THE AUSTRALIAN PHYSICIST

Presidents Column ........................................ 129
Bill Durant .................................................. 129
A Case for an Australasian Physical Society ......... 130
AIP Third National Congress ............................ 131
Gravitational Waves — Part I ............................ 132
What is this thing called Science? ....................... 138
Modern Calculators ........................................ 139
People and Institutions ................................... 141
Science in Australia ........................................ 141
Book Reviews ................................................ 143
Letters ....................................................... 144

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President's Column

A subject that has worried me for some years is the cost of attendance at scientific meetings. We mouth platitudes about bringing science to the people so that they can make informed decisions. We then structure our meetings in such a way that it is very expensive for them to attend. I attempted to persuade ANZASSC to change its mind, pointing out that working scientists have their expenses and registration fee paid or can claim them as tax deductions, while interested members of the public obtain no tax relief and are forced to attend during their annual leave. This approach was completely rejected and I decided ANZASSC could go to its inevitable demise in its own way.

However, two recent two-day conferences have highlighted the problem. Both of these are on the subject of Australia's energy resources and are of potential interest to a large community.

The first was sponsored by the Institution of Engineers, Australia. The registration fee was $85 and the venue was the Lakeside Hotel, Canberra, where the room only rate is $30.

The second is an energy symposium organised by the Australian Academy of Technological Sciences. The registration fee for the meeting is $85. If a participant wishes to take a guest to the dinner an extra $25 is to be paid. The dinner venue is the Lakeside Hotel.

The AIP has consciously taken the other approach. Registration fees are kept to a minimum (that at the Wagga Solid State meeting was zero). Accommodation and catering facilities of university and CAEs are used. The standard is equal to that enjoyed at home by most members. Attempts to keep the costs of meetings down are not confined to the Institute of Physics. The International Solar Energy Society takes the same view.

It is time that Australian science formulated a position on this matter. High fees result in the exclusion of junior members of a field, but do result in a profit to the society. If professional societies do not make a common decision, cross-fertilisation between disciplines suffers. If A rips off B on the assumption that B will rip off A when the time comes, the net result is a draw, which would be obtained with no rip offs. When A and B play different games, antagonism will arise.

I would like to receive views of members on the pricing policy for conferences.

Bill Durant, M.A.I.P.—an appreciation

The untimely death on January 19, 1977, of Bill Durant, Head of the Physics Department at Ballarat College of Advanced Education, was reported in this journal in February. Time then permitted only a brief obituary notice but it is now possible to pay full tribute to him.

Following secondary education at Ballarat High School, W. G. Durant graduated B.Sc., Dip.Ed. from Melbourne University in 1953. After four years as a science teacher at Maryborough High School he was appointed to the staff of the then Ballarat School of Mines, where, in 1959, he assumed control of the teaching of tertiary level physics. He was thus responsible for the Physics Department, which over the next few years emerged by stages, to what ultimately became the Ballarat Institute of Advanced Education.

In 1962, under Bill's guidance a Diploma of Applied Physics was launched at that Institute and this was followed, in 1972, by a course leading to a B.App.Sc. with major studies in physics.

In addition to giving his unbounded enthusiasm to these teaching and administrative duties Bill entered vigorously into numerous other Institute activities, being a member of the Academic Board as well as numerous internal committees. At various times he was a member of the Victorian Education Department physics examiners panel and physics syllabus committee, the V.I.C. physics course development committee, the V.I.C. School Board for Physical Sciences and the V.I.C. ad-hoc committee for Lecturer Education. As a member of the Australian Institute of Physics, Bill served on the Victorian Branch Committee, where he played an active role in organizing branch meetings at Ballarat. He was also active in organizing and administering in Ballarat Institute lectures for local secondary students.

Bill earned himself a high reputation as an inspiring and effective tertiary teacher of physics at the undergraduate level. He had a keen appreciation of the needs of students, who always found him easy to approach and in sympathy with their thinking. He was also very active in church and community welfare work. To his Ballarat and other colleagues, Bill was a good physicist endowed with a keen sense of humour, which made him an informative and entertaining companion. He will be greatly missed by all his many friends in Ballarat. To his wife, Heather, and daughter, Carol, this Institute extends sincere sympathy and takes this opportunity of placing on record its appreciation of his services and support.

Ken Connor and Ray de Groot.
A Case for an Australasian Physical Society (AAPS)

Mohammad Ilyas — School of Physics, University of Science of Malaysia

The problems of the scientific community in developing countries have been receiving some attention recently. The community, in particular physicists, faces problems regarding funds available for scientific and educational research on the one hand and the high cost of scientific periodicals — generally produced outside the developing region — on the other. While in the former case some degree of planning is possible, (concentration on fewer, more directly and readily applicable fields) the problem of information dissemination is still very acute. Recently there have been some suggestions to reduce further aggravation of this problem by reducing the number of scientific periodicals and to alleviate costs by producing cheaper editions for developing countries. However, no collective effort has yet been made by scientists in developing countries to look into the ways and means of overcoming these problems.

On this note we are primarily concerned with physicists and the following discussion is aimed at Physics in Asia.

One of the important tasks of the scientific community in general and physicists in particular, in developed countries, has been the evolution of large scale scientific meetings. Large scale means that a significantly large number of practising scientists on a continental scale are involved and this has revolutionised the speed of dissemination of important scientific information. There are two well known areas of the globe for these meetings i.e. Northern America and Europe. Unfortunately there is an absence of any organisation which can provide the forum for large-scale gatherings of smaller pockets of physics communities in developing countries. This note proposes action to form such a society of Physicists in Asia which may conveniently be called a Physical Society.

The proposed physical society could be formed on the model of the European Physical Society and would seek to produce co-operation and a single unified forum in the developing Asian countries — countries possibly no more diverse than those in Europe. The initial membership could be found in the individual Physical Institutes/Societies of the various countries.

Since there is already a close co-operation — which will increase with time — in different fields among Asian countries, their respective physics societies could form the nucleus of the proposed society.

Australia, (though neither developing nor Asian) can be an important element and could play an important role in the evolution and development and functioning of such a society. It can provide the expertise and could play as great a formal role in the proposed physical society as the United Kingdom has been playing in the European case. It is noteworthy that more and more graduates from South East Asian countries are being trained in Australia in various fields including physics. At the academic level there is already some co-operation through the Australia-Asia Universities Co-operation Scheme (AAUCS) via the Australian Vice-Chancellor’s Committee (AVCC). At the government level also there is increasingly closer co-operation between Australia and Asian in various fields including both economic and educational. In the latter case there are the well-known Colombo Plan and the Commonwealth Scheme.

The Australian Physics Community is small by itself, and it too, is isolated from the two big physics communities. Australian Physicists must go to European and North American meetings and this expensive need of attending long distance meetings frequently, can be available to only relatively few people — generally the young people — for economic reasons. On the other hand, the gatherings of an Australian Physical Society where European and American experts can be invited, would be more readily available.

It should be mentioned here than an interesting development in Australian Physics (particularly planetary sciences) in recent years has been the choice of Australia as the venue of some of the big international meetings, e.g. IAMP/IAPSO first special assemblies in 1974, IGC in 1976 and IUGG scheduled for 1978. Nevertheless, the frequency of these large international gatherings may be limited for quite some time to come, possibly because of financial strains. An important step forward to fill this scientific meeting vacuum was taken through the institution of a bi-annual National Congress in Physics by AIP about two years ago and has been found to be very successful and useful for a get-together of the pockets of Australian Physicists. Although the first congress was oriented towards discussing research activities in Australian Physics, the second congress, however was (in my opinion) more concerned with the National Physics policy matters rather than physics research in Australia directly. This may have been partly due to financial constraints, resulting in a smaller number of research students participating.

In any case, the orientation towards national policy matters is good and should be an essential ingredient of the functions of the individual national organisations of the proposed society.

