similarly oriented. Parhelia formed in some positions are coloured, and in other positions they are white.

K.R. MAKINSON

REFERENCES


Defence Science

Dear Sir,

The survey of jobs for physicists in “The Australian Physicist” (May 1983) revealed the largest potential employer to be the Commonwealth Government (not CSIRO). That single category accounted for 20% of all jobs advertised and over 30% of permanent jobs.

Of these, one third were in the area of Defence Science. However, “discussion with students”, says Professor Prescott, “reveals that many are just not interested in jobs in Defence Science”.

As we Australians try to stand on our own feet more and more by developing our scientific and technological base, it is important that we build an autonomous defence capability. That will require the employment of significant numbers of scientists in Government defence laboratories.

The AIP Science Policy Committee appears to be spending a considerable amount of time on the subject of nuclear armaments, whereas Australia has a very low involvement in this field.

Errata

In the section on Recent Higher Degrees (June issue) R. F. Fleay’s work was carried out in the School of Physics and Geoscience, at the W.A. Institute of Technology. Our original aim was to give credit to the graduand. Do we have any votes for including his supervisor?

Jim Graham
Australian students apparently need to be offered a sound philosophical basis for their involvement in legitimate defence science. What role can physicists play in the development of Australia’s defence capability? How can physicists enhance our nation’s independence and foster stability in South-East Asia?

It is too bold to suggest that these questions would be more profitable ones for the AIP Science Policy Committee to address.

D.M. PHILLIPS
Adelaide

Cavendish Tradition

Dear Sir,

The article by Dr Jenkin (Australian Physicist, March 1983) about the influence of the “Cavendish Tradition” on Australian physics raises several questions which are reflected in my own experience. I am another Sydney physics graduate who was an 1851 Overseas Scholar in Cambridge, and in retrospect I too have mixed feelings about the dominant role the Cavendish played for so many years, directly and indirectly.

The most obvious effect has been that the range of subjects taught, and regarded as respectable fields for postgraduate work, by many Australian physics departments has remained far too limited. The graduates from Cambridge (and occasionally elsewhere in the U.K.) who were appointed to senior posts in Australia in the 1930’s and 40’s brought with them a definite view of what “modern” physics should be like. Unfortunately this perception sometimes did not change much over the years, and the content of courses ignored not only the evolving needs in Australia but also the changes which had taken place elsewhere (even in Cambridge).

As a research student I joined a small fluid dynamics group in the Cavendish — but only by making an abrupt change of field, which was suggested by a job in CSIRO after I graduated. Nowhere in my undergraduate course did I gain either a systematic training in that field, or even the impression that there was anything left in “classical” physics worth pursuing.

Can I make a plea for Australian physics departments to take the teaching of classical physics in particular more seriously? Some at least might broaden their definition of the subject to overlap with neighbouring disciplines (for example geophysics, which is not very strong in Australian Universities as a whole). Notwithstanding the changing labels which have been applied to my fluid dynamics research, and the institutions where it has been done (cloud physics, oceanography, earth sciences) I have continued to regard my training in physics as the basic and most important one. Our subject does not have to be narrowed to “an assembly of particles”, nor should we feel obliged to keep up in fields which have become impossibly expensive for a small nation. There are challenging problems in less fashionable areas which can contribute in diverse ways to the understanding of important processes in the world around us. This would be more widely appreciated if students were given a broader view of physics and its potential for applications in different fields.

J.S. TURNER
Research School of Earth Sciences
ANU

Aspects of Freedom

Professor Casimir (Physics Bulletin February 1983 p53), like many others, seems to feel responsible for the ‘negative consequences’ of discoveries which physicists have made.* This feeling of guilt or responsibility is shared by many scientists, not only physicists. Its origin may be in the dismay at seeing what others have done with these discoveries, but the feelings are heightened by accusations that scientists like to ‘play God’. I claim that these feelings of guilt are, in most cases, mistaken and the accusations are for the most part an attempt by society to find a scapegoat for its own mistakes.

Those who accuse the scientists of playing God should think about what God actually did. According to the Bible, God put the tree in the middle of the Garden of Eden; he knew it was a temptation, he drew Adam’s attention to it and he forbade Adam to eat of its fruit, but he did not put a guard round it. Was God responsible for the fall of man through contributory negligence? Of course God did not do wrong, and Adam and Eve, who actually chose to do something they both knew was unwise, bore the full responsibility for their actions.

Nowadays we find too many examples of this kind of distorted thinking: the criminal is not responsible for his actions, but is a victim of society; when misfortune strikes, find someone who can be blamed and sue him. There is even legislation to protect people from their own folly. But how far back should the chain of responsibility extend? For good practical reasons, English common law tends to limit responsibility to those who actually do wrong, and in many cases it is necessary to prove malicious intent.

Nowadays we find too many examples of this kind of distorted thinking — the criminal is not responsible for his actions, but is a victim of society — when misfortune strikes, find someone who can be blamed and sue him. There is even legislation to protect people from their own folly — you cannot legally buy fireworks now (at least not in North America) notwithstanding that with a little common sense you can handle them quite safely. How far back should the chain of responsibility extend? For good practical reasons, English common law ends to limit responsibility to those who actually do wrong, and in many cases it is necessary to prove malicious intent.

It is impossible to know how new knowledge will be misused in the future. Those who say that scientists should not play God should not expect them to have God’s wisdom and foresight. It is not easy to know what is good and what is evil, and some things which seem to be good at first appear not so good later. Some of the things which were developed especially for war find peaceful uses — this applies to explosives, both chemical and nuclear, and radar. Finally, even when the consequences of a discovery are known, the judgement of its value is uncertain and changeable.

For example, if we discover that a certain drug or treatment will alleviate some hereditary defect and allow the sufferer to live to pass it on to his progeny, is that discovery beneficial or not? These truths have been known for a long time, and are enshrined in our language in such sayings as "mixed blessings", and "it’s an ill wind ... "

Not only are the answers to these questions unknown — no absolute answers are possible for many of them. This being so feelings of guilt are out of place. Guilt is anger directed inwardly — instead, scientists should direct their anger against those who misuse their discoveries.

J.M. Daniels
Department of Physics,
University of Toronto

Reprinted from Physics Bulletin, May 1983

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*A relevant extract from this article is printed here.

[The text continues with further commentary on the themes of guilt, responsibility, and the misuse of scientific discoveries.]

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Hamiltonian Chaos — Applications in Atomic and Molecular Physics

D.A. Jones, Theoretical Physics Department, University of New South Wales, Kensington, N.S.W. 2003.

THE AUTHOR

Dr. David Jones obtained his Ph.D. in Theoretical Physics from Monash University in 1977. He spent 1977-78 at the University of Strathclyde, Glasgow, working on the high frequency behaviour of dilute polymer solutions. From 1978-80 he was at Queen Mary College, London University, working on non-linear dynamics and applications in atomic and molecular physics, and for the past two years has been at the University of New South Wales working on nonlinear laser-plasma interaction theory. David has published extensively and has spoken at many national and international conferences.

PART I — THE IDEAS

In recent years the character of classical mechanics has changed dramatically, due in part to the celebrated theorem of Kolmogorov, Arnold and Moser, and the discovery that the deterministic equations of classical mechanics can have solutions which behave so erratically that they are indistinguishable from those truly random processes. These new ideas and results have applications in many areas of physics, in particular astronomy, accelerator design, foundations of statistical mechanics, chemical reaction theory, and also in the study of the transition between classical mechanics and quantum mechanics. In this article I will attempt to outline some of these advances, which are fascinating in their own right, and then indicate how they are providing new insights into several areas of atomic and molecular physics. It should be noted here that we will only be describing conservative Hamiltonian systems. Similar advances have also been made in the physics of dissipative systems, where the presence of strange attractors in the phase space of the system also leads to chaotic trajectories. There is much interest in this work at present as it provides a possible explanation of the onset of turbulence in fluids, and has applications in non-linear wave interactions in plasmas, the buckling of beams, magneto-hydrodynamic flow, and various other areas of physics. Unfortunately, this work is beyond the scope of the present article (for a review of this area see the article by Ott (1981)).

We will be considering conservative Hamiltonian systems of N degrees of freedom. Hamilton’s equations consist of 2N coupled first order ordinary differential equations and therefore require 2N constants to specify the initial positions and momenta. Once these equations have been solved we can invert the solutions to express the initial momenta and positions as functions of the phase space variables and time t. By eliminating t between these functions we will arrive at 2N — 1 functions of the phase space variables alone which have the property of remaining constant along the trajectory. These functions are called constants or integrals of the motion. If each of these integrals has the property of being isolating, then specification of a particular value for each of the 2N — 1 constants is equivalent to determining the trajectory of the system in phase space, the idea being that each of the constants restricts the motion to lie on a 2N — 1 dimensional hypersurface in the 2N dimensional space, and so specifying all 2N — 1 constants the motion is confined to the intersection of the 2N — 1 surfaces. However, not all integrals are isolating. The simplest example of a non-isolating integral is provided by two simple harmonic oscillators. There are three constants of motion, two of these are isolating and consist of the total energy of each oscillator, while the character of the third depends on the frequencies of the oscillators. If the frequencies are commensurable (i.e. \( \omega_1/\omega_2 \) is a rational number) then the integral is isolating and the trajectory is restricted to the one dimensional line which is the intersection of three surfaces in a four dimensional space. This is the case of a closed Lissajous’s figure. If the frequencies are incommensurable then the integral is non-isolating and the trajectory is free to explore the whole of the two dimensional area in configuration space which is determined by the maximum amplitudes of oscillation.

Hamiltonian systems are most conveniently discussed in terms of action-angle variables I, and \( \phi_i \). This is particularly advantageous when the dynamical system exhibits periodicities in all its coordinates. A canonical transformation is made to new coordinates \( \phi_i \) (the angle variables) and new momenta I, (the action variables) such that the new Hamiltonian depends only on the I, Hamiltonian’s equations then ensure that the I, are constants of the motion, while the \( \phi_i \) increase linearly with time. The frequency of a particular degree of freedom with angle variable \( \phi_i \) is simply given by \( \omega_i = \partial H/\partial I_i \). A system for which such a transformation can be made, and for which the N constants of the motion are single valued, analytic, and...
in "involution", i.e. the Poisson bracket of any two of them vanishes identically, is called an integrable
Hamiltonian system. The phase space motion of
trajectories in such a system is confined to manifolds
having the topology of $N$-dimensional tori. Each set of
values of the action variables $I$, specifies the position of
a torus in phase space, and the corresponding angle
variables $\phi$, specify the position of a trajectory on
that torus. These tori are usually called invariant tori because
an orbit starting out on one remains on it forever. If
the frequencies $\omega$ are commensurable then the orbit
closes after a sufficiently long period of time and the
motion is periodic, whereas if the frequencies are
incommensurable the orbits never close and instead
cover the surface of the torus ergodically. We now
consider the important question of what happens to
the invariant tori of an integrable system when the
Hamiltonian is subjected to a non-integrable
perturbation. The answer is contained in a theorem
which was first conjectured by Kolmogorov (1954), and
then proved by Arnold (1963), and, independently, by
Moser (1962) (hence known as the KAM theorem).
Briefly, it states that most of the tori (i.e. those with
frequencies $\omega$, which are "sufficiently irrational") are
preserved, although in slightly distorted form, for
sufficiently small perturbation. Those tori which are
destroyed by the perturbation lead to regions of phase
space in which the trajectories are wildly erratic and
have a very sensitive dependence on initial conditions,
their behaviour is very different indeed from the much
more regular trajectories of orbits confined to the
invariant tori, and they are variously described as
chaotic, stochastic, and even ergodic, although the latter
is certainly not true in a strict sense. As the strength
of the perturbation increases the volume of phase space
occupied by these chaotic trajectories increase at the
expense of the volume occupied by the regular
trajectories, and in most cases it has been possible to
identify a critical value of a parameter (usually the
energy) at which the character of the motion changes
from predominantly regular behaviour to predominantly
chaotic behaviour. This change can be quite sudden.
It must be emphasized though that the regions of regular
and chaotic motion are interwoven in a most
complicated way, and that no matter how finely we
magnify a particular region of phase space we will
always find a mixture of regular and chaotic trajectories.

![Figure 1: Surface of section for Hénon-Heiles potential at $E = \frac{1}{3}$, indicating completely integrable motion (from Hénon and Heiles 1964).](image1)

![Figure 2: Surface of section for Hénon-Heiles potential at $E = \frac{1}{3}$, showing regions of regular behaviour surrounded by a region of irregular behaviour caused by the wandering of a single orbit (from Hénon and Heiles 1964).](image2)

Proofs of the KAM theorem are mathematically
complex, and the bounds on the size of the perturbation
are quite severe. Moser's proof gives the least bound
with perturbations which must be less than $10^{-48}$
in appropriate units. As one prominent researcher in this
field is fond of pointing out "This is less than the
gravitational perturbation of a pendulum in England
by the motion of a virus in Australia". Numerical
experiments however indicate that the perturbation can
be of order unity and the system will still display the
generic behaviour discussed above. The most famous
experiment of this type is the one due to Hénon and
Heiles (1964). They were interested in the motion of a
star in the average field of a galaxy, and reduced the
problem to the motion of a particle in a plane under
the action of an arbitrary potential. There are three
integrals of motion, one is the total energy and is
isolating, one other integral can be shown, in general,
to be non-isolating, and the interesting question is
what is the nature of the third integral, isolating or non-
isolating? To answer this question Hénon and Heiles
numerically solved the equations of motion for the
system and looked at the behaviour of the trajectories
using the Poincaré surface-of-section method. Because
there is definitely one isolating integral (the total energy)
we only require the values of three of the coordinates
(e.g. $x$, $y$, $\dot{y}$) to completely specify the trajectory, the
fourth coordinate $\dot{x}$ can then be obtained from the
energy equation

$$\frac{1}{2}(x^2 + y^2) + U(x, y) = E,$$

and we can therefore plot the trajectory in a three
dimensional phase space $(x, y, \dot{y})$. The value of $\dot{x}$
calculated from the energy equation should be non-
negative, and this leads to the condition

$$U(x, y) + \frac{1}{2}y^2 \leq E,$$

which defines a bounded volume in the three
dimensional phase space. If there are no other isolating
integrals then the trajectory will have no further
restrictions and will fill this volume. However, if there
is another isolating integral then we will have a
relationship of the form

$$f(x, y, \dot{x}, \dot{y}) = \text{constant},$$

*I.C. Percival, Lecture Notes, 1978.*

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and we can use this relationship, together with the energy equation, to eliminate $x$ and find $x = x(y, y)$. In this case the trajectory will lie on the surface in the $(x, y, y)$ space. The surface-of-section technique follows the successive intersections of the trajectory with the plane $x = 0$ in the upward direction, i.e. the points $P_1, P_2, \ldots$ of the trajectory which lie in the $(y, y)$ plane and satisfy $x = 0$ and $x > 0$. If a second isolating integral does not exist these points will be dense in an area of the plane, which is the intersection of the volume $U(x, y) + \frac{1}{2}y^2 \leq E$

with the plane $x = 0$. If a second isolating integral does exist then the points will instead lie on a curve, which is the intersection of the surface $x = x(y, y)$ with the plane $x = 0$. Henon and Heiles studied the Hamiltonian

$$H(x, y, \dot{x}, \dot{y}) = \frac{1}{2}(\dot{x}^2 + \dot{y}^2) + \frac{1}{2}(x^2 + y^2) + (x^2y - \frac{1}{3}y^3)$$

and plotted surfaces of section in the $(y, \dot{y})$ plane for energies $E$ ranging from the equilibrium energy $E = 0$ to the escape energy $E = \frac{1}{2}$ (increasing the energy corresponds to increasing the strength of the perturbation). For $E = \frac{1}{2}$ the surface-of-section plot is shown in Fig. 1 for several trajectories. As each trajectory consists of a smooth closed curve it appears that a second isolating integral exists and that the Hamiltonian is integrable at this energy. Fig. 2 shows the surface-of-section for $E = \frac{1}{2}$, and now we begin to see the appearance of stochastic motion. It is important to realise that the seemingly random scatter of points in Fig. 2 corresponds to one trajectory, which is obviously no longer constrained by a second integral of motion to lie on a two dimensional invariant torus. Other orbits in Fig. 2 however are still lying on invariant tori and this diagram is a good illustration of the enormous complexity of the phase space behaviour of Hamiltonian systems in general. Remember that integrability is the exception, rather than the rule, and that most Hamiltonian systems will show the complicated intermingling of regular and stochastic motion shown in Fig. 2. This is in rather sharp contrast to our experience of classical mechanics from undergraduate days when experience with the simple harmonic oscillator and the Kepler problem would have us believe that such regularity was the norm. It should also be emphasized that the chaotic trajectory shown in Fig. 2 is completely deterministic and that no external stochastic generator has been added to the Hamiltonian to produce this result. As the energy is increased more invariant tori break down and eventually almost all orbits become stochastic and cover the surface-of-section in an apparently random scatter of points.

