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THE AUSTRALIAN PHYSICIST
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REPRINTS - can be printed separately without extraneous
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$20 per page for 100 copies).

SUBSCRIPTIONS
Non-Members: $30.00 per annum (Australia), $40.00 per annum (Overseas).
Single Issues: $3.00 (Australia), $4.00 (Overseas).
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FRONT COVER
This photon collection unit has been designed to pick up the
very feeble flashes of Cherenkov light, when an electron is
knocked on in the tank of water. It consists of a phosphor plate coupled optically to a wavelength shifting panel of dimensions 70cm x 70cm. The whole assembly is enclosed in a watertight container of perspex. 54 of these units are being currently produced to make up the first detector module for the School of Physics, University of Sydney.

President's column

Two years ago when I was writing my first column, I reflected on the recent changes that had taken place in the role of the AIP in the science policy area. At that time, the Minister for Science, Barry Jones, was a lone voice crying in the science and technology wilderness.

Since then there have been dramatic changes in both the Federal Government's and State Governments' perceptions of the importance of science and technology for the future economic survival of the Australian economy. Coupled with this has come the realisation of the significance of a scientifically educated workforce. As recently as early 1985, representatives of the Federal Government expressed disagreement with the OECD examiners' claim that Australia faced a shortage of scientifically skilled personnel. This is no longer the case.

The statistics collected by the AIP, particularly in respect to the employment and rates of graduation and enrolment of physicists have been a significant factor in convincing government and the media of the crisis faced in the Australian workforce.

At the end of last year I attended the conference 'Policies and Directions for Science and Research' that was jointly sponsored by the Department of Science and the OECD's Committee on Science and Technology Policy. This was the first occasion that such a major OECD meeting had been held in Australia. Its purpose was to serve as a preliminary to the 'Ministerial Level' meeting to be held later this year.

Much of the discussion was centred on the harnessing of scientific research for economic and social benefit and encompassed a wide range of issues concerned with the direction of research, its evaluation, the role of government in targeting specific research areas and many more. What was remarkable, given the quite disparate levels of activity and funding across the countries represented, was the degree of accord in attitudes. Indeed, it was suggested that this 'convergent thinking' or 'herd mentality' might be a matter for concern.

I was struck by the number of physicists amongst the some eighty attendees. I was also amused to hear repeated references to the flexibility of physicists and their ability as prime manipulators of any system. One of the keynote speakers, an ex-physicist-cum-sociologist, was moved to refer to his First Law, There is no system of review that a physicist will not have optimised before the next funding review cycle.

I believe that the AIP can be justifiably proud of the leading role it has played in the science policy debate that has developed here in recent years. I have been privileged to have the opportunity to represent the physics community during my tenure as President of the Institute. I wish to thank all the members of the Executive and Council who have been so supportive with their hard work and encouragement.

T.F. Smith

The statements made and the opinions expressed in the Australian Physicist do not necessarily reflect the views of the Australian Institute of Physics, its Council or Committee.
Editorial

If you took The Australian Physicist out of its plastic envelope last month and looked at it, you may have noticed various changes in the typesetting and the lay-out of the magazine. These were the result of a minor typesetting revolution, some of the changes were deliberate, but others were unintentional by products! The fact is that we have started to type-set the magazine by ourselves on an Apple Mac Plus computer with the software program 'Ready, Set, Go' Version 3. While it is easy to sum up the revolution in one sentence, it turned out to be one hell of a job.

The Editorial Committee had been discussing the possibility of using a computerised system for typesetting for some time, but none of us really knew how to put this into practice. Because of possible problems I realised that the only chance to make this change relatively smoothly would be during the summer vacation, when we were to enjoy one month's rest from publication. I started making enquiries at the beginning of December and was led up the garden path by a well meaning friend thus losing valuable time. Also, I must sadly report that some of my physics colleagues, (not members of the Editorial Committee) who have both the correct equipment and knowledge, were forthcoming with advice but no help. In a small physics community such as ours, all poverty stricken with small budgets, that is hardly a good way to make progress! I was just about to give the whole idea away, when a very generous member of the Q.E. 2 Medical Centre, Dr E.J. Keogh, Medical Director, Reproductive Medicine Research Institute, offered us the use of his Apple Mac Plus free of charge. It is good to know that some generous people exist in the community. He also introduced me to his friend Mr Philip Boswell, Director, Edcom Computer Services who turned out to be a true friend. He shepherded us, myself and two other newcomers, through the first issue. The others, a full-time Photography student, Alison Yates, who is keen to learn typesetting and editing, and a playwright, Steven Deadman, who needs a little more cash flow, undertook the arduous task of typing the manuscript. Like most computer manuals 'Ready, Set, Go' is written in computerese, a computer language which you can only understand after you, yourself, have figured out what you should have been doing in the first place. Furthermore Tab did not function properly, which explains some of the wiggly lines in the printed version, lines which had looked perfectly straight on the video terminal. The software has now been upgraded and the first two pages should be much improved.

'Ready, Set, Go' is a very interesting program. It allows you to set up your page design in advance, i.e. size of columns, headings etc. and then type the manuscript directly into the desired space. It requires less memory than Pagemaker and costs considerably less but it is not that easy to learn. Now that we have experienced some of the pitfalls, we hope that you will find this next issue greatly improved. I must apologise for the spelling mistakes, which hopefully will not appear in this issue. We have set up a file of master pages which should make the appearance of this issue more consistent throughout and we are now tackling the problems of superscripts, subscripts and mathematical equations.

Furthermore I have never been aware that The Australian Physicist had not published on A4 size paper, as we had inherited the page size from the previous editor without question. We have now taken this format on board. It will add 1cm per page and have made the columns wider - they are now 8.5cm wide - we have probably gained a whole page per issue without extra cost.

We also hope to be able to reduce spelling mistakes permanently (!), improve layout, and reduce pressure on the editor, although the first issue was an enormous amount of work. We have been able to reduce the deadline for writing advertising to the 20th day of each month for publication in the first week of the following month. Advertisers please note that the longest delay is now caused by the very slow handling of the presorted mail by the postal service. This is a very uncompetitive service and it may be that we can obtain some improvement.

The greatest advantage will arise, when you, the contributor, send your manuscript together with an electronic copy on an Apple computer disk, as any file can immediately be transferred into our program. We are also hoping to be able to accept disk files from other computers shortly. This will eliminate costly typesetting and spelling mistakes. In due course we will have a modem connected to our computer. Then you will be able to send your file via the telephone and the typed copy via Fax; the whole operation should only take a few minutes. I think that we have truly arrived in 1987.

Editorial Committee. We have been very fortunate to have gained the help of Geoff Davies, who is himself the editor of the Bulletin of the Astronomical Society of W.A. He trained as an Electrical Engineer but gave that away when he discovered Astronautics. He started the Astronomical Society of W.A. and its News Bulletin in 1973 and after a brief retirement from the Committee is now back as Chairman and Editor. We have been very happy with the excellent proof reading support from Birgit Lohmann. She is a lecturer in Physics at Murdoch University. Birgit obtained her B.Sc (Hons) from the University of Adelaide and her Ph.D from The Flinders University of South Australia.

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The Search for Solar Neutrinos
Associate Professor L.S. Peak, Falkiner High Energy Physics Department, University of Sydney.

Talk presented to A.I.P. National Congress, August 1986.

1. The Solar Neutrino Problem
Most scientists would be well aware of the so-called "Solar Neutrino Problem". It could be summarised succinctly by the statement that experiment seems to see far fewer solar neutrinos than are predicted by the standard model of the heating of the interior of the Sun.

Table 1 summarises these predictions which essentially consist of a large flux ($6 \times 10^{10}$ cm$^{-2}$ s$^{-1}$) of low energy ($\leq 1$ MeV) neutrinos, accompanied by a much smaller component ($\approx 10^{9}$ cm$^{-2}$ s$^{-1}$) of higher energy neutrinos ($0 - 14$ MeV) associated with the decay of $^8$B. Whilst the low energy component is almost independent of the model of the Sun invoked, the high energy component is highly dependent upon the interior conditions assumed for the Sun. In addition to the above, there is also a small component expected from the CNO cycle making a total expected capture rate in $^{37}$Cl of $5.8$ SNU. A solar neutrino unit (SNU) corresponds to a capture rate of one per second in a target of $10^{36}$ atoms.

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>ENERGY (MeV)</th>
<th>FLUX ($10^8$ cm$^{-2}$ s$^{-1}$)</th>
<th>$\sigma$ (10$^{-48}$ cm$^2$)</th>
<th>$\varphi_{^37Cl}$ SNU</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p+e^-\rightarrow\nu_e$</td>
<td>0.0-0.4</td>
<td>60,000</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>$pep$</td>
<td>1.4</td>
<td>150</td>
<td>167</td>
<td>0.24</td>
</tr>
<tr>
<td>$^8B$</td>
<td>0.4-0.9</td>
<td>4,000</td>
<td>88</td>
<td>0.95</td>
</tr>
<tr>
<td>$^7B$</td>
<td>0.14</td>
<td>4</td>
<td>2,100</td>
<td>4.3</td>
</tr>
<tr>
<td>$^{13}$N</td>
<td>0.0-1</td>
<td>500</td>
<td>57</td>
<td>0.08</td>
</tr>
<tr>
<td>$^{36}$S</td>
<td>0.2-2</td>
<td>400</td>
<td>99</td>
<td>0.24</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>5.8 SNU</strong></td>
</tr>
</tbody>
</table>

Table 1. Predicted fluxes of neutrinos together with cross-sections and capture rates in chlorine for the "standard model" of energy generation in the Sun's interior.

The well known experiment of Davis and his collaborators first started taking data around 1970 and has only recently been discontinued. Using a large tank (615 tonnes) of $^3$Cl$_4$ buried in the Homestake Mine of South Dakota, the flux of electron neutrinos has been estimated above a threshold of 0.81 MeV. The result for the capture rate in chlorine is $2.0 \pm 0.3$ SNU, and this represents mostly an assessment of the $^8$B neutrinos because of the high cross-section to form an isobaric analogue state of argon with excitation energy about 5 MeV.

It should be emphasised that this experiment of Davis is of the inverse beta type, relying on the reaction

$$\nu_e + ^{37}\text{Cl} \rightarrow ^{37}\text{Ar} + e^-$$

(i.e. $\nu_e$ + neutron $\rightarrow e^- +$ proton)

for the detection of the incident neutrino. This technique is only sensitive to electron neutrinos and any information about the direction of the incoming neutrino is lost.