That the Australian Physics Community is small by itself is also reflected in the two publications; The Australian Physicist and Australian Journal of Physics. The Australian Physicist is not worth the subscription money for ordinary members and has possibly deteriorated in its subject matter. It is not to be compared with the Physics Bulletin or Physics Today. In the case of AJP, serious doubts have been raised about its continuation. Interesting enough, one of the cases for its continuation was argued to be that it projects an image of Australian Physics although the proportion of non-Australian content in it has been steadily increasing, reaching to about 38% of the total articles in 1976 from a 1972 low of 6%. Further, almost 70% of the total outside papers (1972 to 1976) came from East Asia and New Zealand. I believe, the problem in each case reflects...
the small size of the physics community and can be overcome if it becomes an Australasian journal i.e. Asian publications are presented through it.

I would like to bring into the picture the Indian Physics Community. It is interesting to note that the volume of scientific research is the highest of any single country in the Australasian region. The number of scientific and technical personnel in India is third largest on the world scene. This is equally true of Physics in India and this is reflected in the four monthly physics publications. Therefore Indian Physicists could be an invaluable part and parcel of the proposed society. It may be remarked that India is already playing an important role in training South East Asian graduates.

In summary, the proposal is for the formation of an Australasian Physical Society (AAPS) which will seek increased cooperation on the regional scale. The individual national societies should be joined in the society. As a first step, the ASEAN countries may form the proposed association since there is already significant cooperation in various fields among ASEAN countries at formal level. Australia and India will be two important and invaluable components of the association and it would be mutually beneficial to the respective communities. The already existing physics periodicals in the region (Australian and Indian) could become the vehicles of research in the Australasian region. One of the important functions of the proposed society would be the arrangement of frequent cyclic research meetings and to look into the ways and means of making research periodicals accessible to physicists in Asian countries. However, the proposed society should perhaps be evolved in phases increasing its size and activities around ASEAN.

Post-Script:
I am grateful to Professor Chatur Singh for having brought up some of these points at the recent regional conference at my request since I was unable to attend personally. It is heartening to record that the response was overwhelmingly in favour of such an organization.

References
6. cf: According to a Radio Malaysia report (23.6.1977) Australia is training more than 6,000 Malaysian students as compared to 8,000 by Britain. It is expected that more and more students will go to Australia due to higher fees in the UK whereas in Australia, education is free for both local and foreign students.
7. The number of research papers was still not too bad although specialized papers were run through poster sessions, and the oral presentations were generally of discussion types.
11. For example the number of Malaysian Students in India is as much as in Australia i.e. nearly 6,000. The students number is expected to increase as in the case of Australia. (Radio Malaysia Report).
12. Regional Conference on University Physics Education held at University of Science of Malaysia, Penang (16-21 May, 1977).

A.I.P. Third National Congress

The third National Congress of the Australian Institute of Physics is to be held in Perth, Western Australia early in 1979. A Congress Committee has been established and five sub-committees have been formed to work on the various aspects of Congress organisation.

The Congress Committee has as its members:
- Chairman: Dr J. R. de Laeter, Dean, School of Applied Science, Western Australian Institute of Technology, Bentley, W.A. 6102.
- Secretary: Dr M. Lynch, Department of Physics, Western Australian Institute of Technology, Bentley, W.A. 6102.
- Dr J. L. Black, Head, Department of Biophysics, Sir Charles Gairdner Hospital. Professor B. Mainsbridge, School of Mathematical and Physical Sciences, Murdoch University. Dr J. Swan, Department of Physics, University of Western Australia.

The provisional dates for the Congress are 15th - 19th January, 1979, and the venue is to be the campus of the University of Western Australia. This is particularly appropriate since the newly appointed Vice-Chancellor, Professor R. Street, and the present Deputy Vice-Chancellor, Professor A. F. Bayle, are physicists.

Provisional topic headings for papers include geophysics, astronomy, electron spectroscopy, instrumentation and computer techniques, low temperature and solid state physics, education, nuclear physics, environmental physics, atmospheric and oceanographic physics, surface physics and vacuum physics.

Western Australia is celebrating its 150th Anniversary in 1979 and the Congress will be one of the first Conferences of the anniversary year. It is hoped that many physicists will attend the Congress and share in the anniversary celebrations.

Any enquiries concerning the Congress should be made to the Congress Secretary, Dr M. Lynch, at the address given above.
PART I: GRAVITATIONAL WAVES AND HOW THEY CAN BE DETECTED

1. Introduction

Searches for cosmological gravitational waves have so far been unsuccessful.

Many groups have attempted to repeat Weber's original experiment and obtained only negative results. Attempts similar to Weber's have been set up at Moscow, Frascati, Munich, Glasgow, Rochester, Bell Laboratories and IBM (New York).

Meanwhile the theorists have been busy and tell us that it is no surprise at all that room temperature antennae do not detect gravitational waves. In fact, in order to have any reasonable chance of detecting them, it will be necessary to improve on the sensitivity of Weber's detector by at least six orders of magnitude.

Hence the "second generation" of gravitational wave antennae was born. These antennae, designed to work at millikelvin temperatures, are now being built at Stanford, Louisiana State and Rome universities. The Stanford group has already operated a 680kg prototype detector at 2K and at Louisiana State University a five tonne antenna is nearing completion.

About three years ago, we pointed out that a fourth "second generation" detector at Perth, Western Australia could contribute significantly to the efforts of these three laboratories, especially if gravitational astronomy were ever to become a reality.

In principle, astronomical sources of gravitational wave impulses can be located by the relative arrival time of the waves at various global stations. To do this without ambiguity requires at least four stations.

For good angular resolution, and to avoid ambiguity, the fourth station should be well out of the plane of the other three and as far away from them as possible. The site of Perth is a very good choice, being about 400msec, as the graviton flies, from each of the other stations, as shown by Fig. 1 and Table 1. This means that an angular resolution of $\sim 1.5'\mathrm{sec}$ is possible in principle, assuming a resolving time of $\sim 1\mathrm{msec}$.

A further advantage of four stations is that the speed of the gravitational waves can either be checked or used as a filter against noise.

2. Gravitational Waves

There are two solutions to Einstein's equations of general relativity which can be tested experimentally. One of these is the spherically symmetric Schwarzschild solution which is confirmed by the three standard tests of general relativity. The other is the wave solution for weak fields in free space which has yet to be confirmed experimentally.

To understand what is meant by "gravitational waves", we define the metric $g_{ik}$ through the invariant interval $ds$:

$$ds^2 = g_{ik} dx^i dx^k$$

$g_{ik}$ then describes the geometry of space which determines the behaviour of matter. The principle of least action leads to the ten Einstein equations for $g_{ik}$. In the weak field limit in free space, these equations reduce to:

$$\left[ \frac{\partial^2}{\partial t^2} - \frac{1}{c^2} \frac{\partial^2}{\partial r^2} \right] h_{ik} = 0,$$

where $g_{ik} = g_{ik}^0 + h_{ik}$.

$g_{ik}^0$ is the Galilean metric, and $h_{ik} << g_{ik}$.

For a plane wave travelling in the $x$-direction there are two independent solutions of these equations:

$$h_{23} = h_{32} = h(x \pm ct)$$

and $$h_{22} = -h_{33} = h(x \pm ct),$$

representing the two possible polarizations of the gravitational wave.

It is convenient to consider the second solution:

$$g_{ik} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1+h & 0 \\ 0 & 0 & 0 & -1-h \end{bmatrix}$$

Now consider a small displacement in the $y$-direction of proper length $\delta l$. We have $\delta l^2 = (1 + h) \delta y^2$ so that $\delta l = (1 - \frac{1}{2}h) \delta y$, i.e. there is a strain of magnitude $\frac{1}{2}h$ in the $y$-direction and of equal magnitude but opposite sign in the $z$-direction. Thus if a block of matter is in the path of the gravitational wave, it experiences a distortion as shown in Fig. 2. This quadrupole pattern is of course characteristic of gravitational waves. Hence gravitational waves may be detected by observing the strain experienced by a massive object in at least one dimension.