What is the explanation of the breakdown of the isolating integrals and the appearance of chaotic trajectories? Walker and Ford (1969) have done some numerical experiments which suggest that overlap of resonances is the cause of the transition to chaos. They considered the integrable Hamiltonian

$$H_0(I_1, I_2) = I_1 = I_1 - I_1 - 3I_1I_2 + I_2$$

and investigated the effects of adding a 2:2 resonance and a 3:2 resonance, i.e.

$$H(I_1, I_2, \phi_1, \phi_2) = (H_0(I_1, I_2) + \alpha I_1 \cos(2\phi_1 - 2\phi_2) + \beta I_2 \cos(2\phi_1 - 3\phi_2))$$

In terms of the cartesian variables $(q_i, p_i)$ defined by

$$q_i = (2I_1)^{\frac{1}{2}} \cos \phi_i$$
$$p_i = -(2I_2)^{\frac{1}{2}} \sin \phi_i$$

the invariant curves of the unperturbed system in the $(q_i, p_i)$ plane are simply circles centred on the origin. Each resonance in isolation only slightly distorts the invariant tori (it is still in fact an integrable system), although the neighbourhood of the resonant unperturbed torus is seriously distorted and the circle
is replaced by a zone containing crescent like curves centred around a periodic trajectory. The position and width of these resonance zones depends on energy, and for low energies the two resonance zones are well separated and the motion is still regular (Fig. 3). As the energy increases the width of the resonance increases also, and at a particular value the two resonances overlap. It is just this energy that the first chaotic trajectories appear (Fig. 4). This concept of overlapping resonances leading to chaotic motion is the basis of the method proposed by Chirikov (1979) for predicting the energy at which a particular non-integrable Hamiltonian system will undergo a stochastic transition. Chirikov makes canonical transformation to a new set of coordinates with origin at the centre of the resonance. In these new coordinates (and by making a coupling of approximations) the new Hamiltonian has exactly the same form as that of a pendulum and the width of the resonance is simply defined as the disturbance between the two separatrices. A criterion is then obtained by evaluating the width of another nearby resonance and then finding the coupling strength at which the two resonances overlap. The method has been tested on a number of simple systems and generally has been found to be accurate to within a factor or two. The method is particularly appropriate for forced one dimensional oscillators and will be mentioned again when we consider the motion of molecules subjected to laser radiation.

Other methods for predicting the onset of chaotic motion also exist. The Toda-Brunner-Duff method (Toda 1974, Brunner and Duff 1976) is based on the experimental separation of initially close trajectories in the chaotic region, as opposed to their linear separation in the regular region. It has been applied to the Hénon-Heiles system and predicts a transition at $E = E_c$, which is in reasonable agreement with the observed transition around $E = E_c$. The method is not entirely rigorous however and leads to predictions of transition in systems in which none is in fact found to occur. The most accurate method is due to Greene (1968) and is based on the stability property of closed orbits.

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**Women and Undergraduate Physics Education**

Roger Clay, Physics Department, University of Adelaide, Adelaide, South Australia 5001

I have had an interest in the Physics education of women for some years. This interest began when it seemed to me that talented women I met in teaching situations were not obtaining the examination grades which I felt were appropriate. I was concerned that they accepted that they “can’t do Physics exams”. I began to look at the examination performances of men and women and was disturbed by what I found. On reflection I felt that the talents I saw in many women students weren’t being due credit in our assessment. I hope that the following comments may encourage others to examine critically some of their assessment procedures.

Gillian Robertson was recently preparing some material to follow up the ANZASAAS (Women’s Studies Section) discussions on women in Physics. She had read a paper of mine (Clay, 1982) on the achievement of undergraduate women in the Physics Department of the University of Adelaide. This article showed that women here performed, in our overall assessment, about as well as men. I commented in the paper that, on the face of it, this might be surprising since we have relatively few women and were, arguably, therefore dealing with a more highly selected group. It seemed to me that perhaps our existing Physics courses were not well suited to our women students. I speculated that it may be possible to produce an alternative Physics course (or even Physics subject) which, whilst being equally as valid as the existing norm, would be biased for women (as the existing subject is arguably biased towards men) and be taken by our women students. Dr. Robertson understood this suggestion to involve, perhaps amongst other changes to convention, a move from a problem solving Physics education approach to one involving a more descriptive syllabus. Such a change was not particularly what I had in mind. In fact, it had seemed to me that a male was probably an unsuitable person to consider defining such a course. However, since the issue came up I thought it might be appropriate to discuss some of the issues involved, particularly our practice of emphasising problem solving in our teaching and examining.

First of all, let us be clear that we have only a little information on the sexual bias of our Physics courses.
(a) There is circumstantial evidence that very few Physics academics are women. At the best, this means that our women students have very few academics with whom they can relate.
(b) I have been able to show that there is significant sexual bias in some questions which are common in Physics examinations. Women perform clearly better in essay-type questions, men appear to perform better in problem-oriented questions (University of Adelaide preprint). Thus, the mix of question types employed in an examination can determine how the sexes fare.
(c) Finally, looking around at the Physics student population, one notes that the vast majority are men and that, despite the greater selectivity going into the women who chose Physics, there is little or no mean mark advantage to the women.

The reasons for any bias are not clear but sexual bias does exist in our present system and is most likely to continue whilst there is a lack of balance in the sexes of the academics who define the courses and the criteria for success. I believe that women are disadvantaged in the way we examine our students and suspect that they are disadvantaged by our teaching techniques. If one were to begin to redress the balance, one might start by looking carefully at our examinations and the way they assess students vis-à-vis our teaching aims. Women perform less well in problem examination questions. Suppose we were to eliminate such questions, could we still legitimately examine our Physics courses?

It is basic to the beliefs of many of us that Physicists are versatile problem solvers and one can argue that a Physics education should train problem solving ability and examine it. I am not convinced that skill in the solution of undergraduate problems (particularly of the
kind we often employ at present) is a good predictor of Physics achievement. I suspect that the relationship between this type of problem solving and professional physicists is akin to the relationship between crossword puzzling and professional novelists. In my professional life as a physicist I do solve problems in Physics, I do apply physical ideas to new problems to clarify the issues involved, and I do make back of the envelope calculations. However, in doing my research, the solution of simple problems does not take up a large part of my professional effort. I do many other things in experimental Physics and the problems I tackle are usually complex.

It is interesting to look at some relevant data from the University of Adelaide Honours marks in the last five years. The Honours course involves a number of examinations and components. One examination is an explicit problem paper where the recall of physical knowledge and the application of basic physical ideas is required. Another component is a substantial experimental project performed in a research laboratory and occasionally leading to a research publication. My contention would be that the latter situation is as close as an undergraduate can get to actively doing professional Physics. The breakdown of the marks of women and men in these assessed activities is illuminating.

There is an appreciable bias for men to perform better than women in the Physics problem paper. If one determines the ratio of the student's problem result to the mean total Honours result and finds the mean of these ratios for men and women separately, one finds:

Problem Paper
Mean ratio for men 0.81 ± 0.04
Mean ratio for women 0.59 ± 0.04

The women perform less well on the problem paper by a very large factor.

If the same ratios are found for the Honours project the results are:

Project
Mean ratio for men 1.07 ± 0.02
Mean ratio for women 1.07 ± 0.03

The women perform as well in their project as the men.

Let me reiterate that I would expect the project to be a better measure of future performance in Physics than the problem paper.

What of examinations in general then? If we were to reduce our “problem” component, would our examinations be less rigorous? Can a descriptive examination question test physical knowledge adequately? In the South Australian Matriculation Physics examination we require students, amongst other things, to write an essay (perhaps better called a report) on a topic in Physics. It seems to me that this type of examination question is no less rigorous than other conventional questions although, of course, it is more difficult to mark. Indeed, the students find it more taxing, and fear it accordingly. I think it is likely that one discovers at least as much about a student’s understanding of, say, the photo-electric effect from a descriptive essay as from a problem involving use of the photo-electric formula. The latter probably involves no real problem solving (in terms of creative ideas) anyway since the sagacious teachers have extensively drilled their students in the “solution” of such “problems”. Thus, not only are such problem questions arguably sexist but probably, in practice, test student recall in much the same way as critics believe more descriptive questions do. It has been revealing to look through scripts and markers comments for the 1982 South Australian Matriculation Physics examination in my position as Chief Examiner. The problems often presented no great difficulty and showed us little about the candidates but the descriptive questions revealed a host of misconceptions and half-understood Physics.

There is also a problem in the way that we make academics look at our students. The women we teach are different from us and we tend to be critical when we see approaches which are unlike our own. My casual observations suggest that we commonly feel that our women students are less creative than we would like, more suited to routine plodding than their male counterparts, and perhaps without some physical flair. This may be so or it may be just our sexual perception. In any case, I wonder if in general we don’t give enough credit to the student who is patient and methodical in the lab or thorough in answering assignments. Physical insight is important, of course, but in many cases dogged determination on the part of a physicist, can make up for some missed insight. Anyway, we need both: the 1% inspiration may be wasted without the 99% perspiration. So let’s give more credit for the hard work, that is also one way of redressing the balance against women.

The preceding discussion has been biased in favour of women. It is clear that the women we see perform better than the men in the types of questions which I advocate. However, I do believe we have a real problem in Physics in not attracting women into our profession. I have been impressed by the professional abilities of the women physicists I have known and believe we should have serious concern that we are losing too many potential members of the profession. Particularly when there is a clear long-term shortage of physicists. I began by suspecting that the right solution is to teach and examine women separately. I am sure now that this is correct, but unrealistic. As a compromise, I think we must look critically at our teaching procedures and where possible modify them, if necessary to advantage the women somewhat. After all, we have several millennia of neglect to make up for.

Reference

Further Reading
An extensive discussion of issues involved in the scientific education of girls is to be found in “The Missing Half” Kelly, A. (Ed.) (1981) Manchester U.P.

New Journal
Announcing the Journal of lightwave technology, a new publication of the Institute of Electrical and Electronics Engineers and the Optical Society of America. The development of low-loss optical fibres and efficient and reliable light sources and detectors has led to an explosion in the utilization of these components in communications and sensor systems. Much of the material herefof published has appeared in the several journals of the Institute of Electrical and Electronics Engineers (IEEE) and the Optical Society of America (OSA). The two societies have elected to direct all applicable papers to this new journal for publication in order to provide a focus for the vigorous and growing field of lightwave technology.
Women Students In Physics Before And After International Women's Year

Gillian Robertson, Department of Physics, University of Adelaide, Adelaide S.A. 5000

Introduction

The number of female students taking physics at universities has traditionally been much less than the number of male students taking the subject. In International Women's Year, 1975, this situation was brought to the notice of the Australian physics community and the need to encourage more girls to consider physics as a possible career was emphasized (Bird, 1975; Robertson, 1975). Factors thought to be discouraging to girls were social pressures in the home and community, and the attitudes of schoolteachers in the important years when subject choices must be made. There was also a commonly-held belief that physics requires special abilities that girls possess to a lesser degree than boys and that it is taught in a manner unattractive to girls. Another possible factor was the shortage of adult female physicists working as physics teachers or research scientists with whom the girls could identify. It was thought that the activities of International Women's Year might improve the prospects and working conditions of female physical scientists generally but special measures were needed to encourage more female students to consider studying physics.

There is evidence that members of the Australian Institute of Physics have responded to some extent (Prescott, 1976; Frazer, 1977; Fletcher, 1981) and it would be interesting to know whether there has been a change of attitude amongst the students themselves as reflected in university enrolment figures.

In 1975, statistics from the University of Adelaide for enrolment and performance of male and female Science students in physics were obtained for the years 1967 to 1974 (Robertson, 1975). Statistics for the next seven years, 1975 to 1981, are now available and it may be instructive to compare the results for the two periods.

Collection and Analysis of Data

The 1967 to 1974 statistics referred to students enrolled in the Faculty of Science and in the Faculty of Mathematical Sciences from 1973 when this was established as a separate Faculty. The 1975 to 1981 statistics refer to the Faculties of Science and Mathematical Sciences as before, and the Faculties of Medicine and Engineering have been added. In all cases the numbers were broken down into males and females and the grades of pass obtained.

At the University of Adelaide a student hoping to become a physicist takes Physics I, II, III and/or IIIIM for the B.Sc degree. In the Faculty of Medicine all students are required to take a half-subject Physics III(M) (now named Medical Physics) which was taken in first year until 1980 but is now taken in second year. There are thus no figures for this subject in 1981. All Engineering students take Physics I as a first year subject and some, especially electrical engineers take Physics II. Physics II is made up of six physics units, Physics IIIIM has four physics units and two units from another approved subject.

The relative numbers of male and female students enrolled in the Faculties of Medicine and Engineering provide an interesting comparison with the numbers enrolled in the Faculty of Science as shown in Table 1.