2. Possible Resolutions of the Problem
There are logically only three ways to resolve the solar neutrino issue. Either one modifies the model of the Sun (thus altering its predicted flux), or one invokes some loss mechanism for the neutrinos in transit between the Sun and Earth, or one postulates that the Davis experiment was insensitive to the incoming neutrinos for some reason.

2a. Source Effects
There has been a large number of modifications to the standard model over the years.

One class of such modifications (which we could class almost as "conventional") includes such variants as a rotating core, a large magnetic field or a proportion of heavy elements in the centre with far lighter elements seen on the surface. The main aim of all these variations is to reduce the core temperature slightly without affecting the hydrostatic equilibrium.

There is another class of models, which dispenses with the need for equilibrium and asserts that the Sun might be in a changing state. The extreme case here would be the situation where the inner region is now extinct (and we have not noticed it yet because of the million years or so that it takes radiant energy to diffuse to the outside).

Finally we have the extreme or "far fetched" solutions which include postulating WIMPS, black holes or quark catalysis at the centre.

2b. Transit Effects
For many years, scientists have considered the possibility that neutrinos might oscillate between species - this explains the loss of electron neutrinos and the Davis result.

In this regard, there has been a recent highlighting of the issue of matter oscillations, first proposed by Wolfenstein in 1973 and recently reconsidered by Mikheyev, Smirnov and Betehe. It is now called the "MSW Effect" and could have significant bearing on the mix of neutrinos emerging from the Sun.

Restricting ourselves to two types of neutrino for simplicity, the possibility of oscillations between these types emerges if we differentiate between the weak eigenstates ($\nu_e$ and $\nu_\mu$) and the mass eigenstates ($\nu_1$ and $\nu_2$).

In a vacuum then we can write

$$
\begin{bmatrix}
\nu_e \\
\nu_\mu
\end{bmatrix} =
\begin{bmatrix}
\cos \theta & \sin \theta \\
-\sin \theta & \cos \theta
\end{bmatrix}
\begin{bmatrix}
\nu_1 \\
\nu_2
\end{bmatrix}
$$

and the probability of an electron neutrino surviving as an electron neutrino oscillates.

\[
P(\nu_e \rightarrow \nu_e, t) = 1 - \frac{1}{2}\sin^22\theta \left[1 - \cos(E_Z - E_L)t\right]
\]

\[
= 1 - \frac{1}{2}\sin^22\theta \left[1 - \cos 2\pi \cdot \frac{R}{L_v}\right]
\]

\[
= 1 - \sin^22\theta \sin^2\left(\frac{\pi R}{L_v}\right)
\]

where the vacuum oscillation length is given by

\[
L_v = 2\pi \frac{2E_v}{\Delta m^2}
\]

and $R = $ distance traversed by the neutrino beam.

In matter, this oscillation is modified as the $\nu_e$ and $\nu_\mu$ will
scatter forward coherently with different amplitudes. For the electron neutrino, both charged and neutral current reactions can occur - whilst for $\nu_L^+$, only the neutral current channel is available, as is summarised in Figure 1.

FORWARD COHERENT SCATTERING AMPLITUDE FOR ELECTRON NEUTRINOS

FORWARD COHERENT SCATTERING AMPLITUDE FOR MUON NEUTRINOS.

Figure 1. Difference between forward scattering amplitudes for electron and muon neutrinos.

For neutrino oscillations in matter, one arrives at a similar expression written in terms of a matter mixing angle ($\theta_m$) and a matter oscillation length ($L_m$).

Now we have

$$P(\nu_e \rightarrow \nu_e, t) = 1 - \sin^2 2\theta_m \cdot \sin^2 \left( \frac{\pi R}{L_m} \right)$$

with

$$\sin^2 2\theta_m = \frac{\sin^2 2\theta_{L_m}}{\sin^2 2\theta_{L_o} + \left[ \cos 2\theta_{L_o} - \frac{L_v}{L_o} \right]^2}$$

and

$$L_m = \frac{L_v}{\sin^2 2\theta_{L_o} + \left[ \cos 2\theta_{L_o} - \frac{L_v}{L_o} \right]^2}$$

$L_o$ is an eigenlength depending upon the electron density ($N_o$) of the traversed matter

$$L_o = \frac{2\pi}{\sqrt{2} G_F \cdot N_e}$$

For low densities ($L_v \ll L_o$) we have $\theta_m = \theta_{L_o}$ and the situation is unchanged from the vacuum case.

For high densities ($L_v \gg L_o$) we have suppression of the oscillations.

For intermediate densities ($L_v = L_o \cdot \cos 2\theta_{L_o}$) we have $\sin^2 2\theta_m = 1$ and we have resonant amplification of the oscillations.

We can imagine the term $1 - \sin^2 2\theta_m \sin^2 (\pi R/L_m)$ as a suppression factor which can modulate the solar neutrino output - thus reducing the output of some of the electron neutrinos.

Figure 2 shows this suppression factor for normal solar conditions plotted for three values of $\sin^2 2\theta$ as a function of $\nu/\Delta m^2$ in MeV$^{-1}$.

![Graph showing suppression factor for solar neutrinos](image)

Figure 2. Suppression factor for electron neutrinos emerging from the Sun as predicted by the MSW effect.

We can note two things about this effect:

a) It can be instrumental in suppressing either the low energy component or the high energy component, depending upon the choice of parameters.

b) To be relevant to the solar neutrino issue at all, one requires not only $\theta_{L_v}$ to be extremely small (of the order of $10^{-4}$ to $10^{-3}$) but also $\Delta m^2$. If we want the region $\nu/\Delta m^2 = 10^{-5}$ to correspond to $L_v = 1$ MeV we need $\Delta m^2 = 10^{-6}$.

Mass differences as small as this are required if this effect is to explain the missing solar neutrinos.

It is evident from the above that many different solar neutrino experiments are required to examine the different species of neutrino in the different energy regions before we can draw a definite conclusion about the solar neutrino problem, and before we are forced to modify the standard model of the Sun's operation.

2c Detector Effects

The remaining possibility is that the Davis experiment was in some way blind to the incident flux of electron neutrinos. This seems hard to imagine in view of the many careful and detailed tests performed by Davis and his collaborators to demonstrate the viability of their extraction technique.

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constructed as a solar neutrino detector and no directional information is possible.

**Baksan**

This laboratory is located in the USSR in the Caucasus under Mt. Anderchi. It has an overburden of \(\approx 2000\) meters and is accessed by a 4km horizontal drive shaft. The plan is to use 60 tonnes of gallium metal as target and search for the reaction

\[ \nu_e + ^{71}\text{Ga} \rightarrow ^{71}\text{Ge} + e^- \]

This reaction has an extremely low threshold (233 keV) and a very high capture rate (\(\approx 100\text{SNU}\)). The experiment is due to commence running in 1988.

**Gallex**

This experiment also plans to use gallium as a target; however, this collaboration will use 30 tonnes of gallium in solution (GaCl\(_3\)). It is being assembled by groups from West Germany, France, Italy and Israel in the Gran Sasso tunnel at a depth of 1300 m.

The group has already provided impressive demonstrations of the viability of their germanium extraction technique and hopes to have it running by 1990.

**Sudbury**

A consortium of American and Canadian universities are putting together a proposal to mount a heavy water Cherenkov detector in the Sudbury nickel mine in Canada. It proposes to use 1000 tonnes of reactor grade heavy water housed in an acrylic tank and shielded all around by about 5 meters of light water and concrete. The Cherenkov light is to

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NEUTRINOS

be detected by \( \approx 2400 \) phototubes immersed into the light water. The overall dimensions are not too dissimilar to those of Kamioka (cavity size 20m diameter, 20m high).

The experiment would detect neutrinos not only via inverse beta reactions but also via the elastic scattering and deuteron disintegration channels giving a total predicted neutrino interaction rate of \( 13 \pm 2 \) per day with a background of about 5 per day.

It appears as if radioactive contamination from tritium will be a problem unless ultra pure heavy water (\( \leq 1 \mu Ci/kg^2 \)) is used.

This multi-million dollar project is due to be presented as a formal proposal this year (1987). Preliminary feasibility studies are continuing.

We now proceed to a brief description of the Sydney experimental effort to establish Australia's own solar neutrino laboratory at Broken Hill.

4. The Sydney Experiment

Figure 3 shows a schematic diagram of the first Sydney water Cherenkov module, currently being installed in the mine complex of North Broken Hill Ltd. at a depth of 1230m. It consists of a cylindrical fiberglass tank holding some 27 tonnes of water. This water is to be constantly treated by a four stage filtration system, an ultraviolet steriliser and a de-ioniser. The water will also be chilled to something like \( 5 \times 10^{-3} \) to reduce biological growth and photomultiplier noise.

![Figure 3. Schematic diagram of the first module of the Sydney solar neutrino detector currently being installed at Broken Hill.](image)

Into this tank is inserted a cubical frame defining 10 tonnes as the inner fiducial volume. This frame will contain 54 photon collection units (consisting of a 7 inch photomultiplier optically coupled to a \( 0.7 \times 0.7 m^2 \) wavelength shifting panel in a waterright unit). Each face of the cube will have 9 of these units looking inwards to detect the Cherenkov signal from the neutrino scatters. The entire system is to be shielded by some 30cm of lead in all directions to reduce the contribution of background gammas from the surrounding ore body.

The photon collection units are now being mass produced and the tank and water circulation system are currently being installed.

It is hoped that we will be able to take preliminary data (without the lead) sometime this year - and that the fully shielded configuration will be operative in early 1988. This first module will enable us to test the viability of our design in regard to the efficiency of photon collection and background rejection. Should this be satisfactorily, we plan to extend the experiment to its final size of some 100-250 tonnes contained in about 10 similar modules.

The main features of this design are its modular construction of small dimensions and wavelength shifting panels allowing for the reasonably efficient collection of the emitted ultraviolet photons (which dominate the Cherenkov spectrum). The lead shielding allows the whole experiment to be located in an underground chamber of reasonable proportions.

Figure 4 shows the expected performance of the Sydney detector (in its final size of \( \approx 100 \) tonnes). In one year of operation we should be able to test the standard model flux by a means independent to that of Davis, whilst in three years we should be able to attain the Davis flux of \( 2 \times 10^{3} \) cm\(^{-2}\)s\(^{-1}\) at the 2 standard deviation level.

![Figure 4. Expected significance level of the Sydney solar neutrino flux measurement for a 100 tonne water target.](image)

5. Conclusion

It is clear that all attempts to measure solar neutrinos will be long term and difficult. It is also clear that the measurement represents one of the most important astrophysical measurements that needs to be performed - as our understanding of the energy generation of stars in general depends upon the resolution of the solar neutrino problem.