3. Sources of Gravitational Radiation

It is not difficult to make order of magnitude estimates of the energy flux and strain associated with gravitational waves generated by plausible cosmological events. The energy flux or "Poynting vector" of gravitation is given by

$$\vec{I} = \frac{c^2}{16\pi G} \vec{h} \cdot \vec{h}.$$
3.1 Supernovae

Suppose that in a supernova, energy $Mc^2$ is converted to gravitational radiation in a time $T$. (This energy is variously estimated at between 1% and 10% of the total rest energy of the star.) If the supernova occurs at a distance $r$ from the Earth, the instantaneous local energy flux is given by:

$$I \approx \frac{Mc^2}{4\pi r^2 T}$$

(1)

This simple formula assumes spherical symmetry which would clearly not be true for quadrupole radiation. However it does give the required order of magnitude.

It is now necessary to assume a specific form for the wave. A simple choice is that during the time $T$,

$$h = -h_0 \cos 2\pi t / T,$$

(2)

so that averaging over the pulse

$$\langle h^2 \rangle = \frac{2\pi^2 h_0^2}{T^2}.$$

It follows that the local strain is given by

$$\gamma h_0 = \sqrt{\frac{GM}{2\pi c^4 r^2}}$$

(3)

Evaluating this quantity for a supernova in the Virgo cluster of galaxies, at $r \approx 10 \text{ Mpc} = 3 \times 10^{22} \text{ cm}$, assuming (optimistically) that $M \sim 10^4 \text{ M}_\odot = 2 \times 10^{32} \text{ gm}$, and that $T \approx 1.0 \text{ msec}$, one finds that

$$\gamma h_0 \approx 5.0 \times 10^{-21}$$

and $\gamma \approx 1.6 \times 10^8 \text{ erg cm}^{-2} \text{ sec}^{-1}$.

Hence for an antenna of length $2m$, the relative displacement of its two ends is $\approx 10^{-15} \text{ cm}$, which gives an indication of the necessary sensitivity of the detector. For a supernova in our own galaxy, the displacement would be of order $10^{-13} \text{ cm}$.

It is worth noting that the only significant uncertainty in the above calculation is the fraction of available energy converted into gravitational radiation during the supernova collapse.

**TABLE 1 — Locations of Second Generation Gravitational Wave Detectors**

<table>
<thead>
<tr>
<th></th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rome</td>
<td>$-12.47^\circ$</td>
<td>$43.05^\circ$</td>
</tr>
<tr>
<td>Baton Rouge</td>
<td>$91.03^\circ$</td>
<td>$30.83^\circ$</td>
</tr>
<tr>
<td>Stanford</td>
<td>$122.30^\circ$</td>
<td>$37.70^\circ$</td>
</tr>
<tr>
<td>Perth</td>
<td>$-115.82^\circ$</td>
<td>$-31.98^\circ$</td>
</tr>
</tbody>
</table>

**Fig. 1. Distance between proposed second generation gravitational wave stations.**

The Australian Physicist, September 1977 133
TABLE 2 – POSSIBLY OBSERVABLE SOURCES OF GRAVITATIONAL RADIATION

<table>
<thead>
<tr>
<th>Type</th>
<th>Distance per (1pc=3.1x10^16 cm)</th>
<th>Lifetime</th>
<th>Period</th>
<th>Frequency of occurrence</th>
<th>Flux erg/cm² sec</th>
<th>Strain h₀</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Binaries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β Persei</td>
<td>30</td>
<td>3.2x10¹¹ yrs</td>
<td>2.867 years</td>
<td>continuous</td>
<td>1.3x10⁻¹³</td>
<td>2.6x10⁻¹⁸</td>
</tr>
<tr>
<td>i Bootis</td>
<td>12</td>
<td>2x10⁹ yrs</td>
<td>6.46 hours</td>
<td>continuous</td>
<td>1.8x10⁻¹⁰</td>
<td>2.5x10⁻²⁰</td>
</tr>
<tr>
<td><strong>2 Collapsed Objects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m₁ = m₂ = M⊙</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r₁₂ = 1000R₁₂ Sch</td>
<td>1000</td>
<td>19.7 sec</td>
<td>22.1 msec</td>
<td>?</td>
<td>3.9x10⁶</td>
<td>3.5x10⁻¹⁸</td>
</tr>
<tr>
<td>r₁₂ = 12.7 R₁₂ Sch</td>
<td>1000</td>
<td>5.1 msec</td>
<td>1.0 msec</td>
<td>?</td>
<td>1.2x10¹¹</td>
<td>2.8x10⁻¹⁷</td>
</tr>
<tr>
<td><strong>Crab Pulsar</strong></td>
<td>1600</td>
<td>10⁶ yrs</td>
<td>33.0 msec</td>
<td>continuous</td>
<td>3x10⁻⁷</td>
<td>1.4x10⁻²⁴</td>
</tr>
<tr>
<td><strong>Supernovae</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our Galaxy</td>
<td>~10⁶</td>
<td>10⁹ yrs</td>
<td>10³ - 1 sec</td>
<td>.01/yr</td>
<td>10⁴ - 10⁹</td>
<td>10¹⁸ - 10⁻¹⁷ at 1 KHz</td>
</tr>
<tr>
<td>Virgo Cluster (~1000 galaxies)</td>
<td></td>
<td></td>
<td>10³ - 1 sec</td>
<td>1/month</td>
<td>10² - 10⁴</td>
<td>10⁻¹⁸ - 10⁻⁲⁰ at 1 KHz</td>
</tr>
</tbody>
</table>

3.3 Observable Sources

Table 2 clearly demonstrates that the best hope of detecting gravitational radiation lies in the occurrence of supernovae in the Virgo cluster of galaxies (or the nearest 1000 galaxies) for which, provided sufficient sensitivity is available, an event rate of order one per month is probable. Supernovae in our own galaxy, although obviously providing a stronger signal, are too infrequent to be worth considering. Gravitational radiation from pulsars and binary stars is almost certainly not detectable.

Unless they possess some special features of which we are unaware, the assumed properties of supernovae in other galaxies define fairly precisely the necessary sensitivity for a gravitational wave detector and confirm, as is shown in Part II, that the sensitivity of Weber’s antennae was inadequate.

4. Response of a Resonant Antenna to Gravitational Radiation

In the path of a gravitational wave all free masses move in the same way. A gravitational wave cannot therefore be detected unless one compares the movement of a free mass with one which is “mechanically” restrained. The latter may be in the form of a resonant system which is best tuned to the expected frequency of the gravitational wave. The usual arrangement is illustrated in Fig. 3.

It is usual to calculate the effective cross section for the absorption of gravitational radiation by a resonant antenna, in the form, say, of a solid cylindrical bar, as follows.

The energy of oscillation of the bar (in its fundamental mode) is

$$E = \frac{1}{4} m \omega^2 \xi_0^2 = \frac{1}{64} m \omega^2 l^2 h_0^2$$  (4)

where m is the mass of the bar, l is the length of the bar,
\( \xi_0 \) is the displacement amplitude at each end and \( \omega_0 \) is its circular frequency. Substituting eqn (4) into the usual formula for absorption cross section, \( \sigma = \frac{E}{IT} \), and, using the formulae (1) and (3), with \( T = 2\pi/\omega_0 \), we obtain

\[
\sigma = N \left[ \frac{mG^2}{c^2} \right] \frac{V_s^3}{c^2} \lambda^2
\]

where \( N \) is a number of order unity (\( N = 8/\pi \) for a cylindrical bar), \( V_s \) is the speed of sound in the bar and \( \lambda \) is the wavelength of the gravitational wave. This formula is useful only in that it shows that high values of \( m \) and \( V_s \) are advantageous. In practice it is easier to work with formulae containing the strain \( h \).