### Table 1

<table>
<thead>
<tr>
<th>Faculty</th>
<th>Years</th>
<th>Total Number</th>
<th>Male/Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science and Maths</td>
<td>1975-76</td>
<td>1516</td>
<td>4.3</td>
</tr>
<tr>
<td>Science</td>
<td>1975-80</td>
<td>694</td>
<td>1.9</td>
</tr>
<tr>
<td>Medicine</td>
<td>1975-81</td>
<td>1298</td>
<td>19.0</td>
</tr>
</tbody>
</table>

1. In Medicine the ratio M/F remained stable at 1.9 ± 0.4 over the period studied. In Engineering there were 36 male students to every female student in 1975 but this ratio had decreased to 11 in 1981. Although more women are now training to become engineers compared with 7 years ago, the numbers are still small compared with those taking science and particularly Medicine.

The trends in first year physics enrolments in the Science and Mathematical Science Faculties and the ratios of males to females for all the years for which we have statistics are shown in Figure 1. The total enrolment figures reflect the trend away from the technological disciplines in the 1970's and the levelling out of this trend in the last few years. Prior to 1975 the proportion of females taking physics remained relatively stable with a mean yearly M/F ratio of 3.9 ± 0.4. Since 1975 there have been more marked fluctuations with

![Graph showing enrolments and M/F ratio over years]

Figure 1: Enrolments in Physics I in the Faculties of Science and Mathematical Sciences and corresponding ratios of male to female students.
TABLE 2
Enrolments in Physics in the Faculties of Science and Mathematical Sciences.

<table>
<thead>
<tr>
<th>YEARS</th>
<th>PHYSICS I</th>
<th>PHYSICS II</th>
<th>PHYS. III</th>
<th>HONOURS</th>
<th>M.Sc.</th>
<th>Ph.D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T</td>
<td>M/F</td>
<td>T</td>
<td>M/F</td>
<td>T</td>
<td>M/F</td>
</tr>
<tr>
<td>1967-74</td>
<td>2490</td>
<td>3.8</td>
<td>601</td>
<td>10.8</td>
<td>203</td>
<td>11.6</td>
</tr>
<tr>
<td>1972-74</td>
<td>1516</td>
<td>4.3</td>
<td>328</td>
<td>7.4</td>
<td>171</td>
<td>6.8</td>
</tr>
<tr>
<td>1975-81</td>
<td>19</td>
<td>4.8</td>
<td>76</td>
<td>14.23</td>
<td>35</td>
<td>36</td>
</tr>
</tbody>
</table>

TABLE 2A
Proportions of students in Physics subjects going on to the next year.

<table>
<thead>
<tr>
<th>YEARS</th>
<th>Physics II/Physics I</th>
<th>Physics III/Physics II</th>
<th>Honours/Physics III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T</td>
<td>M/F</td>
<td>T</td>
</tr>
<tr>
<td>1967-74</td>
<td>.24</td>
<td>.28</td>
<td>.10</td>
</tr>
<tr>
<td>1975-81</td>
<td>.22</td>
<td>.23</td>
<td>.14*</td>
</tr>
</tbody>
</table>

*Note that if the ratios are taken to the number of students who remain in 3rd term of 1st year, the female figure is much more respectable (Ed).

a mean value of 4.5 ± 1.0. Greater fluctuations become apparent as total numbers fall, but the changes also tend to mirror the drop-off and recovery in total enrolments. It is interesting to speculate on the basis of the 1975-1980 figures that females may be quicker than males to respond to a perceived changing demand for physicists, but the reason for the drop-off in female enrolments in 1981-1982 is puzzling.

The figures for first year enrolments are given in Table 2, together with figures for the other years. The figures in second, third and fourth years show some changes for the periods before and after 1975, notably a decrease in the proportion of males to females from about 11 in 1967-74 to about 7 in 1975-81. The reasons for these changes are seen in more detail in Table 2A which gives the proportion of students in any year who continue on to the next year (assuming it is valid to group the numbers over the two periods and that there is little error introduced in neglecting the fact that the 1975 Physics I students become the 1976 Physics II students etc.). The relative number of all students in Physics I who continue with Physics II has not changed in the two periods, but the relative number of females has increased by 40%. The relative number of all students in Physics II who continued with Physics III has increased in the last seven years and the relative number of females has increased by 100%. It must be kept in mind that the total number of females involved in all classes is very small and the results can be taken to represent possible trends only. In the 1967-1974 period the number of students taking honours was more than half the number taking Physics III. In the 1975-1981 period it is nearer one third. This change may in part reflect the employment situation where some B.Sc. pass students take up job offers as soon as they have a degree. The numbers in the Ph.D group include all students currently enrolled for the degree. As students are now taking 4 or 5 years to complete Ph.D degrees, the number graduating each year may be only 1/4 or 1/5 of the number quoted. The subject Physics IIM was mentioned as an alternative (see above) but figures have not been included in the table as they were not available for the 1967-1974 period. During the 1975-1981 period there were 67 enrolments in Physics IIM of which the proportion of females was not significantly different from that in Physics III.

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The breakdown of enrolment figures showing the numbers of males and females who obtained various grades of pass is shown in Table 3. The grades D, C, and P for distinction, credit and pass, are self-explanatory. The grade N is used to indicate a failure at the examination, exclusion from the examination for some reason such as unsatisfactory practical work or failure to sit the examination. The results are for the November examination only. Some students may have passed at the February supplementary examination. This qualification does not affect the findings on the relative numbers of males and females who passed the subject, but it may give a false impression of the failure rate overall at the University of Adelaide.

In the 1975 analysis it was shown that, in first year, female students are over-represented in the pass grade compared with male students and fewer female students obtain credits and distinctions. In second and third year, however, there is no significant difference between the performance of male and female students. The 1975-1981 figures again show fewer females in Physics I obtain distinctions and credits but the differences are not statistically significant. In second year, females are over-represented in the credit class and in third year the distinction class as well as the N class, but again the differences are not significant. A significantly greater proportion of females in the pass grade occurs amongst the medical students. Amongst engineering students the differences are not significant.

From 1979 records have been kept of the students who withdrew from the course before the end of second term and hence could be classed as “drop-outs”. As these figures were not available for the earlier years they have not been included in the analysis. In the Science and Mathematical Sciences Faculties, 114 Physics I students over the years 1979-1981 have been recorded in this category, of which one third were females (M/F = 2:1). This is a considerably higher proportion than that observed in the various grades of pass recorded and brings to light a somewhat disturbing feature which may warrant further investigation.

TABLE 4
Achievements of Men and Women in Undergraduate Physics courses averaged over several years.

<table>
<thead>
<tr>
<th></th>
<th>Mean mark for men</th>
<th>Mean mark for women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics I</td>
<td>1.22 ± .05</td>
<td>.97 ± .04</td>
</tr>
<tr>
<td>Physics II</td>
<td>1.92 ± .04</td>
<td>.96 ± .06</td>
</tr>
</tbody>
</table>

Discussion

A different approach to the comparison of the results of male and female students was taken by Clay (1982a) who analysed the examination marks of students averaged over several years (Table 4). The result agrees with that quoted above, showing that male students achieve better results than female students in first year, but the difference is not significant in later years when only the most able female students remain. It might be concluded therefore that in first year we are already drawing on the whole population of female students who are capable of doing physics at the same level as males. Clay speculates that perhaps the emphasis of the course should be changed to accommodate the interests and abilities of female students in a special “physics for females” subject. Such a subject might include more descriptive and essay-type work in which females excel and less problem-solving which they find difficult. Many physicists, including female physicists, would argue that such a course would teach students about physics, but not train them to be physicists.

The general conclusion from the investigation is that despite efforts to encourage more female students to take physics there has been little change in the enrolment figures in first year up to date, but there are some indications that more female students are carrying on with physics into the second and third years. We might therefore expect to find a few more females in the physics work force in the next few years. On the other hand if the 1980-1981 ratio of males to females in Physics I is sustained in the future, a greater proportion of females going on to Physics II and III will produce little change in the numbers of females graduating in the longer term.

If we accept the advice of sociologists (Kelly, 1979) that attitudes towards science are acquired very early in a child’s development, we might conclude that it is too early to see a change of attitude towards physics amongst students at university level as a result of the 1975 initiatives. We shall need to wait until the children beginning primary school in the mid 1970’s have reached university age in the late 1980’s. An analysis for the next decade might therefore be a worthwhile exercise.

TABLE 5
Enrolments in the University of Adelaide, Physics Department Summer School

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>% Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>306</td>
<td>34</td>
</tr>
<tr>
<td>1979</td>
<td>350</td>
<td>35</td>
</tr>
<tr>
<td>1980</td>
<td>392</td>
<td>35</td>
</tr>
<tr>
<td>1981</td>
<td>465</td>
<td>41</td>
</tr>
<tr>
<td>1982</td>
<td>489</td>
<td>45</td>
</tr>
</tbody>
</table>

There are some indications that interest in physics amongst schoolgirls in South Australia may be increasing by the attendance of girls at the University of Adelaide Physics Department’s Summer School for Matriculation Physics students. Invitations to the summer school are sent to all secondary schools and allocations of places are made on the basis of numbers of students in the classes. The figures supplied by Briggs (1982), (Table 5), show that increasing proportions of girls are attending. In the last two years, the proportion has been significantly greater than the proportion of boys to girls enrolled in Matriculation Physics in South Australia, known to be about 3 in 1981 (Clay, 1982b).

The reasons why the summer school attracts a greater proportion of the girls who are eligible, than the boys, are complex. One possibility is girls’ greater interest in activities which appear to have a social component, that is, they see the summer school as an opportunity to meet other students. It may also be that the girls attend where the individual teachers show more enthusiasm in providing information and encouragement to their pupils. Whatever the cause the Summer School is providing a positive influence for girls where they find themselves in a “normal population” of boys and girls involved in physics. It is generally agreed that such experiences are necessary to counteract the discouraging attitudes girls have met with in the past. With this idea in mind, the Physics Department staff have made conscious efforts to present physics as a female as well as male activity by their choice of participants in the programme. This applies particularly to the careers afternoon, when a
disproportionately large proportion of the speakers are female physicists.

REFERENCES


This report is a revised version of a paper given to the Women's Studies Section of A.N.Z.A.A.S, in May, 1982.

BIOGRAPHY OF AUTHOR

Gillian Robertson graduated in Melbourne and then went to London to work at St. Bartholomew's Hospital Medical College where she obtained a Ph.D in the field of Physics as applied to Medicine. Since coming to Adelaide in 1958, she has been variously employed in part-time appointments at the Waite Agricultural Research Institute and the School of Medicine at The Flinders University of South Australia. She now works with the Archaeometry Group in the Physics Department at the University of Adelaide. Her experiences have shown the importance of part-time work for married women who wish to combine a career in Physics with family responsibilities and she supports measures to improve the status of these women. In 1981-82 she was Chairman of the S.A. Branch of the Australian Institute of Physics and understands this is the first time a woman had held this position in any state branch.

BRANCH ACTIVITIES

A.C.T.
Views on Physics Teaching

During an extended visit to Australia, Professor Arnold Arons of the University of Washington in Seattle spent a few days in Canberra and on 26 April, 1983 addressed a joint meeting of the A.C.T. Branch and the Science Teachers' Association of the A.C.T. His theme was the cultivation of thinking and teaching methods conducive to the study of physics. He proposed that much present physics teaching is not soundly based, primarily because teachers direct their priorities to the few brilliant students rather than to the much larger body of bright but less-than-brilliant ones. As a result teaching degenerates into unthinking memory work for a passive audience instead of an opportunity to induce motivation through intellectual participation. An excess of 'knowledge' is flung at these students from the start, swamping them beyond their capacity to assimilate, think, reason and understand.

Dr. Arons believes students must be presented with less material but greater motivation to grasp the fundamental meaning of basic concepts. To do this, he propooses that courses should start more slowly, and be planned to accelerate at later stages in accordance with successful progress. More specifically, he suggested that at secondary school level each new concept requires five similar, but not identical, tests using different contexts successively to develop the same thinking process. In his experience this achieves a success rate which grows from only a few on the first test to about 85% of the student body on the fifth. He has conducted the same process during refresher courses for practising secondary teachers, with the same result. Evidently the teachers themselves were not well taught and many are poorly equipped to extend the process.

South Australia

As a prelude, it is hoped, to SA branch news appearing more regularly, a brief reintroduction to our group is given. Though we have not contributed to 'The Australian Physicalycs' for some time the SA branch has nevertheless been quite active. The same format for the calendar of events has been retained for some years now as it has proved to have been quite successful. Average attendances to meetings are around 50, out of a membership of 200.

It has become general practice to precede each meeting with a dinner at a restaurant or staff club. These have become popular social functions and put members in a receptive frame of mind for the lecture!
1. At the first branch meeting of the year, as well as having an invited guest speaker, there is a presentation of the AIP prize to the top Matriculation student in Physics.
2. Each year there is at least one joint meeting with another professional society, such as the Royal Australian Chemical Institute or the Australian Institute of Energy.
3. There is generally one lecture per year that is open to the general public. A prominent speaker, usually one that has been sponsored by the Academy of Science, is chosen for these talks. The calibre of the speakers and the topics are such that large audiences of several hundred people are attracted.

In addition SA AIP together with the Science Teachers Association arrange a yearly Youth
lecture/demonstration for year 11 to 12 school children introducing them, via a good speaker, to the fascination and scope of Physics.

4. One branch meeting is always set aside for a students night in which postgraduate students from the three tertiary institutions in SA, Adelaide University, Flinders University and the SA Institute of Technology present papers on their research work. At the first SA branch meeting for 1983 a lecture on 'Recent Developments in UV and gas lasers' was given by Professor J Piper of Macquarie University. It was very pleasing to hear such an enthusiastic talk by someone so knowledgeable and interested in his field. Having started my working career in lasers, though right at the beginning of the era when 1.0 J ruby laser pulses at a repetition rate of one every five minutes were difficult to obtain, it was particularly impressive to be made aware of the range of powers, wavelengths and repetition rates available today. From virtually being a solution without a problem, lasers now have a vast range of uses, and in many cases it is possible to design efficient devices for a particular wavelength and application. Professor Piper stressed that only by thoroughly knowing the Physics behind laser operation has this increase in efficiency and versatility become achievable.

One of the triumphs of laser physics has been the advent of rare gas halide, excimer, lasers. The definition of an excimer is a molecule which is bound in an excited state, but which is not bound in its ground state. High pressure rare gas excimers exhibit a molecular emission in the vacuum UV region of the spectrum, and offer conversion efficiency from electron kinetic energy to light output. The excitation is produced by the interaction of fast electrons. The highest outputs to date have been obtained from KrF (0.2484 μm), with peak powers of 10-50MW, having been achieved. By employing Raman shifting techniques to excimer laser outputs the whole wavelength range from about 0.130 μm to the visible part of the spectrum can be covered.