It is for this reason that we can look forward to some exciting results in the next few years, as these new experiments (which are now many and varied) are launched onto the scientific scene.

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Quark Effects in Nuclear Structure
A. Watt, School of Physics, The University of Melbourne.
On leave from: Department of Physics and Astronomy, University of Glasgow.

Talk presented to the A.I.P. National Congress, August 1986

Abstract
Some experimental data in nuclear structure physics cannot be explained on the assumption that nuclei consist of inert protons and neutrons. The quark model attributes a definite internal structure to nucleons and implies that their properties should change when embedded in a nucleus. This article reviews some of the experimental evidence for these effects and discusses some new aspects of nuclear structure predicted by the quark model.

Introduction
Protons and neutrons are the main constituents of the nucleus and the observed properties of the nucleus are described by a number of models in which the nucleons are considered at various levels of significance. Collective models ignore nucleons entirely and describe overall changes in shape and density. Microscopic models do recognize the existence of nucleons which are usually thought of as moving in well-defined orbits. The interactions between nucleons used in these studies are derived from the behaviour of nucleons in free space. They are attractive at long range due to pion exchange and strongly repulsive at short range. One consequence of the short range components is that a nucleon should occasionally acquire a very high momentum, but this has never been conclusively demonstrated in spite of several experimental searches. These models assume that nucleons are rigid, inert, structureless particles.

The quark model presents quite a different picture of the nucleon. It is made up of three quarks surrounded by a diffuse cloud of quark-antiquark pairs which correspond to mesons in free space. Properties of the nucleon such as mass, spin, charge and radius are determined by the intrinsic properties of the quarks and the ways in which they are bound together by gluons. Quarks are fermions with many of the familiar properties of nucleons such as spin and flavour, analogous to isospin. In addition quarks have a colour quantum number which is required to satisfy the Pauli exclusion principle. But the most significant aspect of the quark model for nuclear structure physics is simply that nucleons themselves are composite objects which can be deformed or excited into other quantum states, and which can merge with each other to form new structures in much the same way as atoms join up to form molecules.

When we combine these ideas, we get a picture of quark clusters rushing around inside the confines of the nuclear volume. Since the radius of a nucleon is about 0.8 fm and their average separation in a nucleus is about 2 fm, there will be very few nucleons which do not overlap with others. Not only that, but a meson has a radius of about 0.6 fm, so there are no spaces large enough to squeeze in mesons without encroaching on a nucleon. We therefore expect that the properties of nucleons in the interior of a nucleus and their interactions via meson exchange will be rather different from those in free space.

Why then is this not abundantly evident in the huge quantity of nuclear data in the literature? Why do traditional nuclear models work at all? The explanation is that practically all of traditional nuclear physics takes place on the outside of the nucleus. Energy level schemes, beta decay, electromagnetic transitions and most scattering processes involve only particles on the nuclear surface where densities are low and the nucleons behave as if they are essentially free. Those experiments which do probe the nuclear interior are usually sensitive only to average properties. Low energy electron scattering for instance measures the average charge density which could originate from a uniform quark soup, or from protons or indeed from a uniformly charged structureless core. Having said that, there do now exist a few crucial studies of the nuclear interior which have produced results at variance with what one expects from the structureless nucleon picture.

Key results on the interior of the nucleus
Electrons and muons do not interact with nucleons via the strong interaction. Consequently they reach all parts of the nucleus and can be used to study the interior. Electron scattering experiments have mapped out the charge densities of many nuclei to a very high accuracy indeed. The nucleus $^3$He is a crucial example in this context not just because the data is good, but because definitive calculations are possible. Friar et al. [1981] assumed a nucleon model, so that they had to solve a three-body problem. This can be done using special techniques which do not apply in heavier systems. The interaction they used was the Reid soft core potential which gives extremely good results for a wide range of nuclear properties. With this combination of nuclear force and computational techniques, their results are final and no future work on $^3$He within the nucleon model will alter their conclusions. They found that they could not reproduce the observed central dip in the charge density of $^3$He. We are therefore forced to conclude that the nucleon model fails in this case. It is not yet clear that the quark model gives the correct charge density because calculations are very difficult, but results to date are certainly encouraging.

The EMC effect is another result of great significance. The European Muon Collaboration [1981] measured the form factors (Fourier transforms of charge densities) of nucleons in $^{56}$Fe and in deuterium. They found that the results are significantly different. Deuterium consists of one neutron and one proton separated on average by 4 fm, so the nucleons are essentially free, whereas $^{56}$Fe has a large dense core. The experimental results have subsequently been confirmed by electron scattering and demonstrate that closely packed nucleons are not the same as the free variety. This is contrary to the rigid-nucleon school of thought, but is a natural consequence of the quark model in which one would expect the size and shape of a nucleon to be affected by the close proximity of others. There are in the literature a number of quark model explanations of the EMC effect which look superficially different but at a deeper level seem to be merely alternative ways of expressing Noble's idea [1981] that tightly bound nucleons are slightly larger than their counterparts in free space.

The Nucleon-nucleon interaction
Two quarks in different nucleons can interact by gluon exchange, and the net effect of all such exchanges will be a resultant interaction between the nucleons. This observation forms the basis of a number of studies of the nucleon-nucleon interaction in an attempt to relate it to the quark model. Early work treated nucleons as bare triplets of quarks and identified...
the nucleon-nucleon potential as the interaction energy between two triplets.

There are a number of gluon exchange potentials on the market and a variety of computational techniques can then be used to calculate the nucleon-nucleon interaction. Consequently different authors get different results [Liberman 1977, Storm 1983, Faessler 1983]. The significant thing is that a general consensus has emerged regarding the qualitative form of the interaction that one gets from this approach. Gluon exchange produces a short range repulsive potential which is much weaker than the traditional hard core. Also at short distances, the two clusters merge into a single six quark system whose quantum state cannot be interpreted as two triplets with the quantum numbers of the nucleon. The nucleon-nucleon part of the wavefunction is very much reduced which is entirely consistent with a short range repulsion in a simple nucleon picture. In both versions the nucleons stay apart but in the quark model the three-quark clusters do not - they change into something else. Consequently the quark model does not predict high momentum nucleons in the nucleus, which is in agreement with experiment but at variance with the hard-nucleon picture.

The most obvious defect in the work referred to above is the lack of any mechanism which can give rise to an attractive potential at large separations. Gluons carry colour and gluon exchange between two well-separated nucleons would produce two coloured objects which would have a very high energy. Long-range interactions must take place by exchange of colourless objects and this means pions or quark-antiquark pairs. Systems of six quarks plus such pairs are not attractive to practitioners in the field because of their complexity, but Fujiiwara and Hecht [1986] have recently addressed themselves to this problem. They do indeed find that quark-antiquark pairs generated by the normal mechanisms of quantum chromodynamics give rise to long range potentials of the familiar form. They are even able to show that their results have the same analytical features as conventional one-boson exchange potentials. This work represents a major advance in our understanding of the nucleon-nucleon interaction in terms of the quark model.

The Pauli exclusion principle

Quarks are fermions and obey the Pauli exclusion principle that no two quarks can exist in the same state with the same quantum numbers. The wavefunctions used to describe nuclei do not satisfy this requirement. The Pauli principle is satisfied for the quarks within an individual nucleon, but it is violated when one considers quarks in different nucleons. The extent of these errors can be investigated by writing down a wavefunction for a nucleus, and finding out how much it changes when the exclusion principle is strictly enforced. The most comprehensive results to date have been published by Takeuchi et al. [1986]. They find that the deuteron wavefunction is altered by about 1% only, but in 4He there is a 20% effect. The large increase comes about because the quark density increases: there are 12 quarks instead of 6 and the nuclear volume is also smaller. These results have a number of important consequences in 4He and for charge densities in particular, but more work is needed before definite conclusions can be reached.

Violations of the Pauli principle are also expected to have significant consequences in hypernuclei. A hypernucleus consists of protons and neutrons with the addition of a strange particle, a Λ or Σ, which consist of one strange quark coupled to two quarks of the same flavours as are found in nucleons.

Conventional studies of hypernuclei treat the Λ or Σ as a species of particle different from protons and neutrons so that the exclusion principle does not influence the behaviour of a Λ or Σ inside a nucleus. At the quark level, this is not correct because quarks of the same flavour occur in all three types. We are therefore led to believe that the possible states of a Λ or Σ in a nucleus will be affected by the Pauli Principle after all.

When one actually calculates the extent of Pauli violations in light hypernuclei containing Λ particles, the effects are found to be insignificant. In the hyperdeuteron, one proton and one Λ, the effect is precisely zero. This comes about because the quark wavefunctions of the proton and Λ happen to conspire to give effects of opposite signs which cancel exactly. Heavier systems do exhibit effects arising from quark exchanges involving three baryons, but these are small. The results imply that the traditional model should work very well indeed.

The situation is quite different in Σ hypernuclei. Here the wavefunctions do not conspire as above and there are strong Pauli violations resulting in significant modifications of the wavefunctions. This may explain the unsolved mystery of unexpectedly low-lived Σ particles in nuclei, but no definite connection has yet been made.

The presence of Λ resonances in nuclei has been invoked to explain several longstanding discrepancies in nuclear physics: problems with the binding energy of nuclear matter and quenched M1 transition rates for example. The Λ is regarded as a species apart from protons and neutrons although all three are built up from the same types of quarks. This give rise to quite complex and rather strong Pauli blocking. For example a Δ++ cannot exist in the same state as a proton if their spins are aligned, since each of them must contain at least one quark with exactly the same quantum numbers of colour, flavour and spin. These considerations have not yet been included in any serious calculations of nuclear properties.

Conclusions

We have highlighted some of the areas of nuclear structure physics where traditional models built on inert billiard-ball like nucleons are not adequate. The quark model tells us that nucleons are composite and implies that their properties should change when packed inside a nucleus. This information is not really at variance with any of the essential assumptions of traditional microscopic nuclear models. It just means that they have their limitations and we cannot expect them to give precise results in regions of high nuclear density. The last five years have been particularly exciting because many new effects have been predicted by the quark model and a lot of work is in progress to investigate them in detail. We should not expect that any of this work will drastically change our perception of the nucleus, but it will provide us with a much more consistent and satisfactory understanding of the fundamental aspects of nuclear structure.

References


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Two Scientific Instruments
Restored
H.C. Bolton, Department of Physics, Monash University.