The concept of a cross section is of dubious validity for a gravitational wave antenna. The antenna experiences a definite strain, but the energy absorbed by the antenna may vary over a range of positive and negative values. The wave may act in opposition to the thermal motion of the antenna and cool its fundamental mode, or it may act in phase and heat it. At high initial amplitudes the energy absorbed may be increased dramatically yielding a possible means of increasing antenna sensitivity. Only in the ensemble average or the time average over a large number of events does the cross section become a quantity that is independent of the dynamical state of the antenna.

The equation of motion for the displacement \( \xi \) of the end of a resonant bar excited by a gravitational wave is (for optimum orientation)

\[
\ddot{\xi} + \frac{2\omega_0}{Q} \dot{\xi} + \omega_0^2 \xi = \frac{1}{2} h_t \sin \omega_0 t
\]

where \( Q \) is the mechanical quality factor of the bar.

The full solution of this equation for \( \xi = 0 \) and \( \dot{\xi} = 0 \) at \( t = 0 \), and for \( h \) given by (2) with \( T = 2\pi/\omega_0 \), is

\[
\xi = A [\cos(\omega t - \delta) - \frac{1}{X} e^{-\omega_0 t/Q} \cos(X \omega_0 t - \epsilon)]
\]

where

\[
X = \sqrt{1 - \frac{1}{Q^2}}
\]

\( \delta = \tan^{-1} \frac{2\omega_0}{Q(\omega_0^2 - \omega^2)} \),

and \( \epsilon = \tan^{-1} \frac{\omega_0^2 + \omega^2}{\omega Q(\omega_0^2 - \omega^2)} \).

The time independent response amplitude \( A \) is given by

\[
A = \frac{\sqrt{\omega_0^2 h_0^2}}{2Q^2 + \left[ (\omega_0^2 - \omega^2)^2 + \frac{2\omega_0 h_0}{Q} \right]^2}^{1/2}
\]

analogous to the familiar response of an LCR circuit. In the limit where \( \omega = \omega_0 \) and \( Q^2 \gg 1 \), the amplitude of oscillation rises monotonically with time, reaching a time independent value when the resonator losses characterized by its Q-value equal the absorbed power.

In this case \( \xi \) is given by

\[
\xi = \frac{1}{8} Qh_0 \sin \left[ \omega_0 t - e^{-\omega_0 t/Q} \right].
\]

In practice one does not expect the wave to be continuous or monochromatic or the bar to be initially at rest. In fact one expects a continuous spectrum of gravitational radiation with maximum spectral density at a frequency \( \sim 1 \text{ KHz} \) and a duration of only a few cycles at the most. Thus it is the response for times \( t \ll Q/\omega_0 \) that is of interest. As one would expect, \( \xi \) becomes independent of \( Q \) in this limit:

\[
\xi = \frac{1}{8} Qh_0 \omega_0 t \sin \omega_0 t.
\]

Under the same conditions the response of a free mass (\( \omega_0 = 0 \)) at the end of the antenna is

\[
\xi = \frac{1}{8} h_0 \left( 1 - \cos \omega_0 t \right),
\]

which is the limit as \( t \to 0 \) yields a response identical to that of the antenna.

In order words, in times much less than the time taken for sound to travel across the antenna, the ends are displaced as though they were free masses. Only after times of the order \( 1/\omega_0 \), does the relative motion of the bar and free mass indicate the presence of gravitational wave. Also the antenna has memory of the gravitational wave event over a time \( \tau = Q/\omega_0 \), while

![Fig. 3. Schematic diagram of a gravitational wave detector.](image-url)
the free mass has no memory. Hence, after the event, the ringing of the antenna can be seen by the accelerometer.

In Figure 4 the motions of the free mass (accelerometer) and resonant antenna of Figure 3, are plotted for a single cycle gravitational wave, along with their relative motion which is the information given by the accelerometer.

After passage of the single cycle wave, the antenna rings with an initial amplitude of

$$\xi_0 = \frac{\pi}{4} h_0.$$  

There is no intention of suggesting that this single cycle monochromatic wave would be the actual form of a gravitational wave pulse, but it is the simplest function that illustrates the principle of detection.

If it were not for the problems of thermal noise and the smallness of $h_0$, any resonant bar of sufficient length 1 would be capable of detecting gravitational waves, independent of its mass and Q-value.

In the second part of this article, the practical problems and fundamental limitations of gravitational wave detection will be discussed and the special features of the University of Western Australia project will be described.

REFERENCES
Conferences and Courses

Electrostatics 1979
(Fifth Conference organised by the Static Electrification Group of The Institute of Physics.)
The Static Electrification Group of The Institute of Physics is organising the above conference to be held in Oxford from 17 - 20 April 1979. The program will include papers on all aspects of electrostatics including charge generation and dissipation in solids and fluids, measurement techniques and industrial application of hazards. Proceedings will be published.
This first notice is issued to ensure inclusion in diaries and a further more detailed notice and call for papers will be issued in the Spring of 1978. Likely contributors are asked to get in touch with the Conference Secretary, Dr J. F. Hughes, Department of Electrical Engineering, University of Southampton, Southampton, S09 SNH.

Digital Communication Systems Symposium
December 5-7, 1977, Sydney. Information: Secretary, RRB, PO Box 225, Dickson, ACT 2602.

Mechanical Properties of Materials at High Rates of Strain
Department of Engineering Science, Oxford from 28 - 30 March 1979. Information about the program is available from Dr J. Harding, Department of Engineering Science, University of Oxford, Parks Road, Oxford OXI 3PJ.

15th Annual Solid State Physics Conference
University of Warwick, from 4-6 January 1978. Invited speakers will include, Dr P. Dean (RSRE Malvern) - Optoelectronic properties of deep levels in semiconductors; Dr D. J. Fabian (Strathclyde) - Electronic structure of alloys by soft X-ray emission and X-ray photoelectron spectroscopy; Professor J. B. Goodenough (Oxford) - Fast ion transport in skeleton structures; Dr M. Pepper (Plessey Co.) - Two-dimensional transport at semiconductor surfaces and interfaces; Dr G. D. Pitt (STL Harlow) - Solid state physics at high pressure; Dr M. Stoneham (AE&E Harwell) - Theory of defects and defect processes; Dr A. Walton (Open University) - Triboluminescence; Professor A. F. G. Wyatt (Exeter) - High frequency porous in liquid Helium - 4.
In addition two specialist symposia on "Magnetism" and "CDW and Electronic Instabilities" will form part of the conference.
Information is obtainable from the Meetings Officer, The Institute of Physics, 47 Belgrave Square, London SWIX 8QX.

UNIVERSITY OF NEW SOUTH WALES
SAFETY OFFICER
(Ref. 798)
The successful applicant will advise on matters of safety policy; investigate specific safety hazards; consult with a wide range of persons and authorities having special responsibilities in safety matters; organize and contribute to instructional programmes in safety; and collaborate with the Radiation Protection Officer in the operation of a Radiation and General Safety Unit.
Appropriate tertiary qualifications in science or engineering expected; at least five years experience in the field of safety and accident prevention desirable.
Salary: Within one of the ranges $14,242 — $15,168 and $15,775 — $16,741, according to qualifications and experience.
Application form from University Employment Office (663-0351), P.O. Box 1, Kensington N.S.W. 2033. Applications close 7th October, 1977.
What is this thing called Science?


Reviewed by G. W. R. Ardley, Philosophy Department, University of Auckland, N.Z.

We recommend this work to all who seek a concise and intelligible account of the present state of philosophy of science. The style of writing is lucid, the exposition of the several schools of thought currently in the field is as accurate as the sometimes perplexed condition of the subject allows. The discussions, though confined to narrow terms of reference, are discerning, especially in the earlier chapters.