One application of rare gas halide lasers is the stimulation of resonance radiation. eg. 100 of kW of resonance radiation in sodium has been achieved and thallium iodide when pumped with radiation of wavelength 0.190 μm emits resonance radiation at 0.5350 μm which is a useful green line for probing sea water.

Professor Piper then talked briefly about another form of excimer laser, the metal vapour lasers, such as mercury bromide and the copper halides. Both operate at blue-green wavelengths, the latter have outputs of 0.5106 μm and 0.5782 μm. To date mean power outputs of 30 W have been obtained. Applications of these lasers have included the separation of uranium isotopes, and as a pump for dye laser materials such as Rhodamine 6 G.

On April 25 SA AIP held a joint meeting with the Royal Australian Chemical Institute, the speaker being Professor Wilson from the Physics Department of the Royal Military College Dunroven. The topic was 'Nuclear Magnetic Resonance (NMR) for Physicists and Chemists'. On April 27 Professor Wilson also gave a lecture demonstration on NMR to year 11 and 12 school children. Unfortunately your correspondent was unable to go, but by all accounts both meetings were well attended and enthusiastically received.

Victoria

At the Branch meeting held on 28 April, Dr Mogens Lehmann from the Institute Laue Langevin at Grenoble gave an interesting talk on the organization of ILL, some of the neutron scattering facilities available, and the experiments being performed.

Referring to the constant flow of visiting Australian scientists to ILL, Dr Lehmann described the Institute as having been founded by three countries (France, West Germany, UK) largely for the benefit of a fourth, namely Australia! The three founding nations each appoint one director of the Institute; of these, the nominal head is either British or West German, but, by way of compensation, the French director has the largest office! The Institute works mainly in three areas, namely nuclear physics, inelastic neutron scattering, and neutron diffraction. The total staff is about 440, including 60 physicists. The reactor fuel is 205U, the loading 8.6kg and the operating temperature around 500°C. The neutron flux is about 7.5 x 10^13 cm^-2 s^-1, and the available wavelengths range 0.4 — 15 Å.

Dr Lehmann described some recent elastic scattering work on the structure of ice. Its hexagonal structure has been known for several years, but the proton positional disorder remains to be elucidated. Recent data for H2O and D2O, at temperatures in the range 60-223K, confirms an earlier suggestion of an elongated O-H bond (1.01 Å rather than 0.96 Å), but does not support the "bent" H2O-H bond theory (104° rather than the normal tetrahedral angle).

A striking example of the practical benefit of neutron diffraction research is to be found in the study of cement! Its principal ingredients are calcium oxide (C), aluminium oxide (A), and of course the added water. Widely ranging compositions are possible, e.g. C2A, C2AS, CA and CA2. Changes between these compositions occur spontaneously with varying water content, and the changes may be followed conveniently via powder diffraction patterns covering large angular ranges, typically 80°.

Dr Lehmann also talked briefly on neutron scattering applied to the study of magnetism, specifically the determination of the ratio of magnetic and nuclear structure factors and the relationship between the latter and spin density.

Robert Fleming

Inaugural Meeting — A.C.T. Division of ANZAAS

On 12 April, 1983 the Becker Hall of the Australian Academy of Science was the venue for a meeting of A.C.T. members of ANZAAS to adopt a constitution and elect officers for a new Division. The convener was Mr P.J. Judge of C.S.I.R.O. who is a long-standing pillar of ANZAAS, A.C.T. representative on its Council and chair of the provisional committee established in 1981 to prepare for the adoption of A.C.T. divisional status.

A welcoming address was given by Professor Ian Ross, Chairman elect of the ANZAAS Council. Mr R.H. Scott outlined the antecedents to this meeting. The constitution was then formally approved and office bearers and the inaugural committee elected. The first Chairman is Dr R.W. Crompton of the Research School of Physical Sciences at ANU. He is a past Chairman of the A.C.T. branch of AIP. Deputy Chairman is Mr Judge, who is already the Public Officer of ANZAAS and Organising Secretary of the 1984 ANZAAS Congress, to be held in Canberra. The other officers and committee members are: Secretary Mr C.G. Wilcox, Treasurer Dr R. Bell, Divisional Rep. Mr R.H. Scott, members Prof. B.G. Thom, Mr E.R. Hunter, Dr M.J. Campbell, Mr R. East and Dr H. Preston.

Mr Scott and Professor Thom presented initial reports on current activities and Dr Crompton concluded the meeting with a brief summary of promising avenues for the Division's endeavours.

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PART II. What in the world is Quantum Mechanics about exactly?

In his second talk Bell discussed the rules under which quantum mechanics operates as a physical theory rather than as just a mathematical construction. His talk is summarized in terms of three propositions. 1. There is a problem. 2. There is a solution but it is confined to non-relativistic quantum mechanics. 3. There is again a problem in relativistic quantum mechanics.

The title “What in the world is quantum mechanics about exactly?” is carefully chosen. The word “What in the world…” asks where does the formalism of quantum mechanics make connection with the physical world. What elements are supposed to be directly represented in the world and what elements are just mathematical constructs? “Exactly” emphasizes that the ordinary formulations are approximate and ambiguous in a fundamental way although the approximation is so good that it can account for observations as closely as it is possible at present to make them.

Mathematically quantum mechanics deals with things like wave functions, operators, the Schrödinger equation etc., which are supposed to be connected with the physical world by some rules which are outside the mathematical structure.

A simpler analogue of this sort of contrast between mathematical consistency and physical relevance is to be found in electromagnetic theory. The field strength tensor $F_{\mu\nu}$ is supposed to be directly translatable into physical terms and is a case of what Bell calls a ‘be-able’, whereas the vector potential $A_\mu$, whilst very useful, cannot be so directly linked with the world because of its well known gauge variability. It is not an observable.

This sounds like a reasonable differentiation between two sorts of mathematical notions, and is used extensively in quantum mechanics for the physical interpretation of that theory. But the difficulty with this way of looking at things is because the notion of observer becomes elusive. An observer, as part of the physical world, should itself be describable in terms of observables, and so needs, according to quantum mechanics, another observer to describe him. All this is usually expressed in terms of wave functions, and so one may ask whether a wave function $\psi$ itself is a be-able. But the superposition principle immediately shows that this cannot be so. One wave function $\psi$ might have Bell in Australia and another have him in Switzerland and there is nothing wrong with that, but the superposition of the two seems to put him nowhere. The usual answer is that of course one must interpret $\psi$ in terms of statistics of measurements made by someone outside the system under study, and this should be in accordance with the axioms of quantum mechanics. These axioms are of the sort given by Dirac in his book, such as: “Any result of measurement of a real dynamical variable is one of its eigenvalues”. Dirac doesn’t make it clear what a measurement is except that it always causes a system to jump into an eigenstate of the dynamical variable being measured, and such a change is sometimes called the ‘collapse of the wave packet’. So the theory is all about jumps, but it doesn’t say what these jumps are like — when they occur, how long they take, and so on. The absurdity of this situation can be seen by looking at experiments carried out at CERN. Such measurements often take years and the problem of when the jump occurs is not easy to answer. A measurement might start with an experimental proposal which goes before a committee which deliberates and various people haggle and political considerations are balanced against one another and the experiment is accepted. Does the measurement begin then and has the jump taken place? Then the apparatus is assembled and the power is switched on and then later on the power is switched off. Has the jump occurred by then? Or does it have to wait until the results are processed?

Although this account of the occurrence of jumps in experiments is meant to be satirical, the assertion that an instantaneous jump has happened at some point in the course of an experiment appears absurd. A jump cannot be instantaneous and a measurement cannot be instantaneous, but as they are both left unanalyzed one doesn’t know what to say. There are good and bad measurements, but quantum mechanics doesn’t say anything about when a measurement is good or bad. What does quantum mechanics say about processes deep inside the sun where there can be nobody present to make measurements? What happened before human beings or animals appeared on the earth, and who are qualified to make measurements at all? Can an infant child or a cat or a mouse or a Ph.D make a measurement? As put this way the axioms look absurd and no serious person takes them seriously. Although lots of things are written in books and students memorize them, they don’t use them like that. People learn their trade by observing the masters and after a time find out by apprenticeship.

Here is an example which shows what can happen if one tries to take the axioms too seriously and applies them to a process of continuous observation. Just look at something continuously and ask how you would represent that. As a start suppose that the measurements are made very often and then let the interval between successive measurements go to zero. This was done first by Alcock in 1969 and further contributions appeared later in papers by Misra and Sudarshan (1977) and by Ghirardi et al (1979). The probability of getting the same result $\alpha$ each time an observable is measured at time intervals $\tau$ for a total time $T$ is $|\langle \alpha | e^{-iHT} | \alpha \rangle |^{2\tau}$. Then in the limit as $\tau \rightarrow 0$ this becomes approximately

$$\exp \left\{ \frac{\langle \alpha | -iH|\alpha \rangle}{\langle \alpha | \alpha \rangle} \cdot \frac{\alpha \alpha H |\alpha \rangle}{\langle \alpha | \alpha \rangle} \right\} = 1$$

and the probability of always seeing the same result if one looks often enough is unity. So continual observation prevents change! Does this mean that watched kettles never boil, watched clocks never move, or watched unstable particles never decay? This is absurd for as you can see the clock moves even though you are watching it. So people have produced arguments to show why this can’t happen, but the trouble with such impossibility proofs is that they use the various axioms which are being called in question. As the proof also uses those axioms there must be additional assumptions in the impossibility proof which are not explicitly stated. An additional assumption is the well known one that there must always be an interface between the system being observed and the apparatus making the observations. But because the apparatus itself is a physical system the behaviour across the interface cannot be freely prescribed as the laws of quantum mechanics must be involved and they state that...
Although the interface may be chosen arbitrarily, the various conclusions that follow must be related. By judicious choice of the interface the conclusion can be made to be almost independent of where the interface is, and the axioms can be applied with more confidence. The choice that implies this is when the apparatus is macroscopic so that the de Broglie wavelengths are small. Then the quantum interference effects, thought still present, are extremely elusive. So if you have a clock it doesn't much matter whether you say that the interface is at the plate of the camera or only at the developing tank and so on. In this way there can be agreement about what quantum mechanics is saying in a given case, but this agreement involves approximations and depends on the largeness of Avogadro's number for their validity. This is perfectly satisfactory for describing the results of experiment as they can only be approximate, but they cannot be used as the basis of an exact fundamental science. It is necessary to know at the start what are the be-ables of the theory and to use this theory for making practical approximations. The theory itself should not be based on axioms which can make sense only at an approximate practical level.

What is required then for a theory to be fundamental, complete and exact as distinct from one which is phenomenological, incomplete and approximate? Before going on to discuss criteria for it, it is necessary to emphasize the distinction between exactness and truth. Truth is too difficult a goal to try to reach, but exactness can be determined by internal inspection. The equations should form a set complete in themselves and not need to be supplemented by talk and hand waving in the way that quantum mechanics appears to require.

What then are the criteria for a theory to be fundamental, complete and exact? The answer is that the theory, in answer to the question, "What is it about?" should contain any of the following words: system, apparatus, environment, experiment, measurement, observable, macroscopic and record, because all these words contain implied assumptions which prevent the theory from qualifying as truly fundamental. It should be made clear that it is not being asserted that such a thing is the last word, but that only be regarded as a candidate. It would pass some examination and finally fail others, but unless it meets the above criteria it should not even be enrolled. We are distinguishing here between the requirement of truth and the requirement of exactness.

Now why are these various words unacceptable? Let's look at them one by one. The word 'system' should be rejected because it implies a division of the world which is arbitrary. The only system which should appear in the fundamental laws is the system of the world and the laws will then determine when, and to what approximation some sub-system of the world might be regarded as approximately separate. 'Apparatus' is bad because it is just the other side of the division of the world into system and something else. 'Environment' is just another way of saying the same thing. 'Experiment' is not sufficiently precise as we can see from the story of CERN just described. It is useful in everyday life but is utterly inappropriate to serve in the formulation of a physical theory. The word 'measurement' should be banned completely because it has associations in everyday life which make it quite misleading. A quantum mechanical measurement usually does violence to a system, sometimes even destroying it and certainly changing it, whereas a measurement for a suit, remains valid for the prospective wearer at least for a short time afterwards. 'Observable', 'macroscopic' and 'record' can similarly be shown to be deficient.

People have tried in various ways to get close to this goal of a truly fundamental theory, and here are three of them.

The first is to try to push the interface right back as far as possible and to say that the ultimate observer is the mind. As this is surely immaterial it is not surprising that it is not subject to the Schrödinger equation. The story of jumps, collapse of the wave packet etc. can then be regarded as a kind of schematic of the brain/mind interface. Perhaps a mathematical theory for this will be constructed in the future but there could be trouble. First of all if the mind observes the brain continuously it will stop it working because of the quantum mechanical Zeno paradox! Then again the mind is supposed to have access to the instantaneous state of the brain? But an instantaneous state of a system extended in space is not a Lorentz invariant concept, and to avoid this problem some people have even proposed that the mind is a point! But apart from the incommensurability of this statement there could be technical difficulties as point systems are not well behaved objects as the theory of elementary particles has made very evident. There could be divergencies and the need for a renormalizable theory of brain/mind interaction.

A second way to resolve the problem is to modify the mathematics so as to avoid the difficulties of superposition of macroscopically different states. The linear Schrödinger equation is to be altered so as to have non linear terms and one such attempt has been made by Pearle (1976). Although it is probably the most serious attempt of this sort it is not very attractive because it is very ad hoc, non-local and not Lorentz invariant. Such attempts if they are to be successful would have to find some way of modifying the behaviour on a macroscopic scale so as to account for the processes at present described by jumps whilst still not changing successful theories such as that of the Lamb shift or the spectrum of helium.

The third way is, in Bell's opinion, the most successful attempt by far to meet these difficulties and the scandalous thing about it is that although it was first put forward by de Broglie in 1927 and revived by Bohm in 1952 very few people have studied it, and its neglect has been almost total. Studying something about it even as an alternative way of looking at quantum mechanics which has the properties of being exact, fully formulated in its equations and with no measurement problem. The vital thing about this theory is that it considers only the position of things, and this is all that is needed because ultimately all measurements boil down to the observation of positions. Measurements of say, angular momentum, can all be reduced to the determinations of the position of a 'pointer'. They may be called "measurements of angular momentum" or "isotopic spin" or some such thing but what is essential for the experimenter is to know where the pointer goes. In a relativistic theory there has to be some modification because then the objects of study would be a distribution of energy and stress, the tensor $T_{\mu\nu}$, which would be a c-number, and not an operator waiting for somebody to come and look at it. A full relativistic theory cannot be constructed yet, but the $T_{\mu\nu}$ component, which is the energy density is concentrated in particles and they have positions which are be-ables. The non-relativistic de Broglie-Bohm theory consists of two sets of equations. The first is the Schrödinger equation as presently understood:

$$i\hbar \frac{\partial \psi(t)}{\partial t} = \mathcal{H}(\psi(t))$$

with

$$\mathcal{H} = \sum \frac{1}{2m} \frac{\partial^2}{\partial x^2} + V(x)$$

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and the second is the equations of motion for the particles:

\[ m \ddot{x}_i(t) = \frac{\partial}{\partial x_i} \Im \log \psi(t, x) \]

where

\[ L = L_0 - L_1 + \ldots \quad \text{and} \quad x = x_1, x_2, \ldots \]

This is similar to electrodynamics where we have Maxwell's equations which describe the electromagnetic field as a function of position and time, and the equations of motion to the particles with the force on a charged particle being the Lorentz force at the position of the particle. The difference between these two theories is that the electromagnetic field is a function over four dimensional space time whereas \( \psi \) is a function in configuration space with many arguments and instead of \( m \ddot{x} \) being given in terms of the field, it is the momentum \( m \dot{x} \). But these differences are minor. Also \( \psi^2 \) gives the probability density of the particles being in the volume \( d^4x \) which is Born's probability formula.