Recent historical work by the author on optical instruments in Melbourne has brought several artefacts through his hands chiefly from the Department of Physics at the University of Melbourne and the CSIRO Division of Chemical Physics [Bolton]. An historically important instrument, the Shephard micro-ruling engine, made in Melbourne, has been restored in the Monash Physics departmental workshop, photographed and given back to its owner, the Museum of Victoria. The photographs join a small collection on display in the Department of Physics; recent additions have been the photographs of the telescope belonging to Sir John Monash [Bolton, 1985]. An appeal for information about wartime optical equipment in Australia has been reproduced in the British Bulletin of the Scientific Instrument Society [Bolton 1984; 1986]. The department was asked recently if it could examine two scientific instruments. They belonged to Professor W.M. Muntz, the Dean of Science at Monash and both are interesting, not only in their own rights, but also for their associations. Both have been restored in the departmental workshop and their photographs are reproduced here.

Bubble Sextant
Most physicists will be familiar with the conventional marine sextant and, indeed, older physicists may well have had to learn how to use one in their first year laboratory course. The author found "the height of the University Tower at Bristol" by using a marine sextant and triangulation. Recent historical research on sextants is now showing how advances in ruling and scale division were made in the eighteenth century [Moskowitz, 1986; Stimson, 1986]. To get an idea of the accuracy involved it is worth recalling that a quadrant of the earth's surface is about 6250 geographical miles and a minute of arc latitude corresponds to just over a geographical mile which as an error would bring a sailing ship within sight of its haven, if longitude were known. The nautical mile, 6080 feet, was chosen to be exactly equivalent to 1 minute of arc on an assumed spherical earth.

The navigation of aircraft in the early part of the twentieth century posed new problems. The marine sextant needed to have either a visible true horizon or an artificial horizon. But from an aircraft the true horizon may not be visible because of the atmospheric haze. The solution of this problem lay in the use of the bubble sextant until the use of electronic navigational aids. A bubble sextant uses the vertical or more strictly the instantaneous direction of apparent gravity. The bubble is effectively a short period pendulum and responds to the resultant of gravity and the acceleration of the instrument. The aircraft thus had to be given a constant velocity for the navigator to use the bubble sextant as accurately as possible [Glazebrook, 1923]. On a personal note, one of the author's friends from his student days was a navigator on an RAF bomber aircraft in the middle of the 39-45 war and said that he was usually given a minute by the pilot to take his readings.

The present instrument is marked AM Mark IXA 6B/218 No. 6623/43 Brit. Pats. 489112, 490621 and Pending which identifies it from the British Air Ministry, probably 1943, and makes it a late wartime model; we comment on the origin of this design later. Figure 1 shows an outline sketch of the essential features of the sextant. Figure 2 shows the whole sextant looking into the mirrors; the handles and adjusting knobs can be seen on either side. Figure 3 shows the sextant from its right hand side with the angular scales visible. Angles are read to 1 minute of arc and small panels are provided for recording the angles and the time. The sextant was constructed in two halves and Figure 4 shows these halves opened. The illumination of the bubble and of the angular scales was either by two size C dry cells or by a connection through a dropper resistance to the 12 volts supply.

Figure 1. Outline sketch of the Bubble Sextant.

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on the aircraft. The whole instrument has been packaged skilfully and every switch and adjustment lies conveniently under the fingers. The size of the bubble is controlled by adjusting the size of the liquid container with a screw bearing on a diaphragm. On expanding the diaphragm a bubble of vapour is formed. The bubble is illuminated from the side and appears in the field of view as a bright ring against a dark background. The author found that at the beginning it was hard to steady the instrument and to get a star or a planet image centred in this bright ring but several evening’s practice helped.

It has to be remembered that the bubble sextant was designed to be used on a moving aircraft. If two minutes of time were taken to determine the altitude of a star and the north-south speed of the aircraft was 240 geographical mph then the variation in the position of the aircraft with respect to the ground would be 8 miles. This is translated into about 8 minutes of arc and would be readily noted. While following a star the observer would then have to change continuously the altitude recorded on the scale. The way of handling this is to take an average of the angles during the time of the observation. On the present instrument this is done automatically by the averaging clockwork motor which senses the position of the rotatable mirror by a horizontal rod in continuous contact with an arm attached to the mirror. The clockwork mirror is wound by a key on the front of the motor housing and runs for two minutes. When the motor of the present instrument was first run, it was not in adjustment and produced an averaging even if no change was made to the mirror. A simple adjustment of a cog wheel restored this zero setting.

The instrument has a snap ring on its top, for hanging from the Perspex dome in the aircraft. The whole instrument was beautifully made and is a pleasure to handle and use. Its photographs will join the departmental collection.

The bubble sextant was designed as a response to the new field of aircraft navigation and the increasing number of adventurous solo aircraft flights in the 1920’s were making large demands on navigational skills. One of the first civilian pilots to be interested in the technique of air-navigation was Francis Chichester who later made solo voyages in small yachts. Chichester made the second flight (after Bert Hinkler) from England to Australia in 1929 and in 1931 made the first flight from New Zealand to Australia across the Tasman Sea using Norfolk and Lord Howe Islands. The original navigational chart is given in his books [Chichester, 1933; 1934]. Though Chichester had used a bubble sextant in those days he seemed to have more faith in a marine sextant and he relied on sun observations and pre-computed position lines [Chichester, [1933] p.150]. This feat of navigation earned him the Johnson Memorial Trophy for Navigation in 1931. After this flight Chichester flew solo to China and Japan. He was not able to join the RAF as “he was too old and his eyesight was too bad for flying duties”. At the beginning of the 39-45 War he worked for Henry Hughes & Son Ltd whose research engineer, P.H. Everett, designed the Mark IX averaging bubble sextant which became the standard RAF sextant. The present instrument, IXA, must be a later version. Chichester wrote at great length on air-navigation and a list of his articles is given in the Introduction by F.D. Tridgley to his 1945 edition of the Tasman book. One of Chichester’s articles in 1940 was on the Mark IX sextant, but the author has not been able to see this article. He also wrote a three-volume set on astro-navigation [Chichester, 1940]. In volume 1 of this set he thanks P.F. Everett, the designer of the Mark IX, for help in preparation with the books. It is clear that Chichester had accompanied RAF pilots on a series of experimental astro-navigational flights in different types of aircraft. In 1943 he joined the Empire Central Flying School.

Navigation in the Arctic and Antarctic has a similar problem to that for aircraft. “Whiteout” can eliminate the horizon. The most precise and classic way of mapping and of navigation in the Antarctic was by theodolite. A fine example of navigation by bubble sextant was Edmund Hillary’s journey on the three converted Ferguson farm tractors to the South Pole in the Transantarctic Expedition of 1955-1958. Hillary was leader and navigator and explains in his book how he had been a navigator on Catalina aircraft during the 1939-45 war and was familiar with aerial navigation [Hillary, 1961]. He would have liked to have taken a theodolite but one was not available and he used a bubble sextant. He was confident of being able to fix his position to within two miles. On the journey, the sextant developed an unexpected fault; the bubble grew larger as the liquid surrounding it escaped and evaporated and centring the sun’s image became increasingly difficult. Hillary’s skill and leadership enabled his team to be the first to drive vehicles to the South Pole. In the Antarctic season of 1983/84 a bubble sextant was being used for navigation.
HISTORICAL

Figure 5. View of the Original Odhner calculator. The input register carries the number 3.1416; the multiplier register the number 2 and the product register the number 6.2832.

An Odhner Calculator
This is shown in Figure 5. It will have a familiar appearance to older readers who may have done some of their early numerical calculations on one or on the similar Brunsviga machine. Knowing the sturdiness of these early calculators it is no wonder that they are still found, as is this one, in perfect working order. The name Odhner however precedes that of Brunsviga.

There is a long history of calculating aids and machines going back to Napier, Pascal and Leibniz but it seems that the chief difficulty that early machines met was the lack of accuracy in the construction of wheel teeth and it was not until 1820 that the first successful commercial calculator was made by C.X. Thomas of Colmar, Alsace [Enc. Brit. 1947; Glazebrook, 1923]. The Thomas machine was successful but large and clumsy. It is perhaps worth commenting that this tradition of mechanical and electro-mechanical calculators seems to have been independent of the computing engine with which Babbage is associated.

In 1785, F.S. Baldwin patented a machine with a rotating wheel from the periphery of which a variable number of teeth (1 to 9) could protrude. W.T. Odhner in Sweden designed a similar machine about the same time. This latter machine was developed extensively in Germany and sold since 1892 under the name Brunsviga, the Latin name for Braunschweig, the home of the firm. The Odhner wheels allowed the machine to have a very compact design. The wheels fitted closely together on the axle at the back. Each wheel has a setting lever that projects through a slot in the cylindrical portion of the cover plate. This forms the input register. The setting of the lever is the number of teeth projecting from each wheel. Turning the operating handle of the print register makes the wheels mesh with small wheels of the product register which in turn mesh with the number wheels in the right front of the machine. The product register carries a second counter for the multiplier register on the left front of the machine. For addition and multiplication the handle is turned in a clockwise direction and for subtraction and division the handle is turned anti-clockwise. The carriage is moved to the right or left by pressing a stud on the front. The product and multiplier registers are cleared by rotating the small handles through a complete revolution.

After the original Odhner patent expired this type of machine was made by many firms in Europe and USA under 27 other names. The Brunsviga was one of these and was known in France as the Rapide. Names that were familiar in Britain and Australia were Facit (1918) and Muldive (1924). The present machine carries the name Original Odhner. It is unlikely that this name would have been on the original Odhner machine and it is much more likely that it is a product of the Odhner firm when facing the competition from its many rivals. This fits with its known history of being well used in the 1920’s and 1930’s.

With the addition of an electric motor to the operating handle there came the possibility of automatic multiplication and division machines. The first commercially successful keyboard rotary machine was the Monroe (1911) which used the designs of F.S. Baldwin. It was followed in the same year by the Marchant which used the Odhner principle. Former users of these electro-mechanical desk machines will recall that they broke down usually for two reasons; the first arose from the strain upon the toothed wheels during the rotation and the second arose from the carriage hitting something resting on the desk, or, much worse, the wall. It has been the author’s experience that former Marchant users can always recall this latter hazard.

Acknowledgements
The restoration of both instruments has been made by Mr. K.L. Nuske of the Departmental Workshop Monash and it is a pleasure to acknowledge this painstaking work in his last year before retirement. The full understanding of the action of the sextant, especially of the averaging motor, arose from Professor M.J. Canney of the Department of Botany, Monash who had used such a bubble sextant in the field. The information about navigation in the Antarctic came from Dr. B.K. Gatehouse of the Department of Chemistry, Monash, Dr. P.G. Law, sometime Director of the Antarctic Division of Australia’s Department of External Affairs and Mr John Manning, Chief Surveyor, Division of National Mapping of the Department of Resources and Energy.