Dr Chalmers first takes us through the induction theory of science, for centuries the standard theory of how science works: That we make observations and form generalisations; alternatively, that we make hypotheses and test them against the observations. He points out the fatal weaknesses of this theory. Notably: since scientific data are not as a rule just lying about for us to pick up, but have to be recognised or constructed in the light of an antecedent body of ideas, the inductionists must have the situation upsidedown.

With the decline of inductivism there arose the modern falsification doctrine, the elaboration of which has been the life’s work of Sir Karl Popper. This is the idea that a scientific principle or theory is respectable only if it exposes itself to refutation and survives the ordeal. The doctrine has merits, especially in its ability to separate genuine hard science from pseudo-scientific waffle – the latter being so loose that it cannot be refuted, it can only be dismissed. (On this count, Marxism and Freudianism become Popper’s special aversions). But the switch from the verification of the inductionists to the falsification of the Popperians carries the implication that there is no such thing as permanent scientific knowledge, only a succession of candidates for destruction – which in many contexts is obviously nonsense. Taken alone, the Popperian doctrine, like the work of a negation in natural theology, sinks into nihilism.

A new chapter opens the scenario of Thomas Kuhn. According to Kuhn the history of science consists in periods of stability, or ‘normal science’, working under a master paradigm accepted by all. Such a period is terminated by a scientific revolution in which a new paradigm wrests the sovereignty; then another period of normal science commences and so ad infinitum. The thesis is attractive, but it might be thought that Kuhn has done violence to the history of physics: a history which to other eyes is more like a flowing and gathering stream than a succession of volcanic eruptions and fresh starts.

The inductionist idea was bleakly intellectual. Popper and Kuhn seem, at least tacitly, to draw sustenance from political analogies: Popper’s that of atomistic democracy or anarchy; Kuhn’s that of dynastic history, the rise and fall of empires. The Marxists, too, believe that politics is the key to understanding science. Dr Chalmers introduces us to Louis Althusser as an enlightened exponent. This Marxist theoretician assures us that all problems would be resolved if only we would fasten on to the notion of scientific practice as an activity of production which is determined by the structure of society at any given time. The thesis may appear rather obscure to those not versed in dialectical materialism; but Dr Chalmers discovers not a little sympathy with these solemn pronouncements.

The book closes with an all too brief account of the latest figure on the scene, the dynamic Paul Feyerabend, whose versatility of resource is dazzling, whose methods make for social policy, poetical and ecclesiastical rather than political (unless it be the New Left), and who believes that science is there to be enjoyed, not dissected or methodised. Clearly, Dr Chalmers disapproves of such levity. Granted that Feyerabend, like Kierkegaard in his generation, has scant respect for the pompous and the doctrinaire (of which philosophy of science has more than its fair share), yet it seems unkind of Dr Chalmers to dismiss him as an ‘entertainer’ (p.xv).

Looking back over our author’s account of the present state of ‘official’ philosophy of science, the situation is not inspiring. The sundry incumbrators make occasional shrewd points, but seem unable to grasp things as a whole (which is what philosophy is supposed to be about). Their profusion of unexamined assumptions is calculated to make us blush. Take, for instance, the title of this book: ‘What is this thing called science?’. The book, in fact, is practically confined to physics. The implication therefore is that the biological sciences are only of cadet status. Behind this must be the tacit assumption of the mechanistic doctrine of the universe, or something equivalent thereto. This sweeping premise is not examined, not even mentioned, by our author!

From the 17th century onwards, men of science have been wary of philosophers, and with good reason. There is little in the book which would provide grounds for supporting that policy. Not that philosophy of science is intrinsically worthless. On the contrary, we would all like to have clearer ideas about the ultimate value of scientific knowledge, and the true bearing of that knowledge on the mysteries of human life and destiny. The impediment is that few philosophers have risen to the heights of the great argument. Instead of wisdom they have offered us nostrums.

Descartes came forth as the sole inventor and patentee of a ‘scientific method’, a dose of which was guaranteed to bring all sciences to perfection. The genuine men of science remained unimpressed. But the philosophers, ever optimistic, went on producing recipe after recipe. Unable, it seems, to recognise, still less to respect, the moral eminence of the scientific tradition, they persisted in their attempts to vulgarise science, to turn it into a thing of mean devising, a clever mechanical exercise.

There is little prospect that the philosophy of science will command esteem while it proceeds along its present ‘official’ lines. We await the advent of a new breed of philosophers: men with a proper sense of the being and order of things. Until then, physicists would be well advised to maintain their reserve.
Further Programs Exploiting Modern Programmable Calculators

C.J. Milner, Department of Applied Physics, University of New South Wales

A previous paper (Milner 1973) reviewed and illustrated the capabilities and limits of some calculators representing the state-of-the-art available at that time to those of modest means. (See also Seymour 1974). The calculator revolution has progressed far since then, and the machines there discussed are now obsolescent. The present paper aims to indicate the state now reached by development in two main respects (see Burkitt 1975 a, 1975 b, 1977):

1. Much greater power is now available from desk calculators (of the same physical size and in the same price range) than previously and

2. More calculator power than given by the desk machines previously discussed is now possessed by vest-pocket machines, at little more than 10% of the former price, which occupy only 1% of the volume.

Programmable pocket calculators

The introduction of the HP-35 in 1972/3 made a breakthrough, providing built-in transcendental functions in a calculator not only cheap but pocket-sized, together with automatic reversion to scientific notation on overflow or underflow of arithmetic notation. The followers and rivals of the HP-35 (non-programmable), programmable versions thereof, are now manifold. One of the latest is the Hewlett-Packard HP-25 (and the HP-25C, identical but with battery-powered storage of program and register contents for one month or more). Besides the transcendental functions mentioned, built-in statistical and other functions, such as those giving the integral or the fractional part of the argument (vital just because the machines automatically revert to scientific notation, rather than truncating results), or the absolute value, of the argument are provided; also a pause instruction, and several different "jump criteria". When programming this and several other modern machines, two or more keystrokes can be "merged" to constitute a single program step. (Prospective purchasers should consider the extent of "merging" carefully: it can almost double the effective capacity of the program storage).

Program to find prime numbers

An HP-25 program, illustrative of its capabilities, has been devised, which takes every successive odd integer, N, and tests it for primeness by dividing it successively by every odd integer up to \( n \leq \sqrt{N} \); then if N is prime, it is displayed briefly. Count is kept of the primes so far found. In an extended trial, this program found 1000 primes less than 8000 in a run of nine hours. Perhaps the present stage of development, more than any before, shows up "personal" computers adversely because of their low speed of execution – the more so, because of limited storage; in the present case, a sophisticated program to find primes would store each prime as found, and test by dividing only by primes, not by all odd numbers.

Rectifier output for AC input with harmonics

As an example of the use of built-in transcendental functions, another program for HP-25 will evaluate, for any angle \( \alpha \),

\[
V = a_0 + \sum_{k=1}^{3} a_k \cos(k \alpha) + \sum_{k=1}^{3} b_k \sin(k \alpha)
\]

and from this (which may represent the voltage output of an oscillator with harmonic distortion) will evaluate the current I passing through a rectifier for which

\[
I = I_0 \exp(V/V_o) - 1.
\]

(This is, of course, an idealisation; effectively it assumes that the output impedance of the oscillator is zero). Evaluation of \( V \) involves all 8 memory registers (7 to store the constants \( a_0, a_k, b_k \); and the 8th to store the \( x \) and the \( y \)). and takes 42 steps; \( I \) (in arbitrary units) is derived from \( V \) in 7 steps, of which 3 are used for storage of a value for the constant \( V_o \).