The interpretation of the theory is that initially there is a probability distribution \( \psi(0, x)^2 \) which is the initial coordinates of the particles and then both \( \psi \) and \( x \) evolve according to the above equations, and this evolution is deterministic although the theory in general is not. It is a theorem that, with these initial conditions and with these equations, \( \psi(0, x)^2 \) continues to be the probability distribution of the particles at all later times in the same way as Liouville's equation and Hamilton's equations do in classical kinetic theory. One initial probabilistic assumption replaces the continuous infinity of probabilistic assumptions of conventional quantum theory. The interface has now been displaced right out of the system and the only observer left is the 'eye of God' who set the system going. Any measurement which occurs is a process just like any other and it is quite unimportant to decide when the experiment starts. It is just a natural process like any other which continues more or less in the beginning, more or less in the end and there is no need for jumps anywhere.

This is the end of the first part of the talk which posed the problem and gave a solution in the non-relativistic case. But in relativistic quantum mechanics there is still a problem which is associated with questions which were blurred by what Einstein called the 'tranquilising philosophy' from Copenhagen. What is put in disturbingly clear focus is the non-locality of quantum mechanics. The fact is that if you want to know what is happening here you cannot disregard what is happening a long way off at the same time.

To illustrate this consider the special case in which there are two particles in the world with coordinates \( x^1 \) and \( x^2 \). Then

\[ m \ddot{x}_1 = \frac{\partial}{\partial x_1} \Im \log \psi(x_1, x_2) \]

the velocity of particle 1 is determined by the gradient of \( \Im \log \psi \) with respect to the first variable. In the very special case where

\[ \psi(x_1, x_2) = \phi(x_1) \chi(x_2) \]

\[ m \ddot{x}_1 = \frac{\partial}{\partial x_1} \Im \log \phi(x_1) \]

which is independent of \( x^2 \) and things separate very neatly. But with a superposition:

\[ \psi(x_1, x_2) = \sum \phi(x_1) \chi(x_2) \]

\( \ddot{x} \) depends on the \( \chi \)'s as well as the \( \phi \)'s even if all the \( \chi \)'s are very far away, and they cannot be disregarded if the velocity of the first particle is to be calculated. So there is a drastically new form of non-locality in this theory and one is confronted with the possibility of influences going faster than light, which leads to difficulties with causality. At present this is a major obstacle.

In summary, then, a fundamental theory needs beables and if it is to be fundamental one cannot use pragmatic concepts like measurement. Observables have to be made out of beables, and the most serious attempt to do this is the de Broglie-Bohm formulation of non-relativistic quantum mechanics. This theory suggests that the resulting non-locality is essential, and any attempt to formulate quantum mechanics sharply in accordance with special relativity is faced with deep conflict.

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ANZAC Fellowship Scheme

The ANZAC Fellowship Scheme was established in 1967 in response to a suggestion by the then Australian Prime Minister, the late Rt. Hon. Harold Holt. They are awarded to enable Australians of ability to study or train in New Zealand to the benefit of themselves, Australia, and the furtherance of good relations between Australia and New Zealand, and for New Zealanders to study or train in Australia.

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The Consequences of Nuclear War: A Conference Report

R.A. Joseph, Department of History and Philosophy of Science, University of Wollongong.

Introduction

In opening this two-day Conference on the Consequences of Nuclear War for Australia and its Region at the Australian National University (ANU) in Canberra on 30 May 1983, Emeritus Professor Peter Karmel (Vice-Chancellor, ANU) said that men and women were mobilising their intellectual efforts to come to grips with the 'massive problem' of nuclear war, and universities could assist this process by objective analysis of the subject and development of strategies to avert nuclear disaster.

For a conference attended by more than 400 people and addressed by scientists, academics, politicians and others from Australia, the USA, the USSR and Europe, the contribution made by physicists was both enlightening and necessary. Two prominent scientists from the Commonwealth Scientific and Industrial Research Organization (Dr Barrie Pittock and Mr Ian Galbally) addressed the consequences of nuclear war on the atmosphere and Professor Bernard Feld (Professor of Physics, Massachusetts Institute of Technology) considered the role of the scientist. The extensive public interest generated by this conference confirms that there is an important contribution to be made by physicists in not only understanding the consequences of nuclear war but also in assisting the dissemination of information in general.

This report briefly summarises some of the conclusions of the major topics discussed: the nuclear arms race; the consequences of nuclear war; and the prevention of nuclear war. It concludes with some personal observations and comments on the main parts of the conference which I attended.

The Nuclear Arms Race

The predicament of the nuclear arms race was succinctly summarised by Professor Barnaby (Free University of Amsterdam).

'The super-powers have deployed 45,000 nuclear weapons. For comparison, the nuclear arsenals of the other established nuclear-weapon powers (Britain, France and China) contain a total of about 2,000 nuclear warheads. The total explosive power of the American and Soviet nuclear arsenals is roughly 15,000 megatons — equivalent to over one million Hiroshima bombs, or to over 3 tons of TNT to every man woman and child on earth'.

If the existence of this enormous destructive power is not frightening enough, Professor Barnaby informed the Conference of the large number of ways in which a global nuclear war might break out. These possibilities ranged from a deliberate super-power decision through to terrorist attack and machine error. More frightening still was his belief that the nuclear arms race was out of political control. Technological change has made possible the development of very accurate nuclear weapons and this gave rise to perceptions of fighting and winning a nuclear war. The threat of nuclear catastrophe is increasing.

The worrying comments made by Professor Barnaby were to some extent countered by Dr Des Ball's (Senior Fellow in the Strategic and Defence Studies Centre, ANU) views. In his opinion, the likelihood of nuclear war between the USA and the USSR was low. However, in the event of a war, there were three categories of targets in Australia: joint US-Australian facilities; Australian defence establishments; and industrial complexes and urban centres. He listed these in descending order of probability of attack. The US bases (North-West Cape, Nurrungar and Pine Cap) were soft targets, requiring relatively low blast pressures. The casualties induced by the blast effect at the three bases were considered to be extremely low indeed. He also said the Australia was not likely to be greatly affected by radioactive fallout resulting from major nuclear conflict in the northern hemisphere. Reassuring? Well, Dr Ball did say that in the unlikely event of a strike on Sydney, some 180,000 people would die instantly, fallout would claim another 480,000 lives with another 350,000 people injured.

The Consequences of Nuclear War

The topics discussed here included the medical, atmospheric and social and economic consequences. Dr John Langmore (economic adviser to the Treasurer, Mr Keating) presented a soundly argued paper which traced through the likely economic consequences of excessive military expenditure. He made the point that global military expenditure this year was expected to reach $700,000 million — nearly five times Australia's expected national income. Military expenditure was luxury consumption: every dollar spent was a dollar which could not be spent elsewhere. In addition, military expenditure was a very inefficient way to stimulate economic growth.

Discussion of the medical and atmospheric consequences of nuclear war raised some important issues. Dr Michael Denborough (John Curtin School of Medical Research, ANU) said that national medical response could be planned to cope with the massive casualties from a nuclear strike against Australia. He thought that doctors who advocated a building of nuclear shelters 'are guilty of gross medical negligence'.

CSIRO's Division of Atmospheric Physics provided two speakers on the atmospheric consequences: Dr Barrie Pittock and Mr Ian Galbally. Dr Pittock said that scientific discussion on the subject was little more than informed but incomplete inference and speculation. There was a need to study atmospheric effects because the situation was 'fraught with dangerous possibilities, which may well threaten human survival in the northern hemisphere, and from which we in the south may not escape'. Dr Pittock said that since a report from the US Office of Technology Assessment in 1980, it was now thought that the ozone layer would not be completely broken-down in the event of a nuclear war. The existence and deployment of smaller nuclear weapons (less than one megaton) meant that radioactive dust and debris were less likely to reach the stratosphere and so destroy the ozone layer.

Mr Ian Galbally stressed the uncertainty in our knowledge of the behaviour of the atmosphere, let alone the effect on it of a nuclear explosion. He outlined some aspects of an original and innovative model he had been
working on which looked at the problem of dust rise from nuclear explosions. In general, both physicists agreed that the effects of increased ultra-violet radiation would be outweighed by the more direct effects of a nuclear explosion. However, Dr Pittock’s guess was that for southern-hemisphere dwellers, one could survive a nuclear war if one was not dependent at all on modern technology for survival and at least 300-1000 kilometers from the nearest blast.

The Prevention of Nuclear War

This session featured some very prominent speakers including Patrick White, Roland Vogt (Green Party, West Germany) and Dr Oleg Gavrilov (Ministry of Health, USSR). However, I would like to concentrate on the talk by Professor Bernard Feld (Professor of Physics, MIT). He spoke on the role of the scientist. Professor Feld said that the unique and special role of the scientist was mainly in the educative process on the nuclear subject. The following is a quotation at length of part of his talk:

“A major aspect of this special role of scientists and engineers is of historical origin... Not only did the scientists take the initiative — in 1938-39, immediately after the discovery of nuclear fission — in calling to the attention of their governments the unique possibilities for the utilisation of nuclear fission in the production of a superweapon, but they were primarily responsible for the organisation and implementation of the 'crash' programs that succeeded in producing such weapons before the conclusion of the war in the Pacific... Thus, in a real sense, the community of nuclear scientists was deeply involved and implicated in 'the original sin'. Acutely aware of this fact, the so-called atomic scientist community lost little time in their attempts at 'atoneenment'. It was they who campaigned most vigorously, immediately after World War II, for the establishment of a system of civilian control, on both the national and international levels, of further nuclear energy developments; and it was they who insisted, from the start, that the achievement of a successful plan for international control requires meaningful exchanges of information and views between scientists from the East and the West, as well as between the political leaders.

In this regard, an important post-World War II development was the Pugwash Conference on Science and World Affairs. Growing out of the Russell-Einstein Manifesto of 1955, these periodic meetings of scientists from East, West, North and South have played an important role in the preservation of nuclear sanity throughout the world.

These meetings had played a role in the achievement of the few agreements on nuclear arms control (as well as chemical and biological weapons control) that had been accomplished to date... In making their contributions in such areas, scientists and engineers have been most effective when they have concentrated their efforts along the following broad lines:

1. Self-education on the issues — especially the technical ones, but the political problems as well underlying the particular negotiation in question.
2. Education of their fellow scientists and engineers as to the problems involved in resolving the outstanding issues.
3. Education of their governments, through direct contact with governmental officials having primary responsibility in the areas involved, as well as general education of members of involved governmental bodies (e.g. the legislatures that need to enact or approve the required measures).
4. General education of the public in their respective nations on the vital importance of constructive nuclear arms control and to the relevance and value of particular actions under consideration by their governments.
5. And, finally, the keeping alive of the concept, vital for the survival of humankind through the coming decades of 'one world or none'.

Some Concluding Remarks

In reporting on the conference I have not been able to comment on all the views of the many speakers who addressed the Conference. The reporting of points of view, while in itself useful, is not possible in a report such as this to capture the highly charged political atmosphere which pervaded the conference. Professor holds the need for informed debate and discussion.

The lead put forward by Professor Bernard Feld is encouraging to physicists and scientists in general. The AIP by establishing a Working Group on Nuclear Armament and Warfare is already moving in this direction and as a professional society it has shown initiative and provided useful guidance. I think the most important conclusion from the conference for physicists is that there is a need for more research and better understanding of the physical consequences of nuclear war. This refers to, for instance, the explosive effects as well as that of the electromagnetic pulse. If this is an issue of great public concern, do our national scientific research institutions (e.g. CSIRO, the Defence Science and Technology Organization and the Australian Atomic Energy Commission) recognise its importance and is sufficient research being undertaken? Indeed, is there sufficient debate amongst physicists themselves on important issues? This issue is one which may require further study and certainly more lobbying.

Physicists speaking on these issues are conveying very important information but the impact of this message needs to be maximised by effective presentation. This is something which would be usefully explored by individual physicists and groups such as Scientists Against Nuclear Arms (SANA) who have such an involvement. The Conference highlighted this need, particularly for physicists.

Even without contemplating the emotional aspects of this conference, there is no doubt that physicists can make a valuable contribution to enhancing public awareness. Indeed, considering the current situation this now seems more like an obligation.

It is expected that later this year, Croom Helm Australia Pty Ltd will publish the proceedings of the Conference: 'The Consequences of Nuclear War for Australia and its Region', edited by M.A Denborough, ANU. The cost will be about $25 and further information is available from Croom Helm Australia, PO Box 391, Manuka, ACT 2603.

Nuclear engineers

As has been noted many times in the columns of Physics Bulletin, a traditional feature of the British employment pattern is the fact that many of those trained in the pure sciences, particularly physicists, find employment as engineers. Perhaps what is not appreciated is that those in the nuclear field, with the proper pattern of training and experience, are able to register as Chartered Engineers via the Institution of Nuclear Engineers.

This body is the only professional institution in Britain specifically operating for nuclear engineers and related scientists and technologists.

The Australian Physicist, Vol 20, July 1983 — Page 150
Freeze Appeal

We call for an agreement to halt the testing, production and deployment of nuclear weapons delivery systems. Meanwhile, no further weapons or delivery systems should be deployed anywhere.

In October 1982 I was invited to be one of the initial signatories of the above FREEZE APPEAL. The APPEAL was launched by Daniele Amit (CERN), Nina Byers (UCLA), Rolf Hagedorn (CERN), Jack Steinberger (CERN), Victor Weisskopf (MIT), and Christof Wetterich (CERN) and they obtained a small sample of over eighty signatures of physicists from many countries as a first step. In the words of the organisers "We intend to send the appeal with the signatures (or indicating their number) to the nuclear powers, the United Nations, delegates of disarmament negotiations, the World Council of Churches, presidents of parliaments, political parties and other national and international bodies as well as movements which work for nuclear disarmament, and of course, to the media. Our voice will be heard and it will help — if ever so little". Although I would have worded it slightly differently I signed the APPEAL as I felt the need for united action to call a halt to the nuclear arms race. At the Fifth AIP National Physics Congress held in Canberra in August 1982 there was an enthusiastic response to the Nuclear War Forum. Furthermore, there seems strong support for further action. Accordingly, I hope that the vast majority of members will welcome the opportunity to support the FREEZE APPEAL by signing and returning to me the leaflet inserted in this issue. The leaflet is in the form supplied to me by Dr Amit with the addition of the address for Australian signatories.