References
Bolton, H.C. The development of ruling engines in Melbourne, 1890-1940. Preprint
Chichester, Francis C. The lonely sea and the sky (1964). Hodder and Stoughton.
Chichester ibid second edition. (1945) Description of navigation. p150
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BOOK REVIEWS


Reviewed by G.J. Opat, School of Physics, University of Melbourne.

A typical undergraduate course in quantum mechanics is usually so overfull with the formal and experimental side of quantum physics that an "in-depth" discussion of the interpretation of quantum mechanics is left to the last few lectures, where due to pressure of time, it is omitted. This situation is not entirely satisfactory, to the class or the lecturer. Both these small books attempt to interpret quantum mechanics to an interested and informed audience and go some of the way to remedying this omission.

Alistair Rae's recent undergraduate text, Quantum Mechanics (Hilger 1985) has some useful last chapters on the interpretation of quantum mechanics. In his new small book, Quantum Physics, this philosophical material is expanded, cleared, and made insightful, and without much formalism. It assumes a "pass-level" knowledge of undergraduate quantum mechanics. This book addresses such topics as Bell's theorem and "what can be hidden in a pair of photons"; the Copenhagen interpretation; mind and matter; the "many worlds" interpretation; macro vs. micro physics; and quantum mechanics and its relation to the thermal physics as understood by the Prigogine School. I found the book interesting, clear, and a pleasure to read. His chapter on Bell's theorem is a masterpiece of clarity, and for that alone the book is worthwhile.

Polkinghorne's book, although a little more formal than Rae's is in fact philosophically more elementary. It gives an account of the history of those developments which led to quantum mechanics and the solution of atomic problems. The notion of a vector space is presented, as is the way in which such a space represents states. A clear account of the two-slit problem, wave-particle duality, and the uncertainty relations follows. This is followed by a discussion of the Einstein-Bohr-Podolsky issue, Bell's theorem, and Aspect's experiment which supports traditional quantum mechanics. A last chapter addresses philosophical issues. An appendix gives a concise account of quantum mechanics. I feel that a first year student would find Polkinghorne's book interesting, prior to a course in quantum physics, whereas Rae's book would be stimulating to a student after such a course.

THE MYSTERY OF THE QUANTUM WORLD, E. Squires, Adam Hilger Ltd., Bristol, 1986, xi + 170 pp., £8.95 (paper).

Reviewed by R.A. Brown, School of Mathematics and Physics, Macquarie University.

Written for the non-scientist and using non-mathematical language, this book addresses the conflict between the classical doctrines of determinism and "local realism" (by which definite properties are attributed to a body, independent of measurement and independent of measurement which may be made on distant bodies) on the one hand, and the non-deterministic and non-local aspects of standard quantum theory on the other.

Following a thought-experiment introduction to quantum interference and the wavefunction, some alternatives (hidden variables, many worlds, the role of consciousness - even God gets a mention) to the standard view of a non-deterministic "collapse" of the wavefunction upon measurement are described. This is followed by a discussion of the implications (for local hidden-variable theories) of Bell's theorem and the striking confirmation of non-local features of quantum theory which has recently emerged from experimental realisations of the Einstein, Podolsky and Rosen (EPR) thought experiment. A concluding chapter, which includes a small bibliography, is followed by nine brief appendices providing a few mathematical details.

This small book appears to achieve its aim and should provide non-scientists, and many scientists, with a limited understanding of some controversial aspects of quantum theory. The author's stated leanings (towards determinism and realism) do not detract from a reasonably balanced account although many would find unacceptable his view, emanating from an unwillingness to accept the postulate of wavefunction collapse on an equal footing with the second (deterministic) mode of evolution controlled by the Schrödinger equation, that its standard theory and quantum internal contradictions must confess, as does the author, to using quantum mechanics for many years without being bothered by the (albeit interesting) problems discussed in this book but, unlike the author, I remain unconvinced that there really is any problem.

To quote Feynman: "I cannot define the real problem, therefore I suspect there's no real problem, but I'm not sure..."

The book stimulated me to read more-technical articles dealing with the same topics as those in the book. They are papers by London, Bauer and Wigner, in a recent collection by Wheeler [1983], on interpretation and measurement and one by Mermin [1985] on Bell's theorem.

References

1. R.P. Feynman as quoted (more fully) by Mermin in Reference 2.


Reviewed by A.M. Stewart, Research School of Physical Sciences, The Australian National University.

Two of the most important problems in the physics of condensed matter are phase transitions and the behaviour of disordered media, the first because it is by a phase transition (solidification) that the complex condensed phase develops from the trivial gaseous phase, the second because all condensed phases are in practice disordered, and the disorder will produce radical changes in the properties due to effects such as scattering and localization.

The subject of metal-insulator transitions involves both phase transitions and disorder. A metal-insulator transition may occur in a material when some parameter such as temperature, pressure, composition, disorder or magnetic field is altered, resulting in a change in the electrical conductivity of many orders of magnitude. These transitions occur in a wide variety of materials: transition metal oxides, expanded metals (metals near the liquid-vapour critical point) metal-ammonia solutions, organic metals and doped semiconductors.

There are three basic mechanisms believed to be responsible for the metal insulator transition. The simplest is the crossing of the conduction and valence bands of a semiconductor that may occur under the influence of external parameters such as pressure or composition. The second involves correlation between electrons and is known as the Mott transition. The basic idea is that if the density of electron donating atoms becomes great enough the screened Coulomb potential will not be sufficiently strong to have a bound state and a delocalised metallic state will consequently form. The third mechanism is due to disorder and is known as Anderson Localisation. If the disorder of atomic energy levels
BOOK REVIEWS

is great enough then the electronic wavefunction at a given atomic site will not have sufficient amplitude at another site with similar energy to be able to travel to it by quantum mechanical tunnelling. The electronic wavefunction will then possess localised states at the primary site rather than extended throughout the solid and the material, that in the absence of disorder would be a metal, becomes an insulator. The Mott and Anderson transitions can occur, and prelocalisation behaviour associated with the interplay of disorder and correlation has been observed in the resistivities of many amorphous metals. Rather curiously the criteria for the occurrence of a metal-insulator transition driven by either the Mott or Anderson mechanisms are much the same, and only by using appropriate models to make detailed predictions of physical behaviour near the transition is it possible in a few cases to determine the primary cause of the transition.

The volume reviewed here is a collection of fourteen essays on aspects of the metal-insulator transition. The book is dedicated to Sir Neville Mott on the occasion of his 80th birthday and the first chapter, written by him, describes the historical development of the concepts in the field. The next chapter by T.V. Ramakrishnan surveys the current state of theoretical understanding of metal-insulator transitions in a clear and simple manner accessible to the experimentalist. Apart from one chapter on the much older Herzfeld-Goldhammer theory which attempts to describe the occurrence of metallic or insulating behaviour across the periodic table, the remainder of the chapters in the book review in detail the behaviour and understanding of separate physical systems in which metal-insulator transitions occur. The quality of the book is generally excellent and it is essential reading for anyone with interests in the field. It should be available in the library of any institution that carries out research in solid state physics.


Reviewed by M. Herman, CSIRO Division of Mathematics and Statistics, Lindfield.

Contrasts are statistical tests of focussed questions, which can be used in conjunction with an analysis of variance. The usual result of a standard analysis of variance is an unfocussed omnibus test, which is less powerful for answering specific questions than appropriate focused tests. As an example, suppose that multiple readings are taken from a measuring device at each of a number of points in time. The output of a standard one-way analysis of variance will provide an omnibus test of possible (statistically significant) differences between readings at different times. However, it in no way accounts for the time-ordering of the date. A suitable contrast, on the other hand, might test for the presence of a linear or quadratic trend in the data, and is more likely to detect such a trend than is the standard analysis of variance.

This monograph examines contrast analysis in some detail. It assumes a basic knowledge of one- and two-way analyses of variance, and deals with such issues as the use of multiple contrasts, designing experiments with particular contrasts in mind, and how to compute appropriate error sums of squares when there are several sources of variation in the data. The book is directed at non-statistical data analysts, mainly in the social sciences. It has a minimum of formulae; the approach is more tutorial in nature, involving detailed examples drawn from the social sciences, but using artificial data constructed to illustrate the logical bases of the computational procedures.

The general topic of the monograph should be of interest to many physicists, especially those concerned with experimental science. The detailed working-through of the examples may appeal to those physicists uncertain of their statistical footing, but many others will prefer a shorter, more mathematical treatment such as can be found in a number of statistical texts oriented towards the physical and engineering sciences.

RECENT PROGRESS IN MANY BODY THEORIES, H. Kummel & M.I. Ristig (Eds.), Springer-Verlag, Berlin, 1984, ix + 422 pp., $US19.40 (paper).

Reviewed by J. Dobson, School of Science, Griffith University.

This book comprises the Proceedings of the Third International Conference on Recent Progress in Many-Body Theories, held at Odenthal-Altenberg, West Germany during August-September 1983.

The papers are aimed at researchers in the field, there being no introductory or primarily pedagogical contributions. Nevertheless, a beginning postgraduate student in the field of many-body theory might find it useful to skim through this volume to gain a feeling for the range of systems and methods covered.

The systems include nuclear matter (sometimes analysed at the quark level), the homogeneous and inhomogeneous electron gas, and liquid hydrogen and helium (including the exciting spin-polarized forms). Quantum solids are not covered. Nor is the quantum Hall effect, which apparently inspired considerable verbal discussion, but was too new a topic to be represented among the papers.

The methods include diagrammatic perturbation theory, other Green function approaches, correlated basis functions, coupled clusters, and Monte Carlo computer experiments. The local density functional approach to inhomogeneous systems elicited only one paper.

The authors include such well-known workers as Pines and Ashcroft, and it is good, also, to note an Australian contribution (from Green, Neilsen and Smyeanski of UNSW).

In summary, this could be a useful library book for theoretical physics departments, but probably only researchers in the field would want to buy a personal copy.


Reviewed by C. Keen, Department of Physics, University of Newcastle.

When the ill-fated Space Shuttle Challenger exploded 78 seconds after lift-off it devastated the American space program. It did not do much good for The Space Business, either.

Much of Peter Marsh's book is centred on the role of the space shuttle and the Soviet Salyut in expanding human experience in space. He argues both sides of the spacemen versus robots case as well as the related issue of reusable versus expendable launch vehicles.