Modern programmable desk calculators

Another, superior, class of machine is currently well-represented by Compucorp 327. This programmable desk machine may be regarded as a natural successor to the two, then-current, calculators discussed in the previous paper (Milner 1973) viz Canon 167P and Sharp CS 364P-III. (The prices are/were about the same, and comparison notably shows how much more power can be got, year by year, for a given expenditure. The Compucorp 327 provides 416 program steps (on average about 1.7 keystrokes merge into each step); has 44 data registers, all with register arithmetic and indirect addressing. Programs (alternatively, the contents of any selected number of registers) can be recorded in successive "blocks" on a tape cassette. The program contents can be edited, not only by substituting for undesired steps, but also by inserting steps between any two existing ones (and by deleting steps).

Since "read program" can be programmed, a long program can be recorded in segments which are successively read-in during execution, each "overlying" the previous one. (Any recursive loop, however, must be confined within one segment).

For an example of what this machine can do when fully extended, solving sets of simultaneous linear equations has been explored. As previously reported, the Sharp CS 364P-III just sufficed to solve 4 such equations. This was done by Gaussian elimination; within the limits of that machine, no "pivoting" could be undertaken. As the number of equations increases, it seems that pivoting strategy becomes much more vital in securing accurate results, or even results at all.

Solution of 6 simultaneous linear equations

A program has been developed for solving sets of 6 equations which uses Gaussian elimination with "scaled partial pivoting", much as described by e.g. Conte and de Boor (1972). The 36 "coefficients" and 6 "right-
hand sides” which specify such a set occupy 42 of the 44 registers, and programming “dodges” have been necessary to accomplish the task within the limits of the machine.

“Partial pivoting” implies that the variables, say $x_1$ to $x_6$, are eliminated in a fixed order – in this case, $x_6, x_5, \ldots, x_2$; but that at each stage that equation, in which the variable to be eliminated has the coefficient with largest absolute value among all the equations, is selected as the “pivotal” equation; i.e., the said coefficient is divided into each other coefficient of that variable, to generate multipliers for all other coefficients.

“Scaled partial pivoting” implies that the “largest absolute value” is taken relative to the largest (in absolute value) of all the coefficients in that equation – to the so-called “size” of the equation. One way of proceeding is to divide through each equation by its “size”, i.e. to scale all equations exactly to size 1. In this program, however, only order-of-magnitude scaling is performed: each equation is divided by $10^N$, where its size is $10^N (N = \text{integer}, 1 \leq S \leq 10)$. This only marginally reduces the accuracy of the solution, while the “dodge” allows the N’s for all 6 equations (provided each is $-50 \leq S \leq 49$) to be stored in coded form as a single 12-digit integer: $N$ is added to one pair of digits of the number 505,050,050,050.

In the program, scaling factors are thus obtained and coded, and applied to the 36 coefficients which alone are input in the first phase. The elimination procedure is then applied to the scaled coefficients, the successive permutations of the pivoting being also recorded in code as successive digits of another single number. (As described by Conte and de Boor, the multipliers used are stored in place of coefficients which are progressively eliminated). By means of indirect addressing, the above, which would otherwise occupy 800 or more steps, can just be confined within the 416 steps of Part 1 of the program: this part concludes by reading-in Part 2. This decodes the scale factors into 6 registers previously used as “pointers” in indirect addressing; and then calls for the entry of 6 right-hand sides, which are multiplied into the scale-factor registers. Then the scaled right-hand sides are permuted in the sequence recorded as above; next, the Gaussian-elimination computations are done on them. Finally back-substitution gives the solution values for, successively, $x_1$ to $x_6$; each value is stored, then rounded and printed. (Part 2 also takes up all 416 program steps, but only 12 labels; Part 1 needs all 16 labels).

Apart from periods for entries, solution as above takes c. 70 s; if however after that only a new set of right-hand sides is entered, the new solution is reached in only 15 to 20 s. The two Parts of the program are recorded (3 times, alternately) on an endless tape, so that reading the next block always readies the machine for a new set of coefficients.

**Optical ray-tracing program**

The above examples tend to display a fresh kind of limit to the “power” of modern personal calculators, viz., that they work only at a limited speed. Clear evidence of this may be seen as follows. The author has developed (for the 12-memory Compucorp 325) a program for optical design which, for each of 51 rays in a pencil diverging from each of 3 points in an object plane, computes the point of incidence on a second spherical surface after refraction at a first spherical surface; and which iterates this calculation for each of a series of coaxial spherical surfaces, data regarding the surfaces and media being recorded on an endless tape, read again for each successive ray. (This program occupies 416 steps). Execution as described, for the case of only a triplet lens, takes 60 to 70 minutes! Obviously, practising lens designers need a central-computer installation.

**Conclusion**

As in the previous paper, the author’s aim has been here to discuss, with examples, the extremes of capability and the limitations of small programmable calculators. It is submitted that, whereas in past years there has been great gain to be had by seizing on the latest and best in, say, the “$1,000 class”, from now on the time taken to master, and to use to the full, novelty in this class might be better spent in central-computer practice; on the other hand, the powers, and the convenience, of pocket programmable machines, still burgeoning, make the “$300 class” seem highly attractive for years to come.

Listings and/or flowcharts of the example programs herein described will be gladly provided on request.

**REFERENCES**


People and Institutions

Max Born Medal and Prizes
The Institute of Physics, London, and the German Physical Society announce the award of the 1977 Max Born Medal and Prize to Professor W. E. Spear of the University of Dundee for his work on charge transport in non-crystalline semiconductors.

The presentation will take place in September 1977 during the annual meeting of the German Physical Society in Karlsruhe.

Uranium from sea-water.
Asahi Chemical Industry Co. (Japan) recently reported that it is proceeding with the study of application technology for the recovery of uranium from sea-water. The process involves the adsorption of uranium from sea-water using titanate acid. The basic studies are reputedly complete although the cost of the process at present is three times the cost of uranium from other sources. — Chemistry in Australia, Vol. 44, No. 7, July, 1977.

Professor Street, new Vice-Chancellor, University of W.A.
The Director of the Australian National University’s Research School of Physical Sciences, Professor Robert Street, has been appointed Vice-Chancellor of the University of Western Australia. He will succeed Emeritus Professor R. F. Whelan who resigned last year to take up appointment as Vice-Chancellor of Liverpool University in England.

Professor Street was elected a Fellow of the Australian Academy of Science in 1973. He is a Fellow of the Institute of Physics, a Fellow of the Australian Institute of Physics, a member of the Institution of Electrical Engineers and a Fellow of the Royal Society of Arts.

U.S./Australia Research Projects
The Minister of Science, Senator Webster, has announced 17 collaborative research projects and six seminars to be conducted under the U.S./Australia Agreement for Scientific and Technical Co-operation.

Projects which are likely to be of particular interest to Physicists include the following:

Visits by Australian Scientists to the U.S.
1. Professor B. H. J. McKellar, University of Melbourne, will work with Professor M. D. Scadron of the University of Arizona during November - December 1977 on mesonic effects in nuclei.

2. Professor S. Rosenblat, University of Melbourne, will undertake collaborative mathematical research with Professor S. H. Davies at the Johns Hopkins University during October - November 1977 on bifurcation from infinity, a theoretical project concerning the problem of turbulence in fluids.

Visits by U.S. scientists to Australia
1. Professor G. W. Robinson, Texas Technical University, will work with Drs R. Cropper and J. M. Morris of the University of Melbourne for two years, beginning January 1978 on picosecond spectroscopy.

2. Professor J. Keren, Northwestern University, will work with Professor G. I. Opal of the University of Melbourne for twelve months beginning in September 1977 on bubble chamber analysis of antiproton-proton interactions.

3. Dr T. F. O’Malley (unaffiliated) will work with Dr R. W. Compton of the Australian National University for twelve months, beginning in October 1977, on anomalous pressure dependence and derivation of electron-atom cross sections from transport coefficients.