The Science Policy Committee has established a working party on nuclear armament and warfare and the working party will be organising several activities to help scientists obtain a greater awareness of the issues involved. Two main activities being pursued at the moment are the symposium on nuclear warfare being organised as part of the 54th ANZAAS Congress being held in Canberra in May 1984 and the FREEZE APPEAL. The working party, of which I am chairman, has been requested to ensure that balanced views are put forward. Since I am not sure that I can propose the FREEZE APPEAL with total objectivity I shall add some comments in a purely personal capacity. Members may care to consult the January 1983 issue of Physics Today for the articles on "Freeze on nuclear weapons development and deployment: pro and con" where different viewpoints are proposed by Harold Feiveson and Frank von Hippel, and by Harold W. Lewis. However, the title is somewhat misleading as Harold Lewis is not opposed to the FREEZE proposal. Rather, as I understand him he feels that it does not tackle the central issue of avoiding nuclear war, an objective which he regards as paramount. The March issue of Physics Today is a special issue largely devoted to Nuclear Arms Education with an editorial by Hans Bethe. I recommend the accompanying articles for background information.

Many people, myself included, were not active in the "Ban the bomb" movement when we felt the deterrent was an effective way of preventing nuclear war. Now we are in the midst of a transitional period in which new nuclear weapons are being installed or developed. Ironically, the MX missile has been named the "Peacekeeper" whereas in the opinion of many it is an important element in destabilising the nuclear peace. Nuclear submarines are being upgraded with the deployment of the Trident class submarines and missiles. The issues which have received more public attention are the introduction to Europe of Cruise and Pershing II missiles. The specially worrying feature about the Pershing II missile is that it requires the time in which the attacked country has to decide on retaliatory action from 20 minutes to 10 minutes or thereabouts — unless it decides with admirable restraint to assess the situation after a nuclear onslaught. This effectively eliminates the likelihood of rational decision-taking and has led to the launch-on-warning approach whereby counter-attack may be started as a result of a false alarm generated by a computer malfunction or series of malfunctions! The cruise missile is also dangerously destabilising as it is not subject to the same surveillance controls as the massive ICBM placements. The first cruise missiles are scheduled to be deployed in Europe before the end of the year and it seems to be that once they are in place it will be very much harder to negotiate arms limitation treaties.

Since I am conscious of having concentrated on recent developments in the US arsenal I note that the Soviet Union also has a comparable nuclear arsenal with increasingly accurate and sophisticated delivery systems. At this time there is no need to comment on the futuristic 'Star Wars' scenario being envisaged, which involves laser and particle beam anti-missile weapons, except to remark that these are highly problematical weapon systems of immense cost.

The present situation is one of extreme danger, but there is still time for the peoples of the world to let their views be known. Accordingly I invite all physicists, whether or not members of the AIP, to sign the FREEZE APPEAL. Please invite non-members amongst your colleagues to sign your form — the greater the number of signatures the greater the impact.

References

Alan Runciman

The following statements, which bear on the Freeze Appeal, have been transmitted by the International Council of Scientific Unions.

The 19 General Assembly of ICSU:

EFFECTS OF NUCLEAR WAR

Recognizing the need for public understanding of the possible consequences of the nuclear arms race and the scientific competence that can be mobilized by ICSU to make an assessment of the biological, medical and physical effects of the large-scale use of nuclear weapons, (the Assembly) Urges the Executive Board to appoint a special committee to study these effects and to prepare a report for wide dissemination that would be an unemotional, non-political, authoritative and readily understandable statement of the effects of nuclear war, even a limited one, on human beings and other parts of the biosphere.
Nuclear Arms

In the picturesque language of the Americans: ‘You get more bang for your buck with nuclear’.

A convenient unit in describing the size of a bomb is the ton of TNT. Most of the bombs used in the second world war weighed between 0.1 and 1 ton; the largest was 10 tons, the maximum weight the aircraft of the day could lift and carry to its destination. In sharp contrast, the Hiroshima and Nagasaki bombs each had an explosive capacity equal to about 15,000 tons of TNT. But these were mere firecrackers compared with the subsequently developed hydrogen bombs which are typically a thousand times larger still: the largest ever exploded had an estimated yield of 58 million tons of TNT, 4000 times that of the Hiroshima and Nagasaki bombs. To visualise the destructive power of such a weapon is beyond the power of human imagination.

The size of the world’s nuclear arsenal, according to a recent authoritative UN estimate, is 40,000 nuclear weapons! It is very hard to comprehend the size of this nuclear arsenal, the degree of overkill. To begin the attempt at comprehension it may be pointed out that it is the equivalent in explosive power to a million Hiroshima or Nagasaki bombs.

Large numbers are of course difficult to grasp with but one huge number that is reasonably familiar is the age of the known universe: fourteen billion years from a big bang to the present day is one reasonable estimate. Imagine the existence of a bomb factory with a weekly production capacity of one 50 lb TNT bomb. This is quite a small weapon, even by second world war standards, but able in favourable circumstances — say exploded above the terraces at a football match — to kill up to a thousand people, thus our little factory would have a potential killing capability of about a hundred people a day, and this is not inconsiderable. Now suppose that this factory had been in production since the beginning of time, i.e. for fourteen thousand million years, then its total accumulated output, in terms of explosive capacity, would only now just about equal that of the world’s nuclear arsenal. From big bang to big bang, so to speak.

A further chilling statistic is that for every man, woman and child on the surface of the earth there is the equivalent of three tons of TNT in the nuclear arsenal.

Not to mention all this is really quite an oversight on the part of the exhibition organisers.


Study will look at bringing voltage down

An independent study is to investigate the feasibility of changing WA’s electricity voltage standard.

WA presently uses a 250V system. The study will look at converting to 240V.

The two-stage study will be carried out by Merz and McLellan and Partners.

Stage one will involve assessing work already performed, with stage two a more extensive and detailed examination of costs and strategies, leading to a final report.

WA is out of step with the rest of Australia with its present 250V system.
The Minister for Science and Technology in the Labor Government, Mr Barry Jones, is the Member for Lalor in Victoria. The former Minister, Mr David Thomson, was not returned in the election.

Mr Jones was for almost two years, a member of CSIRO's Advisory Council and was on the Council's Standing Committee on Information and Social Contact. Formerly a public servant, high school teacher, university lecturer and lawyer, Mr Jones was a Member of the Victorian Parliament for five years from 1972. At that time he was Shadow Minister for Social Welfare, Aboriginal Affairs, Transport and the Arts.

Mr Jones was Deputy Chairman of the Australian Council for the Arts between 1969 and 1973, and took a leading role in reviving the Australian film industry. He has been active in penal reform and as a successful campaigner against the death penalty. Other interests include films, music, travel, collecting autographed documents, antique terracottas and paintings and reading.

His best-seller, 'Sleepers, Wake!: Technology and the Future of Work', was published by Oxford University Press in 1982; a Japanese edition will appear in 1983. Mr Jones has also written five other books.

A team of Sydney University physicists who designed and built the University's tokamak has been awarded this year's prestigious ANZAS Esso Energy Award.

Dr Rodney Cross, Dr Brian James and Associate Professor John Lehane, of the Wills Plasma Physics Department, were joint winners of the $5,000 award, which was presented at the opening of the 53rd ANZAS Congress in Perth.

They shared the prize with Mr John Ballinger, the Director of the Solar Architecture Research Unit at the University of New South Wales, who has made important contributions to energy conservation through novel architectural design.

In its citation, ANZAS said that the work of Dr Cross, Dr James and Associate Professor Lehane could contribute materially to Australia's range of energy options in the 21st century.

The three jointly conceived, designed and supervised the construction of the research tokamak TORTUS (Toroid of the University of Sydney), the citation said.

'They hope to develop a form of radio frequency heating, Alfvén wave heating, to provide temperatures sufficient for a fusion reactor.

Dr Stig Steenstrup has joined the Division of Chemical Physics as a guest scientist. Dr Steenstrup is from the Orsted Institute at the University of Copenhagen, and will be with the Division until the end of the year. He has studied in France and Denmark, and his research interests include the theory of the stopping of charged particles by matter and the scattering of X-rays and neutrons by crystals undergoing a phase change.

Dr Angelo Delsante, from Division of Building Research, CSIRO, is presently in Japan, presenting a paper on the computer simulation of heat flow into the ground at the fourth International Symposium on the use of computers for environmental engineering related to buildings held in Tokyo.

The Chief of the Division of Computing Research, Dr Peter Claringbold, has been elected a Governor of the International Council for Computer Communication for a six-year term.

The appointment was in recognition of the work of the Division of Computing Research in the development of the CSIRONET packet switched network, and more recently, its work in the local area networking at the central site.

Two researchers from the Division of Applied Physics are at present overseas. Dr Laurie Besley is attending the Cryogenic Fundamentals Conference in Cracow and Wrocław, Poland, to deliver an invited talk on cryogenic resistance thermometry. Dr David Eagles is spending six months at the Max-Planck Institute in Germany working with Professor Fuld.

Later in the year, he plans to visit laboratories in the United Kingdom and the United States before returning home.

Dr Besley plans to visit laboratories and industrial facilities in Scandinavia, Europe and the United Kingdom, looking at the possibilities of research in the field of high gradient magnetic separation techniques.

Ron Banyard, of the Division of Applied Physics, retired recently after 27 years working in the field of precision electrical measurements and calibrations. Ron first joined CSIRO in 1955, and worked for the Organization until his retirement apart from a short break in private enterprise.

La Trobe's Professor Keith Cole was elected a Fellow of the Australian Academy of Science in April, as noted last month.

The Australian Academy of Science was constituted by Royal Charter in 1954. Its main objectives are: to promote, declare and disseminate scientific knowledge; to establish and maintain standards of scientific endeavour and achievement in the natural sciences in Australia; to recognize outstanding contributions to the advancement of science.

Keith Cole is La Trobe's Foundation Professor of Physics and Head of Division of Theoretical and Space
Physics. The Division has set up an ionospheric field station at Beveridge, Victoria, and is involved in international collaborative programs which have been awarded grants totalling over $300,000 from the A.R.G.S. and the Radio Research Board for the purchase of equipment.

Last year he was elected an Associate of the Royal Astronomical Society in London.

Over the past 20 years, Professor Cole's extensive contributions included several "firsts".

In 1962 he was the first to predict the effects on the earth's upper atmosphere of the dissipation of electromagnetic fields in the polar ionosphere and showed that the global energy input thereby at altitudes greater than 100 km was comparable to, and sometimes exceeded, that put in by the well known UV and EUV radiation of the sun.

In 1965 he was the first to give the explanation of the stable auroral red arc which is a sink of energy in the atmosphere for the magnetospheric ring current. Also in the same year, it was his work which was the key to the explanation of pre-dawn effects on the electron temperature in, and airflow from the ionosphere.

In 1966 Keith Cole first pointed out the magnitude of a simple exchange process in the energising of neutral hydrogen atoms for escape from the gravitational field of the earth. This is now accepted as being dominant over the classical Jeans escape rate. In 1971, he first pointed out a significant effect of auroral ionospheric electric fields on the velocity distribution of ions and predicted the generation of magnetic field-aligned irregularities at night in equatorial regions on account of unsymmetrical action of winds and internal gravity waves about the geomagnetic equator in the ionosphere. This theory has stimulated a lot of interest and has received considerable experimental support.

Keith Cole is currently working in the Laboratory for Planetary Atmospheres in NASA, Maryland, as a co-investigator in one of the experiments on board one of the pair of "Dynamics Explorer" satellites launched in July 1981. He will be returning to La Trobe early in July. In February of this year he was invited by the Norwegian Academy of Science and Letters to deliver a paper at a meeting to commemorate the First International Polar Year 1881-83 on "the role of the polar region in the solar-terrestrial energy coupling".

***

The Australian Journal of Physics recently appointed two Corresponding Members to its Advisory Committee. They are the distinguished physicists Professor Richard H. Dalitz (Oxford) and Professor Michael A. Morrison (Oklahoma). The Corresponding Members will recommend suitable referees and adjudicate in the case of controversial papers in fields of physics not already covered by other members of the Advisory Committee.

Professor Dalitz was born in 1925 in Dimboola (Victoria) and had his undergraduate training in mathematics and physics at the University of Melbourne. He was then sent to Trinity College, Cambridge, holding the Aitcherson Travelling Scholarship of Melbourne University and took the Ph.D. degree there in theoretical nuclear physics in 1950. During 1949-50, as a Research Assistant at Bristol University, he became involved with research on strange particles, especially concerning the \( \pi \) meson, now known as the K' meson. After that year, he was Research Fellow and then Lecturer in Professor R.E. Peierls's Mathematical Physics Department at Birmingham University. His best known contributions from that time are "Dalitz pairs" in \( \pi \) decay and the "Dalitz plot" used for analysing \( \tau \rightarrow 3 \pi \) decay. He pointed out that the \( \tau \rightarrow 3 \pi \) and \( \theta \rightarrow 2 \pi \) decay characteristics required that the \( \tau \) and \( \theta \) states do not have the same parity despite their similarity in other respects, an observation which led Lee and Yang to their celebrated work on parity nonconservation in the weak decay interactions.

Dalitz also contributed much basic research on the properties of A particles in nuclei, especially in hypernuclear ground states; this work, carried out mostly whilst he was Professor of Physics in the Enrico Fermi Institute for Nuclear Studies of the University of Chicago (1956-63), led to an assignment for the (KA) parity, the deduction of hypernuclear spins, an empirical estimate of the AA interaction and a shell-model formalism for A-hypernuclear states. His name is also known from this time for the "CDD-ambiguity" in the solution of dispersion equations, and the "Dalitz-Tuan resonance" \( A(1405) \), deduced from phase-shift analysis of low-energy \( \gamma \).

After taking up a Royal Society Research Professorship at Oxford in 1963, he turned his attention to the quark model for mesons and baryons and played a leading role in its general acceptance, showing as early as 1968 that the numerous pion-nucleon resonances, established at that time to have negative parity, could all be accounted for as resulting from an excitation of the internal orbital motion of a three-quark system. He has also been prominent in the recent revival of hypernuclear physics, to do with the formation of excited hypernuclear states through strangeness-exchange reactions, and the analysis of their resulting \( \gamma \)-cascades. His present interests are primarily in the field of quark theories with quantum chromodynamics and their applications and also in a number of aspects of hypernuclear physics.

In consequence of this work, Dalitz has been awarded the Maxwell Medal (1966), the Jaffe Prize (1969), the Hughes Medal (1975), the J. Robert Oppenheimer Memorial Prize (1980) and a Royal Medal (1982), and has held a number of named Lectureships, such as the Bakelan Lecture (1969), the Racah Memorial Lecture (1973) and the Larmor Lecture (1982).