The Space Business contains quite a number of fascinating snippets of information, brief anecdotes and interesting quotes from people intimately involved in the space race. Most of them I have not encountered previously. They spice the otherwise dry facts and figures of space achievements.

For many readers the main value of this book will lie in the tabular material, which gives it a sort of reference status. It is handy to be able to see at a glance Ariane's launch record or the characteristics of the various Intelsat satellites. But it is a pity that the data does not extend beyond the end of 1984, or that only the geostationary satellites visible from Great Britain or the USA are listed. But you don't get much for under ten dollars these days.

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NEW PRODUCTS

QUENTRON OPTICS

Quentron awarded US Patent for use of pulsed light for cancer photoradation therapy.

US Patent No. 4 614 190, titled 'Photoradiation Method and Arrangement' was awarded to Quentron on the 30th September, 1986. Quentron already holds a similar patent covering Australia.

The patents cover the activation of hematoporphyrin derivative, HpD, or other photosensitisers used in photoradiation therapy (PRT), by pulsed light. Cancer photoradation therapy (photodynamic therapy or photo-chemo therapy are terms also used) is one of the most promising new treatment methods developed in the last decade.

It involves injecting a drug into the body and then illuminating the cancer with light three days later. When the light shines on the tumour the drug becomes toxic and kills the tumour. Surrounding normal tissue is left unharmed or recovers. The drug has no known side effects except its toxicity when activated by light of a certain colour range. This leads to the only known adverse side effect of HpD, namely that the patient has prolonged skin sensitivity to sunlight. This persists for one to three months due to the retention of small amounts of the drug in the body requiring the patient to avoid bright light. New drugs under development are eliminated from the body in a matter of 24 hours instead of 1 to 3 months. These are expected to overcome the prolonged skin sensitivity problem and open the road for PRT to become clinically approved over the next 2-4 years.

Australia has two research groups developing PRT, the Queen Elizabeth Hospital in Adelaide, and the Ludwig Institute of Cancer Research in Melbourne. Another is expected to start up soon in Sydney.

Lasers must be used to generate the light so that it can be focused into an optical fibre and delivered to any part of the body. A preferred form of the Quentron patent is the use of light produced by a gold vapour laser. The pulses from this laser have a peak power in the order of 10 kilowatts creating a very high instantaneous light dose in tissue.

The efficiency of pulsed laser excitation in phototherapy means that ultimately HpD drug levels could be lowered when used in conjunction with gold or other pulsed lasers or light sources.

Quentron believes this patent will be the key to the US PRT market for gold vapour lasers and copper laser pumped dye lasers. Quentron is the first company in the world to produce a fully automated medical laser based on gold and copper vapour laser technology.

Other types of pulsed lasers (excimer/dye, YAG/dye) may work in PRT but must have peak powers that are so high that when the light is focused into optical fibres the ends of the fibres are damaged.

Quentron's lasers have been installed in Australia, New Zealand, Japan and Europe.

Since 1982 Quentron pioneered the use of pulsed light for phototherapy with gold vapour lasers in Adelaide at the Queen Elizabeth Hospital in collaboration with Dr Ian Forbes, Reader, Department of Medicine, University of Adelaide.

For information contact:
Quentron Optics,
G.P.O. Box 2212,
Adelaide, South Australia 5000.
Phone: (08) 223 6224
Telex No: QTRON A004209.

After Chernobyl, ADCAM Shone!

As soon as United States government officials became aware of the release of radiation as a result of the Chernobyl accident, a major U.S. research institute, under contract to the U.S. government, was called upon to put high resolution gamma-ray measuring equipment into two airborne vehicles within 48 hours and make atmospheric measurements for the next two weeks. The institute was also required to collect filter samples for later analysis.

They had recently purchased two MCA 100 systems into which they had incorporated two COMPAQ PCs. One system contained two 918s and a Gilvronix, the other one, a 918 and a 476 multiplexer-router. They decided to try to put these systems on line as fast as possible. One system, with two dipstick germanium coax detectors, was installed in a DC-3; the other system, with two hand-held detectors, was put in a Beechcraft twin engine King Air. The equipment was hurriedly strapped down. Assisted by Vance Harmon and Jerry Cox of our Customer Service group, a few start-up problems were overcome. Within the two day time window that had been allotted, both planes were flying.

The planes first flew up and down the west coast of the North American continent. Flights were made as far as Minneapolis, Minn., Boulder, Colo. They were able to successfully perform real-time gamma spectroscopy, doing analyses while collecting data.

Both systems discovered the presence of I-131, newly created, from Chernobyl and 'old' Co-60 and Cs-137 from previous Chinese atmospheric tests.

Despite the serious vibrations to which the equipment was subjected throughout the flights, the ADCAM equipment worked perfectly, excellent data being obtained at all times. The research institute people were delighted.

The results obtained established that the levels of radiation encountered were several orders of magnitude below that which was being observed in Europe.

The moral of this story: If you want a reliable, high performance MCA, ADCAM is the answer. You will be just as pleased as were those at this research institute.

Quentron Optics

ETP OXFORD

New Thorn EMI Photon Detection System delivers the Right Measurement at the Right Time

THORN EMI's new computer controlled photon detection system (PDSTM) makes photon counting accurate and easy, broadening the scope of this analytical technique for low light level measurement. A unique combination of software and hardware ensures ultimate signal detection sensitivity from one of THORN EMI's range of high performance photomultipliers and accurate synchronisation of the measurement with the period when light is emitted from the experiment or instrumentation.

A comprehensive software package, for use with users BBC or IBM compatible microcomputer, controls system functions, calibration, gives access to all system facilities and allows the simple programming of complex operational sequences, easily and directly from the computer screen. Consisting of a detector unit and a control unit, the system comes complete with software package on disk and a detailed "GUIDE TO OPERATIONS" manual, ready for immediate coupling to the microcomputer.
Applications for the PDSTM include astronomy, spectroscopy, bio- and chemiluminescence and all forms of precision photometry. A leading authority on Raman spectroscopy, Professor D.A. Long, commented 'Because of the ease with which the automatic scanning and data processing can be set up, this system is making a very significant contribution to our work, particularly in terms of speeding up research.'

9400 Honoured for Performance and Friendliness

Recently honoured with an IR-100 award from RESEARCH AND DEVELOPMENT magazine for its unique specifications and user friendliness, the LeCroy 9400 Digital Oscilloscope offers 150 MHz bandwidth, 32 000 words of memory per channel, with 192K words of waveform memory in total.

It samples single events at 100 megasamples per second at 8-bit resolution, while repetitive phenomena are digitized at equivalent speeds as high as 5 gigasamples per second.

Several waveform processing functions - signal averaging up to 1 000 000 signals, arithmetic processing, integration, differentiation, digital filtering, etc - can be incorporated into the 9400 through the WPO1 Waveform Processing Package. WPO2 Fast Fourier Processing firmware is an option which may be supplied with the LeCroy 9400 or fitted retroactively to a 9400 equipped with WPO1 firmware.

For further information, contact:

Sydney
ETP Oxford Pty. Limited,
31 Hope Street
ERMINGTON, NSW 2115
Mr. Fred Blake
(02) 858 5122

Melbourne
ETP Oxford Pty. Limited,
214 Berkeley Street
CARLTON, VIC 3053
Mr. Greg Tate
(03) 347 0733

THE UNIVERSITY OF NEW SOUTH WALES

RESEARCH FELLOW
(Ref. 22)
SCHOOL OF PHYSICS
To work with Dr. J.W.V. Storey on a National Research Fellowship Scheme project on the development of infrared imaging systems. These systems, which will be based on our in-house metal-silicide CCD arrays and on commercially available infrared arrays, will have applications in astronomy, industry and natural resources. The position will be filled at the Research Associate or Research Fellow level and the appointment will be initially to 31 December 1987 with prospects of renewal for up to a further two years. Applicants must hold a PhD in physics, and preference will be given to newly qualified graduates with experience in infrared techniques, optics, cryogenics or electronics.

Further information from Dr. J.W.V. Storey,
(02) 697 4546.

SALARY: $327,859-$34,102.

Please submit written application to the General Staff Office, P.O. Box 1, Kensington, N.S.W. 2033, Australia, by 3 April 1987.

Equality of employment opportunity is University policy.

THE UNIVERSITY OF NEW SOUTH WALES

PROFESSOR
OF PHYSICS
Applications are invited for appointment to a Chair of Physics in the area of Experimental Physics. The appointment will be available from January 1988.

Applications are invited from physicists with substantial research experience preferably related to the present activities of the school. Preference will also be given to applicants whose fields are relevant to areas of modern technology at present existing in Australia or likely to be developed in the near future.

The new professor would be expected to serve as head of the Department or Head of School for a term or terms if so requested.

The School of Physics comprises five departments: Theoretical Physics, Biophysics, Condensed Matter Physics, Astrophysics & Optics and Applied Physics, and has the largest enrolment of graduate students of any Physics School in Australia.

Enquiries regarding the Chair may be addressed to Professor D.S.C. Black, Acting Dean of the Faculty of Science (02) 697 4657 or from the present Head of School, Associate Professor J.G. Kelly (02) 697 4674, from whom further information may be obtained regarding specific areas of research interest in the departments of the School.

Salary: $55,348 per annum.

Subject to consent by the University, professors may undertake a limited amount of higher consultative work.

The University reserves the right to fill any Chair by invitation.

Details of the position, together with conditions of appointment and application procedure, are available from the Academic Staff Office, P.O. Box 1, Kensington, New South Wales 2033.


Equality of employment opportunity is University policy.

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POSITIONING

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David Thomas Pegg has been appointed to the vacant chair in physics in the School of Science at Griffith University.

Professor Pegg first came to Griffith University as a Senior Lecturer in 1974 and was promoted to Reader in 1978. A graduate of the University of Queensland where his PhD was conferred in 1967, he went to Oxford to work with G.W. Series on radiofrequency atomic spectroscopy. His dedication to theoretical physics dates from this time when, having begun an experiment to resolve a conflict in reported values of the hyperfine constants of potassium, he found that the problem could be resolved theoretically. In 1969 he moved to the University of Reading with Professor Series and worked on the semiclassical theory of dressed atoms.

In 1970, Professor Pegg was appointed to a lectureship at James Cook University. As well as continuing his work in atomic physics, he returned to the field of his PhD, cosmology and the theory of time.