4. Professor K. J. Nygaard, University of Missouri, will work with Professor E. Weigold of the Flinders University of South Australia for twelve months beginning in January 1978, on electron impact ionization and electron drift velocities.

Science in Australia

1977-78 Budget — CSIRO
(Statement by the Minister of Science, Senator J. J. Webster)
The 1977/78 Budget provision of $134,048,000 for the operations of the CSIRO would enable the Organisation to press ahead with scientific research programs vital to Australia. The figures represented an increase of $13,198,004 or 10.9 per cent over last year’s appropriation from Consolidated Revenue. Redeployment of staff had meant CSIRO could obtain a modest expansion of activity in high priority research areas such as energy and biological control and this is despite a reduction of 78 in the CSIRO staff ceiling.

$5,745,000 of the increase resulted from:
• transfer to funding of the Kimberley Research Station from the Department of National Resources to CSIRO as from 1 July 1977 — ($0.6m).
• CSIRO’s assuming responsibility for the Materials Research Laboratory in South Australia from the Department of Defence as from 1 September 1977 — ($0.745m).

The balance provides $7,453,004 for inescapable rises in salaries but makes no provision to offset inflationary increases in other operating costs. This means CSIRO has to exercise economies wherever possible to maintain its existing level of research activities.

The Government also recognises that in recent years the redeployment of resources within CSIRO has been made particularly difficult by the inability of Rural Research Funds to meet the rising cost of research. Therefore it has been necessary for CSIRO to redeploy
some staff out of the Rural Industry Research activity. This is a problem which the Government has recognised and has taken into account in its decision following the report of the Industries Assistance Commission into the funding of rural research.

Lowering staff ceilings reduces the degree of flexibility CSIRO would otherwise have in selecting those research activities which should be expanded. In formulating the present Budget it has been necessary for the Government to pay particular attention to this, and it is essential for these problems to be clearly borne in mind in the future. For only by so doing can we preserve the valuable investment this country has in scientific manpower and attempt to maintain the high degree of resource flexibility necessary to initiate and expand research in areas of national importance. — CSIRO News Release.

Australian Support for Space Probe

The Minister of Science, Senator Webster, has announced that the Honeysuckle Creek and Tidbinbilla space tracking stations near Canberra will play a major communications role in support of the two Voyager spacecraft in their extensive reconnaissance of the outer planets.

The two tracking stations, which are managed for NASA by the Department of Science, are being equipped with new computer-based data processing and monitoring equipment to handle communications with the Voyager and future planetary explorer spacecraft.

The new equipment, which has up to ten times the capacity of the old equipment, has already been installed at Honeysuckle Creek and is in the process of being installed at Tidbinbilla.

The two Voyager spacecraft's decade-long mission will take them to as many as 15 major heavenly bodies, including Jupiter and the ringed planet Saturn, several moons of both planets, and possibly Uranus.

Honeysuckle Creek will track the spacecraft while they are en route to the planets. During the voyage they will gather information on the electro-magnetic fields and particles in interplanetary space and observe comets, asteroids and stars.

Tidbinbilla will take over the tracking role from Honeysuckle Creek during the planetary encounters as its larger and more sensitive 64 metre antenna will be needed to handle the greatly increased flow of data — especially the television pictures which will be sent back by the spacecraft. — Minister of Science Media Release.

Australia to have Receiving Station for Earth Resources Technology Satellites

The Minister for Science, Senator Webster, has announced that the Government will establish facilities for receiving and processing pictures from the United States LANDSAT earth resources technology satellites.

The facilities, which are estimated to cost $4.2 million, will comprise a satellite tracking and receiving station near Alice Springs and a data processing centre.

From its central location at Alice Springs, which should begin operation towards the end of 1979, the receiving station will be able to obtain high-resolution photographic imagery of every part of the continent.

The minister said the highly detailed photographs will have important applications in fields such as mapping and minerals exploration, estimating crop yields, assessment and management of water resources, management of land resources and the environment generally, and monitoring of floods and bushfires.

Senator Webster said that in the near future, the Department of Science will undertake a detailed study of the need for advanced computer-based facilities for analysing LANDSAT data, in addition to the data processing centre already planned.

The Australian LANDSAT program will be managed by the Department of Science. A contract for operation and maintenance of the tracking and receiving station and data processing centre will be awarded to private industry.

Senator Webster said the project represents an important new initiative by the Government in applying advanced space technology to the exploitation and management of Australia's natural resources.

The LANDSAT earth resources technology satellites are operated by the U.S. National Aeronautics and Space Administration (NASA).

Two LANDSAT satellites are in orbit, a third is scheduled to be launched in late 1977 and additional satellites are in the planning phase.

142 The Australian Physicist, September 1977
Books

Books Received

The following books have been received for review. Space limitations will probably not permit the publication of review or notices of all of them. Would anyone interested in reviewing a particular book communicate with the Book Review Editor, G. A. Bell, National Measurement Laboratory, Chippendale, NSW 2008.


MAGNETIC IONS IN METALS, R. H. Taylor. Taylor and Francis London 1977, V + 118 pp. £6.00


VECTOR FIELDS, J. A. Sherriff. Cambridge University Press 1977, XI + 329 pp. £4.25 (paperback)


AN INTRODUCTION TO REGGE THEORY AND HIGH ENERGY PHYSICS, P. D. B. Collins, Cambridge University Press 1977, XIII + 445 pp. £29.00


EUROPE'S GIANT ACCELERATOR, M. Goldsmith and E Shaw. Taylor and Francis 1977, X + 261 pp. £35.00


Book Reviews


Reviewed by A. F. Collings, CSIRO National Measurement Laboratory

This volume conforms to the excellent standards, both in scientific content and presentation, set by the earlier volumes in the series. It consists of four contributions: 'Scaling, Universality and Operator Algebras' by Kadanoff, 'Generalized Landau Theories' by Luban, 'Neutron Scattering and Spatial Correlation near the Critical Point' by A.Nielsen and the lengthy 'Mode Coupling and Critical Dynamics' by Kawasaki.

The article by Kadanoff is an admirable succinct, albeit somewhat personal, view of critical phenomena and a very readable introduction to the concepts underlying the renormalization group approach. All but the hardy will find Luban's discussion of the Landau Hamiltonian and the associated theory of phase transition heavy fare. Mode-mode coupling has provided an explanation of time-dependent critical phenomena which successfully bridges the hydrodynamic and microscopic regimes. Such a thorough and readable treatment as provided here by Kawasaki is long overdue and sufficient justification by itself for Volume 5A.

Since these three articles deal with theoretical concepts that by A.Nielsen, which is essentially concerned with matching current theory with experiment, would be more appropriate in Vol. 5B. The editors have, however, suggested that Vols. 5A and 5B be regarded as a single entity. This presupposes that neither has an individual market and that they will form part of a library set. Mixing theoretical and experimental articles makes this probable.


Reviewed by P. E. Ciddor, National Measurement Laboratory

This book contains the lectures given in (English) at an International School of Applied Physics in Erice, Italy, in June 1970. The text has been reproduced directly from the lecture notes, which varied from letterpress to typescript with free-hand diagrams and formulas. It is therefore inexplicable that production of the book should have taken six years. The result of the delay is a lack of topicality in many of the lectures, because laser physics is a rapidly advancing field. The Australian reader will find some of the Italian typographical conventions disturbingly unfamiliar, and some of the English rather quaint.

Within these limitations, the book is a fairly clear survey of the principles of most types of lasers, and of applications ranging over holography, communications, machining, surgery, atmospheric scattering, and plasma physics. The contributors are well known, and include Arcetri, Kaiser, Roess, Roachi, Siegmund, Sona and Tordal of Fabio.


Reviewed by J. Middlehurst, CSIRO Division of Food Research, North Ryde.