Professor Morrison was born in San Antonio, Texas in 1949. He received his B.A., M.A. and Ph.D. degrees from Rice University in 1971, 1974 and 1976, respectively, and then spent a year as a National Science Foundation Postdoctoral Research Fellow at the Los Alamos Scientific Laboratory. He joined the faculty at the University of Oklahoma in 1977, where he is now an Associate Professor. He is a member of the American Physical Society, the Institute of Physics, the American Association of Physics Teachers, Phi Beta Kappa, and Sigma Xi; in 1982 he received a research award from the latter organization for his work in low-energy electron-molecule collision theory.

This collision theory has been the primary focus of Morrison's research effort, which has been carried out at Oklahoma and with collaborators at the Los Alamos National Laboratory, the Joint Institute for Laboratory Astrophysics, and the Australian National University. His additional research interests include the quantum mechanics of molecular structure, various electron scattering processes, and heavy-particle collisions. A secondary field of interest is physics education. In addition to having written numerous research and review papers, he is the author of two books on quantum mechanics for undergraduates, 'Quantum States of Atoms, Molecules and Solids' (Prentice-Hall: 1976) and 'The Joy of Quantum Physics' (Prentice-Hall: forthcoming).
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<th>Performance Category</th>
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<th>Cavity Dumped</th>
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<td>Pulse Repetition Rate</td>
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Figure 1. Typical Tuning Curves for Operation with 07 Model Ion Laser and up

Figure 2. Typical System Configuration for Mode Locked Cavity Dumped Dye Laser Operation

Figure 3. 1.2 kW Pulse From Extended Cavity Ion Laser Synch-Pump System Operating with R6G

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Officers of the Institute and Branch Secretaries are listed inside the front cover of each issue, with the exception of the Past President, Prof. N.H. Fletcher,CSIRO Institute of Physical Sciences, P.O. Box 225,Canberra, A.C.T. 2602. Branch Chairmen and Treasurers are listed below.

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Mr G.A. Bell
Physics Roundabout
Tokamak to ‘graduate’ to full-scale research

‘Undergraduate days’ will soon be over for the University's tokamak.

Researchers at the School of Physics say the tokamak has performed well in tests, and has been upgraded to the point where it is now ready to graduate to the full-scale research program for which it was designed.

Associate Professor John Lehane, of the Department of Plasma Physics, said that since the tokamak started functioning in mid-1981 it had proved extremely trouble-free and easy to operate.

However, he said, only relatively straightforward research had been possible so far because the machine had lacked 'diagnostics' — instruments to gather data about what is happening inside.

'We have now added most of the diagnostics that will be necessary for full-scale research, and we've also built up a sophisticated computer system for storing and analysing data', he said.

'We'll be going ahead with a busy program of experiments aimed at finding out what happens inside the plasma when large amounts of power are put into the plasma in the form of radio frequency waves.'

The project has already received two large grants from the National Energy Research, Development and Demonstration Program, which has just announced a third grant, of $175,000, for the next two years, from mid-1983 to mid-1985. The University has also recently provided a grant of $40,000 for additional new equipment to allow the detailed and definitive research to begin.

Professor Lehane said that although the Sydney University tokamak is small compared with the multimillion dollar research tokamaks in the U.S., Europe, Russia and Japan, it is nonetheless in a position to make a valuable contribution to international research into nuclear fusion.

Nuclear fusion has occurred on earth only in the uncontrolled reaction of a hydrogen bomb. However a controlled thermonuclear reaction holds out the prospect of a cleaner, safer and longer-term source of energy than nuclear fission, the process by which today's nuclear power plants produce their power.

Although it will probably be proved technically feasible within the next decade, there are serious doubts about the economic viability of nuclear fusion and most scientists predict that at least a further decade of fundamental research will be necessary to arrive at the most cost-effective technologies.

According to Professor Lehane, the University’s choice of radio-wave heating of plasmas as a topic of study has assumed more importance over the past few years, because of the success of the first large-scale wave heating experiments overseas.

'It has been clear for a long time that ohmic heating — the sort of heating that occurs when you switch on your electric radiator — will not be enough to get the plasma up to the temperature of 100 million degrees Celsius that is required for a fusion reaction to take place,' he said.

This is because the resistance of a plasma falls as it gets hotter. There will have to be some form of supplementary heating after a certain point, and heating by radio waves is one possible method.

'We're experimenting with radio waves in the 1-30 MHz frequency range, which are launched by antennas surrounding the plasma.'

Professor Lehane said that experiments would be conducted using different frequencies in combination with different densities of plasma, different antennas to launch the waves, and different magnetic fields to contain the plasma within its doughnut-shaped stainless steel vessel.

U. Sydney News

Australian Journal of Physics

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Andrei Sakharov

Amnesty International continues to be concerned about the health of Andrei Sakharov, aged 62, who is reported to have suffered two mild heart attacks in May 1983. On 2 June he was examined by Dr Pylaev and Dr Grigor'ev of the USSR Academy of Sciences, who recommended that he be admitted to hospital for treatment of heart disease and urological disease. The Soviet authorities have reportedly refused permission for Andrei Sakharov to receive appropriate medical treatment from his own doctors in Moscow.

In May 1983, he accepted an invitation to take up a teaching post at the University of Vienna in Austria. The official Soviet news agency TASS announced that he would never be allowed to emigrate because he possessed state secrets.

Amnesty writes: "Please continue to send telegrams/express letters/letters expressing concern at these latest reports of the deterioration in the health of Andrei Sakharov and urging that he be granted permission to see his Moscow doctors. Appeal for his release from internal exile."

Addresses were published in the March issue, p.56.

Women’s survey report soon

A final report on a survey which examined the attitudes of women employed by CSIRO, will be tabled at the October meeting of the Organization's Consultative Council.

The Chairman of the Council’s sub-committee on the employment of women, Dr Judith Koch, said she expected the results of the survey to be made available to all staff after the Council meeting.

Almost 3000 men and women completed questionnaires on the role of women in the Organization during June and July 1981, and an analysis of responses has been undertaken by Dr Cecily Neil, a researcher in the Division of Building Research in Melbourne.

To establish a point of reference for its investigations and to complement information gained from the survey analysis, the sub-committee has prepared a statistical report on the recruitment, deployment and promotion of women in CSIRO between 1976 and 1982.

'A number of changes are evident from these statistics and the significance of these changes is being examined'.

Dr Koch said.

Equal Opportunity Project

In March every employee at Macquarie University received a questionnaire as part of Macquarie’s Equal Opportunity Project.

One of the main objectives of the project is the assessment of the position of women at the University and opportunities for their advancement. Information deduced from the questionnaire will be used to formulate policies to assist in making the University a more equitable place.

Although a number of bodies around campus, such as Women at Macquarie (WAM), the Health & Research Employees Association and administration have contributed to formulating the questionnaire, the driving force behind it has been Dr Ann Eyland, Senior Lecturer in the School of Economic and Financial Studies.

Dr Eyland was commissioned by the Vice-Chancellor, Emeritus Professor Edwin C. Webb, last year to advise him on the present status and opportunity for advancement of women in the University, both as students and employees.

In setting out the brief for the project, the Vice-Chancellor had suggested that the Federal Government’s Equal Opportunity Guidelines for Employers be used as a guide for the project.

Women academics and discrimination

Australian universities promote academic men at a faster rate than they promote women academics despite equal achievements between both groups in the areas of educational qualifications, publications, teaching experience and administrative involvement, an extensive study of the Australian academic scene has found. The main explanation for this disparity is said to be partly because women are responsible for child-rearing and withdraw from the workforce for periods, and partly because of entrenched discrimination against women.

These findings, among many which give an incisive picture of the careers experiences of Australian women academics, are related in Why So Few? Women Academics in Australian Universities (Sydney University Press), by Cass, Dawson, Temple, Wills and Winkler, which was published in March.

Why So Few? the only book of its kind ever produced in this country, gives a comprehensive picture of Australian women academics, covering such areas as social background, sex-role attitudes, work history, academic career patterns, discrimination, and women in science.

Senator Susan Ryan, the newly appointed Minister for Education, a graduate of the University of Sydney, states in the foreword that the book is important because it explores the relationships between men and women at universities in contemporary Australian society and demonstrates that serious discrimination exists at the tertiary level despite meritocratic aspects of our society.

The book is based on a study over four years, 1974-1977, the period of stability in Australian universities after the years of expansion in the early seventies. All academic women at universities in Sydney — the University of Sydney, the University of New South Wales and Macquarie University as well as at the Institute of Technology — were sent a detailed questionnaire. Some 60 per cent — almost 500 — responded. A number of taped interviews were also made. A random sample of men at these institutions was also a modified questionnaire, and 25 per cent, or about 120, replied. Other material drawn upon includes a FAUSA survey of 1978, and studies centred on Melbourne University and ANU, and English and American studies.

U. Sydney News

"Mathematics is music for the mind; Music is mathematics for the soul" D.E. Hall

PLAN TO ATTEND THE AIP

SIXTH NATIONAL CONGRESS
BRISBANE, QUEENSLAND
27-31 AUGUST, 1984

for further details contact—
Dr. B.W. Thomas, Physics Department, Q.I.T.,
Box 2434, G.P.O. Brisbane, Qld. 4001.
New IOP Group

The Council of The Institute of Physics has given approval to the formation of a new Group, the Instrument Science and Technology Group, under the Chairmanship of Dr K C Shotton of the National Physical Laboratory. The object of the Group is to provide a forum for the discussion of the science and technology of measuring instruments and measuring systems. It will be particularly concerned with the physical principles of sensors and transducers and their industrial applications.

The proposal to form the Group came from members of the Editorial Board of the Journal of Physics E: Scientific Instruments, and it is intended that the new Group will maintain close links with the Journal.

Although most physicists use instruments of one kind or another and many become involved in instrument design, there is very often a gulf between the researchers who study the basic physical principles and measurement systems, utilized in instrumentation, and the physicists and engineers who design the commercial instruments used routinely in laboratories and workshops. It is the intention of the new Group to take a lead in bridging that gap by promoting broader awareness of new measurement technologies and encouraging their exploitation by instrument designers, manufacturers and users.

Extinction of the species?

Since the turn of the century, increasing specialization, particularly in science, has led to a complete removal of arts and humanistic subjects from the degree course. Comments received even today confirm that there is so much new "physics material" available as result of new developments that not all of it can be incorporated in a degree course. This is now used as a reason for not including arts and humanistic subjects.

Because of a lack of courses in his degree that contribute to the development of interpersonal relationships and communications, amongst many others, the physicist tends to be arrogant, narrow-minded and introverted and only capable of communication with his own kind. Since he cannot communicate his subject to persons outside his field, the impression generated in the mind of the public is one of "aloof insularity" and an inability to contribute anything of significance outside a narrow technical field.

Obviously unaware that physics underpins all technology, it is still the products and applications that capture the public's imagination. In the habit of judging by tangibles, the application of rational thought that leads to the discovery of a new truth, is not capable of measurement against a material standard with which the public identify, even though the contributions of physicists to the well-being of mankind have been substantial. This is perhaps the single most important factor that has contributed to the growth of the engineering and medical professions, and the decline of interest in physics.

The future growth of an interest in physics amongst the public and industry, is to train students at schools and universities for advanced physics as well as "everyday" physics. Particularly for the industrialist, who sponsors research at the universities and today has come to expect no return on his investment, to devote "less time to seeking new knowledge for its own sake and more to industrial R & D which will lead to the translation of laboratory discoveries into products desired by the industrialist and public alike.

Only by "strengthening the links between the science of physics and the technology of its application" can the physics community hope to regain some semblance of its former image with the public by displaying a high profile in an area of activity with which the public can readily identify.


Editorial from Meson, the South African Institute of Physics Paper

Transistors

Researchers in the Joint Microelectronics Research Centre at UNSW have produced transistors two-and-a-half times more effective than any made anywhere in the world.

Associate Professor Martin Green and Dr Bruce Godfrey believe that within the year they will also have succeeded in 'speeding up' the operation of the new transistors, which will allow computers to process information much more quickly.

The amplification factor in a conventional transistor is up to 10,000 times. But the new type made by Green and Godfrey can change the incoming signal into one 25,000 times bigger.

The new transistors create negative charges in the top layer not because of impurities in the silicon but through a 'sandwich' consisting of a piece of metal and an insulator on top of the silicon wafer. Professor Green says this metal/insulator/silicon (or MIS) contact is a more effective source of negative charges. Because the active area on top of the transistor is thinner, it is possible to have better control over the way the signals pass through the transistor on their way to the furthest reaches of the circuit.

It is this thinness that also makes it possible to speed up the movement of the signal, an area the two researchers are working on now.

Uniken

Celebration for PLUTO

PLUTO, the second of Harwell's high-flux, heavy-water-moderated materials testing reactors (MTRs), celebrated its silver jubilee in October 1982. It was commissioned in 1957, and together with its sister reactor DIDO has played a key role in testing the materials and components for the UK's reactor systems. The current emphasis of PLUTO's work is on continued support for the Advanced Gas-cooled Reactor programme. This role is likely to expand following the recent closure of the experimental AGR at Windscale, and the experimental irradiation facilities in PLUTO are being extended.

For many years PLUTO has been a major producer of radioactive isotopes which are sold throughout the world by Amersham International. Its products include isotopes for medical research, diagnosis and treatment, and gamma-ray sources used to sterilise medical equipment and pharmaceuticals. More recently Harwell's MTRs have been used for the irradiation of silicon crystals required in the manufacture of semiconducting devices. Harwell is now the world's largest irradiator of silicon crystals and its customers include most of the world's major silicon suppliers. To meet the increased demand for this service a new silicon irradiation rig has been installed in PLUTO.

The Australian Physicist, Vol. 20, July 1983 — Page 159
Tasmanian X-ray telescope goes to Rio

Early in March a team from the University of Tasmania’s Physics Department travelled to Brazil for the launching, from a site near Rio de Janeiro, of a 1-tonne balloon-borne x-ray observatory built at the University. The observatory includes two x-ray telescopes, one from the same University and the other from Imperial College, London. The design altitude was 38km, which would put it above all but 0.3% of the atmosphere.

The same observatory has previously flown twice from the balloon launching station at Alice Springs. This facility was closed down by the federal government in 1980, at a saving of about $240,000 a year — two-thirds of the total upkeep costs, the rest coming from the USA. (At the time of the decision to shut down the station there was an expression of interest from the UK in also paying a one-third share). The Astronomy Advisory Committee, which favoured keeping the Alice Springs station, was subsequently abolished by the ‘Razor Gang’.