At Griffith University, Professor Pegg has continued to work in atomic physics extending his interest to quantum optics and quantum measurement theory. One of the highlights of this work has been the application of quantum absorber theory to fundamental problems in atomic physics. From time to time, he has interacted with the experimentalists of the laser-atom physics group in the School of Science. He has also continued with work on the theory of which he says, he has found to be the most difficult and the least productive of his areas of research. On the other hand, the most productive area has been the development of NMR spectroscopic techniques with a member of the NMR group in the School of Science. They developed an NMR pulse sequence, called 'DEPT', which exploits the Einstein-Rosen-Padolsky paradoxical spin states. This pulse sequence is now in routine use in many chemical laboratories throughout the world. He has published approximately 110 papers, one book and holds six patents. He has been active in the Queensland branch of the AIP.

AJP New Appointments
The Australian Journal of Physics recently appointed three new members to its Editorial Board. They are the distinguished physicists Dr J.G. Collins (CSIRO Applied Physics), Dr P. Hannaford (CSIRO Chemical Physics) and Professor E. Weigold (Flinders). The new members succeed Professor Fred Smith and Professor Lew Chadderton who served on the Board since 1979 and 1981 respectively. Professor Smith's position as Chairman of the Board has been taken up by Professor Don Melrose.

John Collins was born in Geraldton W.A. in 1933 and entered the U.W.A. in 1951 from Perth Modern School. He graduated with 1st-class honours in physics in 1955, and subsequently was awarded an MSc (W.A.) and PhD (Cambridge) in theoretical physics. In 1961 he joined the CSIRO Division of Physics, which was part of the National Standards Laboratory. For many years he also held a part-time lecturing position in applied mathematics at the University. He spent 1965-6 as a Fulbright Fellow at the Ames Laboratory of the U.S. Atomic Energy Commission and at the Department of Physics, Iowa State University. He is presently an Assistant Chief of the Division of Applied Physics, now located at Lindfield.

Collins was active in the CSIRO Officers' Association in the 1960s and early 1970s and became its President in 1972-4, subsequently he was elected to Honorary Life Membership for services to the Association. In 1977 he was elected Honorary Registrar of the A.I.P., and since 1985 has been Vice President. He is a Fellow of the AIP and of the Institute of Physics, London.

Collins has wide interests in physics and has consulted in various areas of work within the Division. His primary research interests are in the thermophysical properties of materials, particularly at cryogenic temperatures. In this field he has made contributions to the theory of transport properties, heat capacity and thermal expansion of solids.

Peter Hannaford graduated in Physics from Melbourne University in 1962 and subsequently completed his doctorate on the subject of Mössbauer studies of irradiation effects in solids. In 1967 he joined the CSIRO Division of Chemical Physics, where he is now a Senior Principal Research Scientist in the Spectroscopy Section. During his time with CSIRO he has spent periods as Visiting Research Fellow at the University of Reading, Griffith University, the University of Otago, and the Australian National University.

Hannaford's research interests include high resolution laser spectroscopy, atomic coherence phenomena, foreign gas broadening processes, atomic lifetime determinations, laboratory astrophysics and the physics of gas discharges. In 1985 he was awarded the Australian Institute of Physics Walter Boas Medal for his work on the application of sputtering vapourisation techniques to fundamental laser spectroscopic investigations on atoms.

In recent years he has served as Secretary and Treasurer of the Victorian Branch Committee of the AIP, and is presently Vice Chairman.

Erich Weigold was born in 1937, in Palestine, and brought to Australia in 1941 by his family. After interment for five years near Tatura, Vic., the family was allowed to remain in Australia and they settled in the Barossa Valley.

After completing a physics degree at Adelaide University he started his PhD in nuclear physics at the A.N.U. in February 1959. Upon completion of his PhD in February 1962 he held an AINSE Fellowship at the A.N.U. before returning to Adelaide University in November 1962 as a Lecturer in Physics.

There he founded a research program in experimental atomic physics involving electron scattering from hydrogen atoms.

In May 1964 he joined the Air Force Office of Scientific Research in Washington, DC, being the Chief of its Nuclear Physics Division for over three years. While there he also served on the US Technical Committee for High Energy Physics and on the Interagency Committee for Nuclear Physics.

In August 1970 he returned to Australia to take up a Senior Lectureship in Physics. At Flinders he developed a research program in experimental atomic and molecular physics. The major part of this work was devoted to coincidence experiments, both electron-electron and electron-photon coincidences. The former evolved into a new form of spectroscopy, variously known as (e,e2) electron coincidence or electron momentum spectroscopy (EMS). He was promoted to Reader in 1974 and Professor in 1978.

Weigold was appointed to the ARC in 1981, becoming Chairman of the Physical Sciences Subcommittee in 1981 and Deputy Chairman of the Committee for 1986. He has also represented Australia on the International Union of Pure and Applied Physics and was selected a Fellow of the Australian Academy of Sciences in 1986.

His wife died in February 1986 and his two children (Adam, 20, and Charlotte, 19) are attending University.

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General News

The Australian Seismological Centre
The Minister for Resources and Energy, Senator the Hon. Gareth Evans QC, opened the Australian Seismological Centre (ASC) in Canberra in September 1986.

The ASC is a national seismological facility established by the Australian Government to monitor earthquakes and study their effects, and to detect and identify seismic waves originating from underground nuclear explosions.

The facility is operated by the Bureau of Mineral Resources (BMR) of the Department of Resources and Energy and is located in Jamieson House, Constitution Avenue, Reid. The ASC receives data from seismological monitoring stations throughout Australia and in the Antarctic. Approximately 100 seismic events are recorded each day by the ASC, which relies heavily on automated computerised techniques to receive and process the data.

The ASC provides the Australian Government with an independent analysis of nuclear tests being conducted within the Centre's detection range (covering the Chinese, French, Indian and main Soviet test sites), and will play an integral part in achieving the Government's objective of securing a Comprehensive Test Ban Treaty.

Further information from:
Dr John Adkins
Bureau of Mineral Resources Phone: (062) 499563

Southeast Queensland Airborne Survey
The Bureau of Mineral Resources (BMR) of the Department of Resources & Energy has commenced an extensive airborne geophysical survey covering almost 100,000 square kilometres of southeast Queensland.

The survey is part of BMR's Australia-wide geophysical mapping program and will complete the airborne coverage of Queensland. It will provide magnetic and gamma-ray spectrometric data to assist the geological understanding of important provinces including the Yarral Basin, Maryborough Basin and the Esk Trough.

The survey will cover the standard 1:250 000 map sheet areas of Mackay, Port Clinton, Rockhampton, Heron Island, Monto, Bundaberg, Sandy Cape, Mundubbera, Maryborough, Wide Bay and Chinchilla, and will involve BMR's two survey aircraft (a Twin Otter DHC-6 and an Aero Commander). The aircraft will record geophysical data along traverses spaced 1.5 kilometres apart and at an altitude of 150 metres above ground level.

Both aircraft are equipped with proton precession magnetometers (capable of measuring subtle variations in the Earth's magnetic field), gamma-ray spectrometers (able to sample up to 256 different energy levels of radioactivity), doppler navigation systems, and video flight path cameras (to record precisely where the planes have flown). Computers on board the aircraft control the data acquisition process.

Further information from:
Mr Ken Horsfall
Bureau of Mineral Resources Phone: (062) 499216

New BMR Magnetic Maps to assist Mineral Exploration
The Bureau of Mineral Resources (BMR) has released the first map in a new series of magnetic maps designed to assist geophysical and geological specialists and prospectors in their search for undiscovered mineral deposits.

The maps, known as Magnetic Domain Maps, are intended as a new mineral exploration tool and to increase geological knowledge and understanding of some of Australia's most promising minerals exploration areas.

The Albany 1:1 000 000 Magnetic Domains Map is the first map in the series to be released, with several other maps
New Monazite Processing Plant in Western Australia

PRESS STATEMENT FROM THE MINISTER FOR RESOURCES AND ENERGY SENATOR GARETH EVANS Q.C

I am happy to join with the Western Australian Government and the French chemical company Rhone-Poulenc in announcing that Rhone-Poulenc will build a two stage monazite processing plant at Pinjarra in Western Australia.

Construction of the plant is expected to commence soon, with production scheduled to begin in 1989. The plant will produce rare earths from monazite, a mineral sand mined in Western Australia, and will have the capacity to process up to 15,000 tonnes per annum, taking up most Australian production.

The value added to Australian monazite, export of which is currently worth around $11 million per annum to Australia's balance of trade, should be of the order of $100 million per annum when the plant is fully operational, with potential for further downstream processing in the production of alloys and metals. Investment in the plant will be between $80 and $120 million, with employment for a work force of around 100.

The rare earth elements to be produced - of which there are fifteen, including lanthanum and praseodymium - have important applications in metallurgy, ceramics, electronics, chemicals, oil refining and glass-making. Our goal should now be to pursue a fully integrated rare earth industry in Australia. We propose to proceed with this project only if the Commonwealth can show confidence in its long-term viability and Australian capacity for its development.

In line with our policy to promote minerals processing in Australia, the Commonwealth Government has worked closely with the Western Australian Government on the development of this proposal. I held detailed discussions with representatives of Rhone-Poulenc to satisfy myself that the project held genuine benefits for Australia and was consistent with the Government's resource industry, environmental and nuclear safeguards policies. Having been done, the Commonwealth has fully supported the project, and has assisted in various ways, such as by lengthening the term of a licence to assist local industry.

I welcome also the announcement today by the Western Australian Government and Rhone-Poulenc that a gallium processing plant will be established in conjunction with the monazite plant at Pinjarra: gallium is a relatively new product produced in small amounts for use in high-speed computing, laser diodes and other high technology industries.

Further processing of our mineral resources makes good sense in view of Australia's position of comparative advantage - a point which was clearly registered in the talks I had recently at the Australia-Japan Ministerial Committee with my counterpart, the Japanese Minister for International Trade and Industry, Mr Tamura.

To the extent that minerals processing is economically feasible and consistent with sound industrial development it provides optimum economic benefits to the industry and the Australian community from our resources, including high added value for exports, increased employment and important downstream processing. In the case of rare earths there is also a strong link with high-technology manufacturing, which is expected to experience strong growth internationally in the medium term.

The importance of this, in the context of Australia's current high level of payments and employment situation and the need for us to broaden our manufacturing base, hardly needs emphasizing.
Recent Higher Degree in Physics: "Aspects of Optical Bistability in Atomic Sodium"

W.E. Schulz, School of Science, Griffith University

A bistable system is one which can have two stable output states for a given input. The selection of the output state depends on the immediate past history of the system. In general, for a system to be bistable it must possess a strong nonlinear property associated with some feedback mechanism. This thesis investigated, both experimentally and theoretically, the optical bistability of low finesse optical cavities with intracavity atomic sodium.