This is volume 12 of an excellent engineering series and is of the same high standard as previous volumes. The purpose of the series is to present review articles of monographs on special topics of current interest. The articles in the series always start with fundamentals but proceed fairly quickly to the engineering aspects of the subject.

The four topics in this volume are: "Dry Cooling Towers" by F. K. Moore, "Heat Transfer in Flows with Drag Reduction" by Y. Dimant and M. Poreh, "Molecular Gas Bond Radiation" by D. K. Edwards, and "A Perspective of Electromechanical Transport Phenomena" by A. S. Roy.

The first author pleads the case for abandoning the water cooling towers, used by large power generating stations, with their cloud-like plumes and horizon-decorating shapes. He prefers very large fans of lower height but much greater noise level and somewhat higher cost.

Flow with drag reduction refers to the effects of very small quantities of, e.g. poly(ethylene oxide) on flow regimes. The authors put forward a phenomenological but nonetheless new and exciting theory that describes the turbulent flow regime. They have not had to invoke constant shear stress or restrict themselves to constant flux conditions to solve the equations or to predict the Stanton number. Using this they have been able to show that the apparently widely varied results reported in the literature can be made to coincide by allowing for the variable fluid properties and the effect of the entrance region.

D. K. Edwards first sets himself the task of showing how to make a nongrey radiation heat analysis for molecular gases with infrared vibrational-rotational bands where the gas is in thermodynamic equilibrium. He then carries on to the nonequilibrium case for certain simple but practical geometries relevant to furnaces and boilers.

In the last paper, the aim is to formulate a simplified yet adequate model of electrochemical transport compatible with the practical model of mass transport usually used to solve engineering problems. The effects of the ions on the various diffusivities and the need to introduce additional mobility terms into the commonly used equations are emphasized. It is shown that a full thermodynamic treatment requires much more detailed knowledge of chemical potentials and activities before it can yield useful results, whereas the author's approach, based on concentration gradients yields practical answers rapidly and is formally related to the equations for the potential gradients.

The book is clearly intended for engineers but any physicist in industry who has to deal with any of the subjects covered in the book must certainly borrow it.

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

The authors of this book, one of the Cambridge Monographs on Physics series, have managed to provide a quite readable account of the basic symmetry principles of elementary particle physics and their associated conservation laws. They have accomplished this by avoiding esoteric mathematics and complicated notations and by omitting descriptions of the methods by which the experimental results used to illustrate the theory were obtained.

The first two chapters contain very brief summaries of the prerequisite particle physics and quantum mechanics. These are followed by longer chapters on angular momentum, Lorentz invariance, parity, time reversal, charge independence, charge conjugation and C-parity. The higher symmetries SU(3) and SU(6) and their relation to the quark model are discussed in the final two chapters. Four appendices give additional information about cross sections, transition probabilities and polarisation density matrices and the phase conventions and Clebsch-Gordan coefficients for SU(3). There is also an extensive list of references at the end of the book.

I feel that postgraduate students and newcomers to the field would find this a useful book; since quantum field theory is not used, it would also be a suitable text for fourth year courses to both experimentalists and theoreticians at Australian universities.


Reviewed by B. H. J. McKellar, Physics Department, University of Melbourne.

The title of this books is somewhat misleading, wide areas of contemporary physics being unrepresented. Perhaps "Contemporary Mathematics in Physics" would have been better, but still the applications of contemporary differential topology and group theory are not included, the book being restricted to the applications of modern functional analysis in physics.

This is an area in which the cross fertilisation between physics and mathematics has always been strong, and some of the ablest practitioners have contributed both to the mathematics and the physics. Today such people as Simon and Nelson carry on this tradition of Weyl and von Neumann.

This book records the courses given at a symposium in 1971, and is by now somewhat dated, missing out the recent substantial developments in constructive Euclidean field theory. It does however provide an outline of the modern mathematical tools: Functional Analysis and operator algebras and their application to constructive field theory, representations of commutation relations and statistical mechanics. The introductory lecture by Haag is a particularly valuable survey.

Unfortunately none of the chapters (or lectures) is in enough detail to be pedagogically useful to a student, who would be forced to turn to the references provided. This brevity is carried to the ultimate absurdity in Hepp's chapter on scattering theory which contains only the references.

I would recommend the book to physics and mathematics libraries to show physicists brought up on Whittaker and Watson that useful physical results can be obtained from "modern mathematics", and to show mathematicians that physics can still provide the intuitive framework for developing new results in mathematics. If it manages to convince even a few traditionalists on both sides that the symbiotic relationship between physics and mathematics at the forefront of each is not dead it will have served a very useful purpose.


Reviewed by E. T. Inacoe

This attractively lucid and broad survey of an important aspect of heat and mass transfer in fluids will particularly interest graduates of applied physics, aerodynamics, chemical engineering, and hydraulic engineering. Also there is a brief section related to atmospheric and oceanic turbulence. These six chapters by different well-known authors are well integrated, after a useful introduction by the editor. The varied authorship provides up-to-date expertise throughout the field and references are numerous, though quoted in an unhelpfully cryptic style. The price is appalling, of course, but that's a general complaint nowadays.

Letters

Dear Sir,

With regard to the paragraph "Nonionized Media Symposium Visit" in "People and Institutions" of the July edition of The Australian Physicist unfortunately lines were omitted. The second sentence should have read:

"He presented a paper entitled 'Precision VLF phase measurements for delineation of subsurface conductivity perturbations' and also read a paper for Professor J. F. Ward (James Cook University) entitled 'Phas shift gradient determination of high precision for VLF field investigation above sub-surface strata'."

I am indebted to Professor Ward for some financial assistance for the trip and so would appreciate this correction being drawn to the attention of your readers.

David V. Thiel
School of Science,
Griffith University, Queensland

Dear Sir,

Last January our President's Column spoke highly of a book called The Flying Circus of Physics by Pearl Walker. A copy has just passed through my hands.

I would be more than reluctant to recommend it. It is written in that peculiar condescending style the American adopts towards teenagers, for whom the book is obviously intended. Some of the problems are trivial, but the general standard is pretty high.

There are no answers.

References are given and quite a proportion are definitely obscure. The book is therefore of no value unless the reader has ready access to a very good reference library. Some problems have no references and there is at least one which carries the statement that the answer is secret because it exists in a private communication.

It might be of interest to a teacher looking for a subject matter, but I doubt whether it is suitable for the teenager to whom it is addressed. In particular I do not like the experiment in which the teenager is urged to short out an electric light fitting in order to enjoy the resulting bang.

Dr. H. H. Macey,
10 Kinrose Crescent,
Floreat Park, W.A. 6014
FIFTH INTERNATIONAL CONFERENCE
GAS DISCHARGES
UNITED KINGDOM
11-15 September 1978
UNIVERSITY OF LIVERPOOL

Organised by the Science, Education and Management Division of the Institution of Electrical Engineers in association with the Institute of Physics and the Institution of Electronic and Radio Engineers.

SCOPE: The Conference will cover the engineering applications of gas discharges and relevant fundamental processes such as:—

APPLICATIONS:
- Arc furnaces
- Compress-gas insulation
- Display devices
- Fuses
- Gas-blast switchgear
- Gas-discharge lasers
- Gas-filled valves
- High-voltage technology
- Lamps
- Vacuum switches
- Welding, cutting and machining

FUNDAMENTALS:
- Corona
- Electrode-less and radio-frequency discharges
- Electrode phenomena
- Glow discharges
- High and low pressure sparks
- Laser produced plasmas
- Lightning
- Long sparks
- Plasma diagnostics and measurement techniques
- Pre-breakdown phenomena
- Radiation from discharges
- Spectroscopy
- Transient and steady-state phenomena in high and low-pressure arcs

Contributions on discharge chemistry, MHD generation and fusion are not invited.

It is intended to arrange a number of review lectures on various topics.

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