The value of balloons in x-ray astronomy arises from their cheapness compared with satellites. There is at present one small Japanese x-ray satellite, which was launched in 1979. Balloon-borne observatories are particularly suitable for the high-energy end of the x-ray spectrum — above about 20 keV: at these energies attenuation by the upper atmosphere is not important, but the radiation flux density is relatively low, requiring large detectors. For the Japanese satellite 20 keV is about the upper end of the energy range, whereas the Tasmanian observatory detects radiation up to the order of 200 keV. Two further x-ray satellites are expected to be launched this year, by Japan and Europe.

The Tasmanian instrument is the world’s largest x-ray telescope. It is essentially a xenon-filled proportional counter containing a complex array of anodes; x-rays are stopped within the detector, whereas cosmic particles are not. The Imperial College system, designed for higher energies, uses two layers of different phosphors, in which a coincidence indicates a particle and non-coincidence an x-ray photon.

Dr Peter Fenton, the University of Tasmania project leader, hopes that the Alice Springs launching station may yet be brought back into action. Last year the Senate Standing Committee on Science and the Environment recommended that it should be operated by an Australian/UK-US consortium. It was in any case time, he said, to begin work on an improved telescope (the present one having been designed in 1974). This might take advantage of the large capacity of the space shuttle, which could become available for this purpose around 1990. However, advances were also evident in balloon technology: a free-drifting balloon recently circled the world, starting and finishing in Australia with a load of 1700kg.

Innovation centre

A wheelchair that climbs up stairs and over obstacles. A positive-drive differential to give cars extra power and better handling. A device for tightening the skin on a drum without weakening the drum itself.

These are some of the inventions being promoted by the Innovation Centre of NSW which opened in April in Sydney. Housed at the University of NSW, the Centre was established by the Innovation Council of NSW.

It is supported by the University, NSW Institute of Technology, NSW Chamber of Manufacturers, Metal Trades Industry Association of NSW, Institute of Patent Attorneys of Australia, NSW Department of Industrial Development and Decentralisation and the Federal Department of Science and Technology.

There will be similar innovation centres in other states.

The Centre aims to facilitate commercial development of inventions in NSW by providing inventors with access to information, expertise, services and facilities, and by seeking partners to help produce, market and finance new ventures.

It will also promote greater interaction between inventors, manufacturers, educational institutions, government and financial organisations, and develop educational and promotional activities to encourage innovation in local industry.

Executive director of the centre is Dr Neville Stephenson, who has been seconded from the NSW Institute of Technology where he is head of the faculty of science.

According to Stephenson, the Centre will service high and low technology products and processes.

Basic services will include preliminary technical and commercial assessments, advice on patents and patent searches, and referrals to potential industrial partners and sources of financial assistance.

“For selected projects the Centre could negotiate a royalty or equity position as well as providing laboratory space and some administrative support,” he said.

“We also hope to help with engineering development, market assessments, proposals for raising venture capital and putting together management teams.”

“Another very important function will be running workshops, seminars and lectures to give students the background, skills and experience they need, not just to generate innovative ideas but to develop them into useful products and establish successful businesses.”

Student teams will also be involved in developing projects.

The Centre has been launched with $45,000 in donations and grants from the sponsoring organisations, but eventually it aims to be self-supporting.

Revenue will come from royalties, fees for services, consulting fees and income from workshops, seminars, exhibitions and sponsorships.

The Harkness Fellowships

The Fellowship programme was established in 1925 by an American philanthropic foundation, The Commonwealth Fund of New York.

FOUR FELLOWSHIPS, tenable for between 12 and 21 months are offered. The award includes return fares to the United States, living and family allowances, travel in America (with car rental allowance), tuition and research expenses, a book and equipment allowance and health insurance.

Candidacy is open to men and women in any profession or field of study who are over the age of 21 years. Preference will be given to applicants who will be under 36 years of age.

Selection of Fellows, which is made by the Australian Selection Committee, is based on personal qualities as well as on a proven level of academic or professional excellence and on those with outstanding records who have a chance of success.

The closing date for applications is 31st August 1983 and application forms will not be made available after 15th August 1983.

APPLICATION FORMS may be obtained by individual candidates on request to the Australian Representative: Mr L. T. Hinde, Reserve Bank of Australia, G.P.O. Box 3947, SYDNEY, N.S.W. 2001.
TO ALL PHYSICISTS

(Please copy and distribute further)

Concern about the danger of a nuclear holocaust has grown in the last year. So far, however, most initiatives to reverse the nuclear arms race have been taken at national levels. We think that a call from physicists all around the world to stop the arms race could strengthen these efforts.

On the basis of recent experiences of the freeze movement in the U.S. and the peace movements in Europe, it appears that a call for an immediate nuclear freeze may find worldwide support.

As a professional community we physicists bear the historical burden of having not only made possible but having actually constructed the first nuclear bomb; moreover the general public is well aware that a large number of physicists is actually continuing this work and pushing it to ever more horrible possibilities.

Under these circumstances the voice of physicists has a particular weight. Physicists know each other around the world, and it should be possible to find among ourselves an international consensus on such an initiative. If we physicists unite our worried voices irrespective of political differences, our appeal should have considerable impact.

We are therefore asking you to support the following freeze appeal:

WE CALL FOR AN AGREEMENT TO HALT THE TESTING, PRODUCTION AND DEPLOYMENT OF NUCLEAR WEAPONS AND NUCLEAR WEAPONS DELIVERY SYSTEMS. MEANWHILE, NO FURTHER NUCLEAR WEAPONS OR DELIVERY SYSTEMS SHOULD BE DEPLOYED ANYWHERE

You might wish to have this text changed to the stronger or weaker side, included this and excluded that - we would enter into an endless discussion. Please put your doubts aside and realize that something MUST be done.

The freeze appeal has been signed already by a representative sample of well known physicists, the names of whom are printed overleaf.

We hope for many thousands of signatures from all over the world and YOURS is as important as any other. At the end of this campaign the appeal with the signatures will be presented to the concerned governments, to international organizations and made public through the press and other forums. We hope that this freeze appeal would then exert some influence on the peace activities of the United Nations and on negotiations on disarmament.
A CALL TO HALT THE NUCLEAR ARMS RACE

Despite many efforts, conferences, and negotiations the nuclear arms race is accelerating. There are now more than fifty thousand nuclear weapons, some of which have yielded a thousand times greater than the bomb that destroyed Hiroshima. This means some three tons TNT equivalent for every person on earth. The counting of number of warheads and missiles is no longer relevant for security. On the contrary, the nuclear arms race diminishes security and brings us closer to nuclear holocaust.

Mankind’s fate is in its own hands. The catastrophe of nuclear war can and must be prevented. The nuclear arms race must be reversed. It must be reversed now, there is no time to be lost. It can be reversed if people from all over the world work together for this common goal. Let us unite all voices to call for an immediate freeze of the nuclear arms race. This is a necessary first step towards nuclear disarmament. It is simple and comprehensive. People with different political and religious convictions, organizations and movements from many nations may work together to achieve it. The freeze should not be postponed until the conclusion of time consuming negotiations. We, physicists from all over the world, support the following appeal:

WE CALL FOR AN AGREEMENT TO HALT THE TESTING, PRODUCTION AND DEPLOYMENT OF NUCLEAR WEAPONS AND NUCLEAR WEAPONS DELIVERY SYSTEMS. MEANWHILE, NO FURTHER NUCLEAR WEAPONS OR DELIVERY SYSTEMS SHOULD BE DEPLOYED ANYWHERE.

First signatories include: H. ALFVEN (Sweden), J. ALTSHULER (Cuba), E. AMALDI (Italy), D. AMATI (Italy), N.G. ANTONIOU (Greece), A. ARIMA (Japan), D.R. BATES (N. Ire.), N. BASOV (USSR), J.S. BELL (UK), D.R. BES (Argentina), H.A. BETHE (USA), N. BLOEMERGEN (USA), S. BLUDMAN (USA), N. BOGOLIUBOV (USSR), E. BRODA (Austria), N. BYERS (USA), F. CALOGERO (Italy), H.G.B. CASIMIR (Netherl.), G. CHARPAK (France), P.A. CHERENKOV (USSR), W. CHINOWSKY (USA), S.G. COHEN (Israel), J.W. CRONIN (USA), F. DYSON (USA), R. FEYNMAN (USA), R. FIESCHI (Italy), J.M. FRANK (USSR), Gr. GHIKHA (Romania), S. GLASHOW (USA), H.S. GREEN (Australia), T. GUSTAFSON (Sweden), R. HAGEDORN (Germ. Fed. Rep.), S.W. HAWKING (UK), S. HAYAKAWA (Japan), E.M. HENLEY (USA), H. HOGAASSEN (Norway), D. JACKSON (USA), P. KAPITZA (USSR), A. KASTLER (France), T.W.B. KIBBLE (UK), R. KUBO (Japan), F. LALOE (France), K.V. LAURIKAINEN (Finland), L. LEDERMAN (USA), M.A. MARKOV (USSR), E. Mc MILLAN (USA), M.G.K. MENON (India), N. MOTT (UK), W. NAHM (Germ. Fed. Rep.), J.V. NARLIKAR (India), Ph. NOZIERES (France), R. PEIERLS (UK), J. PNIJEWSKY (Poland), A.M. PROKHOVOR (USSR), F. RAVNDAL (Norway), M. REES (UK), T. REGGE (Italy), M. ROSENBLUTH (USA), A. ROSENFELD (USA), C. RUBBI (Italy), W.A. RUNCIMAN (Australia), M. RYLE (UK), A. SALAM (UK), N.C. SANCHO (Spain), F.D. SANTOS (Portugal), K. SIEGBAHN (Sweden), L. SOHNSWIKI (Poland), T.D. SPEARMAN (Ireland), P. STEIN (USA), J. STEINBERGER (USA), I. TALMI (Israel), V.L. TELEGDI (Switzerland), W. THIRRING (Austria), J. TIOUNO (Brazil), S. TITEICA (Romania), I.T. Todorov (Bulgaria), M.-J. TREDER (Germ. Fed. Rep.), A. UHLMANN (Germ. Fed. Rep.), S. WEINBERG (USA), V.F. WEISSKOPF (USA), Ch. WETTERICH (Germ. Fed. Rep.), Y.A.B. ZELDOVIC (USSR), A. ZICHICH (Italy).

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Collected signatures should be sent to one of the following addresses:--
2. Prof. Nina BYERS, Phys. Dept., University of California, LOS ANGELES, CA 90024, USA.
3. Prof. D. AMATI, CERN, Theory Division, CH-1211 GENEVA 23, Switzerland.

PLEASE COLLABORATE ACTIVELY BY COPYING AND DISTRIBUTING THIS APPEAL; COLLECT SIGNATURES
Conferences and Meetings

1983
Sept 1-3 National Conf. on Computer-aided Learning in Tertiary Education, St. Lucia.
*Marshall Harris, CALITE Conference, Dept. of Computer Science, University of Queensland, St. Lucia 4067.*

*M.R. Wells, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, UK*

1984
Prof. R.K. Moore, Remote Sensing Lab. U. of Kansas Centre for Research, Inc., 2291 Irving Hill Dr — Campus West, Lawrence, Ks 66045, USA.

Feb 7-10 Australia/New Zealand Condensed Matter Physics Meeting, Pakatou Island.
Dr R.G. Buckley, Physics and Engineering Laboratory, DSIR, Lower Hutt, NZ.

Apr 11-13 Conf. on Nuclear Structure Physics, IOP, Bradford.
IOP, 47 Belgrave Sq., London SW1X 8QX, UK

Aug 27-30 Conf. on Agricultural Engineering Innovations, Bundaberg.
Conf. Manager, Agricultural Engineering, The Institution of Engineers, 11 National Circuit, Barton 2600

Sept. 17-21 9th European Conference on Thermophysical Properties, Manchester.
Meetings Officer, IOP, 47 Belgrave Sq., London SW1X 8QX, UK

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**RADIO RESEARCH BOARD POSTDOCTORAL FELLOWSHIP**

**GENERAL:** As part of its activities designed to foster research in electronics, telecommunications, radio science and related fields in the universities and other appropriate organizations, the Radio Research Board offers a Fellowship Scheme. Under this scheme Fellowships are awarded each year for full-time research by young scientists or engineers of exceptional promise and proven merit. These are postdoctoral awards tenable for a period of two years in an Australian university, approved research institute or industrial laboratory as determined by negotiation between a prospective Fellow and the Board. The agreed area of research will also be determined by negotiation but the Board is prepared to consider any proposal relevant to its interests.

**QUALIFICATIONS:** The applicant should have a PhD degree or its equivalent and be preferably under 30 years of age. Radio Research Board Fellowships are available to applicants of all nationalities but they are asked to indicate their future plans.

**STIPEND:** The stipend will normally follow that applicable to the Queen Elizabeth II awards, currently $23,437 (25,446 over 28 years of age). Stipend is subject to income tax.

**ALLOWANCES:** Appropriate allowances and travel expenses are available. Host institutions may be paid an allowance towards the cost of supporting the Fellow.

**APPLICATIONS:** Persons interested in applying for the above Fellowship should obtain application forms and a statement of the conditions from the Secretary, Radio Research Board, P O Box 225, Dickson ACT 2602.

Applications close on 23 September 1983 and in the normal course of events candidates may expect to be advised on the outcome of their applications in December 1983.

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**PERTH,**

**WESTERN AUSTRALIA**

Applications are invited from suitably qualified persons for the following position which is to be taken up on 1 January, 1984 or as soon as possible thereafter.

**SCHOOL OF MATHEMATICAL AND PHYSICAL SCIENCES**

**TENUREABLE LECTURESHIP IN PHYSICS**

(REF: EN0519)

The School of Mathematical and Physical Sciences has responsibility for teaching in the areas of Chemistry, Computing, Mathematics, Mineral Science and Physics leading to both pass and Honours degrees.

Established research interests include solid state, theoretical solid state physics, biophysics, photovoltaics, thin films, electrochemistry and holography. Opportunities also exist for research in inter-disciplinary areas within the School or in conjunction with other Schools of Study at Murdoch.

Continuing expansion in student numbers in Physics has created the need for an additional academic appointment and we are seeking a person who will make a positive contribution to the development of Physics at Murdoch.

Applicants should have experience and an interest in University teaching and hold a higher degree, preferably a PhD in Physics. Post-doctoral experience in research and teaching would be an advantage.

**GENERAL**

Salary Range: $A 22,450 to $A 29,467 per annum

This is a tenureable appointment and conditions include superannuation, long service leave, outside studies programme, payment of fares to Perth for appointee and dependent family, removal and settling-in allowance and house purchase scheme.

**PROCEDURE FOR APPLICATIONS**

There is no prescribed application form, but TWO COMPLETE SETS of detailed applications quoting the appropriate reference number, including full personal particulars, details of preliminary qualifications, career history and description of posts held, area of special competence and interest, research completed or currently being undertaken, membership of professional institutions or societies and positions of responsibility in these; list of relevant material published by the applicant, when available to take up appointment if offered and the names and addresses of three professional referees should reach the Personnel Officer, Murdoch University, Western Australia, 0162 by Friday 28 August, 1983.
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