As a first exercise, bistability was observed in a Fabry-Perot etalon filled with sodium vapour and injected with laser radiation whose frequency was swept cyclically through a D transition. Bistability and switching were evident in this situation with a distorted cavity transmission peak. The data also confirmed that the dominant nonlinearity was the dispersion. A similar experiment was carried out with sodium vapour inside a three-rings mirror ring cavity. This was the first demonstration of optical bistability in a ring cavity.

A novel feature was discovered in the transmission of the Fabry-Perot etalon below threshold for optical bistability. Within a narrow range of parameters, an etalon transmission profile split into three peaks, the central one of which was found to be quite narrow (~ 50 MHz) and at a fixed atomic frequency. No similar behaviour was observed in the ring cavity. By using a three-state, lambda-type model for the sodium energy levels associated with the D transition and developing a computable theory for the interaction of these atoms with the standing wave in the cavity, simulated transmission profiles were obtained in good qualitative agreement with the experimental data.

The last aspect of this work was the design and commissioning of an atomic beam system so as to investigate optical bistability conditions under conditions where the Doppler-effect induced complications of the vapour system could be reduced. To maintain sufficient atomic density so that the bistable regime could be reached, a linear array of 25 sodium atomic beams were produced as the intracavity medium. The residual Doppler width was approximately 200 MHz. The cavity mirrors were mounted inside the vacuum chamber and their positions controlled by mechanical and electrical feedback. Conventional methods were employed for mechanical and ring cavities were employed. Optical bistability was observed when cycling the laser frequency as before, and also when the laser intensity was varied using an acousto-optic modulator. Finally, the bistable system was subjected to a light pulse of width up to 500 ns and rise time of 1 ns produced by an electro-optic device from the c.w. laser light. The response of the system showed clear examples of the threshold switching phenomenon called "critical slowing down".

Publications


Visitors to Queensland 1987.

Dr P.L. Knight, Optics Section, Blackett Laboratory, Imperial College of Science and Technology, Prince Consort Road, London SW7 2BZ, England.
Theoretical Quantum Optics, 4-20 April 1987 (approx.)
(visiting University of Queensland and Griffith).

Prof G. Agarwal, School of Physics, University of Hyderabad, Hyderabad 500134, India.
Theoretical Quantum Optics, 18-22 May 1987 (approx.)
(visiting University of Queensland).

Prof J. Eberly, Department of Physics & Astronomy, University of Rochester, Rochester, NY 14627, U.S.A.
Theoretical Quantum Optics, 28 July - 3 September 1987 (approx.)
(visiting University of Queensland).

Mr Gao Jie, South-West Technical Physics Institute, Peoples Republic of China.
(visiting Griffith University).

W.A.

Visit of Mr. Geoffrey Perry, MBE

In November 1986, Mr. Geoffrey Perry, MBE, visited Perth on the first stage of a three week Australian tour. Mr. Perry is the founder of the Kettering Satellite Tracking Group based at the Kettering Boys School (UK) and since his "retirement" in 1984 he has continued to serve as an advisor on space programs to British Television networks and to the US Library of Congress. The New York Times has described him as the leading non-government expert in the area of the Russian space program and those who heard him speak and met him can well vouch for the truth of this proposition.

The visit to Australia was initiated through an approach by Mr. Geoff Davies of the Astronautical Society of WA to the WA Branch Chairman who then canvassed Branches at the August Council Meeting in Adelaide for support. The British Council paid the UK/Australia return airfare while travel within Australia was covered jointly by The Institution of Engineers, Australia and AIP Branches (WA, QLD, NSW, Vic, SA) with additional sponsorship from COSSA (CSIRO) and the Space Association of Australia.

In Perth, Mr Perry spoke to the AIP at Murdoch University at a late afternoon meeting on the 12th of November with the title "Military and Civilian Satellite Applications". In addition he addressed the Science Teachers Association of WA ("Educational Aspects of Satellite Tracking"), a Physics seminar at UWA ("Decay of Nuclear Powered Satellites") and a joint meeting of the Astronautical and Astronomical Societies of WA as well as giving several media interviews. This round of engagements was typical of his busy schedule.
during a sweep through other states which terminated with a "debriefing" in Perth in early December in orbit back to the UK.

At this session it was apparent that our visitor had enjoyed his tour as much as we had enjoyed his lectures and meetings; notwithstanding the busy routine he had found time to supervise personally the English demolition of our Test cricketers and to swim in the Australian surf. He made a number of suggestions for organisers of such future tours, notably that visitors should have sufficient free (i.e., totally uncommitted) days to unwind! Among memories of his many encounters he recalled especially the magpies, who so thoroughly scavenged any left overs at the delightful Brisbane barbecue. Among other comments he noted the possibility of launches into sun-synchronous orbits from Cape York, which orbits cannot be achieved from many other established launch sites.

In WA, and I am sure in other states, Geoff Perry left a very warm personal impression and at all his talks his audience came away enthusiastic over space happenings and fascinated at the very significant and positive deductions that can be made from continuous monitoring and recording of relatively simple data. His own enormous fund of information on all aspects of space travel and his instant recall of detail is remarkable and the way he has used space science as a vehicle for teaching Physics in school is a model for teachers at all levels who seek to enthuse their students. We thank him for the great effort he put into his library of talks for this tour, for the way in which he responded to the very taxing schedule which was mounted for him and we congratulate him on his success at the various meetings. He is assured of a hearty welcome should he come this way again.

The major portion of the detailed organisation within Australia was ably shouldered by the Institution of Engineers, Australia, for whom Mr. Rob Breen and Ms. Linda Pitkin arranged all the interstate travel and much of the accommodation; without their effort the visit could not have proceeded as it did. In WA, Mr Geoff Davies and Mr. John Cullow of the Astronautical Society of WA, which initiated the whole venture, generously hosted Perry in their homes.

S. Thurgate.

***

LASERS '87 AWARD

To be given at the 10th International Conference on Lasers & Applications, Lasers '87, to the best contributed paper on any of the following topics:-

LASER PHYSICS
LASER DEVELOPMENT (OR ENGINEERING)
LASER APPLICATIONS

Selection will be made by the Program Committee based on originality, timeliness and importance relative to the relevant field. The award consists of a metal plaque and a cash prize.

Authors are requested to submit two copies of both a 35 word abstract and a 200 word summary of their paper. The summary should be specific. Deadline is May 15, 1987.

Lasers '87 will be held in Lake Tahoe, December 7-11, 1987.

Write to:-
Lasers '87
P.O. Box 245
McLean, VA 22101
U.S.A.

Dr Frank Duarte, a graduate from Macquarie University, now with Eastman Kodak (Rochester, NY), has been named Program Chairman of the Tenth International Conference on Lasers and Applications, Lasers '87, to be held in Lake Tahoe, Nevada, December 7-11, 1987.

In the tradition of previous conferences in this series, Lasers '87 will emphasize laser physics and laser development. In addition, the use of lasers in Medicine will be highlighted with at least three sessions on the subject. Lasers '87 will also include a panel discussion on SDI with participation of many well known laser physicists.
Conferences and Meetings

1987

Dr B.V. Smith M/OA, Department of Electronic and Electrical Engineering University of Birmingham,
P.O. Box 363, Birmingham B15 2TT U.K.

Apr 20-24  11th International Conference on Particles and Nuclei, Kyoto, Japan.

May 3-6    18th Annual Scientific Meeting, ANZ Society of Nuclear Medicine, Brisbane.
18th AGM Nuclear Medicine Society. ACTS GPO Box 2200 Canberra ACT 2601.

Conf. Chairman, Future Directions Conf., RMIT, GPO Box 2476, Melbourne, Vic., 3001.

The Conference Secretary, The Institution of Engineers, PO Box 417, Darwin NT 5794.

The Conference Manager, Computer Systems Conference 1987, The Institution of Engineers, 11 National Circuit,
Barton, ACT 2600.

Jun 30-Jul 2 3rd Nat. Space Engineering Symposium, Canberra.
Conf. Manager, Institution of Engineers, 11 National Circuit, Barton, ACT 2600.

Course Secretariat, QSEARCH, Queensland Institute of Technology, GPO Box 2434, QLD 4001.

Mrs D. Uherkova, Gorheko nam. 23, 112 82 Prague 1, Czechoslovakia.

Jul 8-9    Technology and Exports, Brisbane.
Lee Rystand, The Institute of Engineers, Australia, 11 National Circuit, Barton, ACT, Australia.

Jul 14-16  Automated Vision Technology, Caulfield East
Dr C.F. Osborne, Applied Physics Department, Chisholm Institute of Technology, 900 Dandenong Road,
Caulfield East, Vic. 3145.

The Conference Manager, Information Technology Conference 1987, The Institution of Engineers, Australia, 11
National Circuit, Barton, ACT 2600.

Aug 3-8    International Symposium on Experimental Gravitational Physics, Guangzhou, China.
Dr D. Blair, Department of Physics, University of W.A., Nedlands, W.A. 6009.

Aug 4-12   4th International Symposium on World Trends in Science and Technology Education, IOSTE, The Netherlands
J. van Trommel, P.O. Box 2061, 7500 CB Enschede, The Netherlands.

Aug 8-10   Neutron Scattering Symposium, Sydney.
The Secretary - ANBUG, C/- AINSE, Private Mail Bag, P.O., Sutherland, NSW 2232.

Aug 12-30  XIV Int. Congress and General Assembly, UC, Perth.
Dr E.N. Maxlen, Crystallography Centre, University of W.A. Nedlands, W.A. 6009.

Dr J.H. O'Donell, Department of Chemistry, University of Queensland, Brisbane, Queensland 4067.

Aug 17-21  ICAME87 - International Conference on the Applications of the Mössbauer Effect.
ICAME87, Department of Physics, Monash University, Clayton, Victoria 3168.

E.H. Nickel, Division of Minerals & Geochemistry, CSIRO, Private Bag, Wembley, West Australia 6014.

Dr. S.W. Wilkins, CSIRO, Division of Chemical Physics, P.O. Box 160, Clayton, Victoria 3168.

Dr J.H. O'Donell, Chemistry Department, University of Queensland, Brisbane, 4067.

Prof. J. Rose, 5 Margate Rd, Lytham St Annes, Lancs. FY 83EG, U.K.

Oct 6-9    Int. Conf. on Electrical Machines and Drives, Adelaide.

Nov 5-9    International Conference on Lasers, Xiamen, China.
Professor Deng Ximing, P.O. Box 8211, Shanghai, China.

Dec 7-11   10th Int. Conf. on Lasers & Applications, Lake Tahoe.
Lasers '87, P.O. Box 245, Mclean Va 22101, U.S.A.

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