Spectra-Physics Lasers

- Argon Ion Lasers
- Krypton Ion Lasers
- Pulsed Nd: YAG Lasers
- Ti: Sapphire Lasers
- Ultrashort Pulse Ti: Sapphire Lasers
- Dye Lasers
- Excimer Lasers

TSUNAMI ULTRASHORT PULSE TI-SAPPHIRE LASER

Newport

- Laser Optics
- Optical Tables & Mounts
- Motion Control Systems
- Optical Instruments
- Holography Systems
- Fibre Optics Components

Spectra-Physics
2-4 Jesmond Road Croydon, Victoria, 3136. Phone: (03) 723 6600. Toll Free: 008 805 696. Fax: (03) 725 4822.
# CONTENTS

<table>
<thead>
<tr>
<th>PRESIDENT'S COLUMN</th>
<th>82</th>
<th>A Call For Support. A. Thomas</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUEST EDITORIAL</td>
<td>83</td>
<td>Using Computers in Our Teaching. I. Johnston</td>
</tr>
<tr>
<td>OBITUARY</td>
<td>84</td>
<td></td>
</tr>
</tbody>
</table>

## 10TH AIP CONGRESS

86 - 108


## LETTERS

108

## PRODUCT NEWS

109

## BOOK REVIEWS

110

## THE BRAGG GOLD MEDAL

115

## CONFERENCES & MEETINGS

116

Published 11 times a year, on behalf of the Australian Institute of Physics and the New Zealand Institute of Physics by ImpresS Studies.

Enquiries & Advertising
Judith Nikolaev
Production Manager
ImpresS Studies
41 Kemp Street
The Junction NSW 2291
Phone (049) 61 3319
Fax (049) 61 1844

Editorial Address
Australian & New Zealand Physicist
Department of Physics
University of Newcastle
University Drive
Callaghan NSW 2308
Phone (049) 21 5442
Fax (049) 21 6907

Design and Layout
ImpresS Studies, Newcastle
Printer
Newcastle Camera Print
ISSN 1036-3831
Copyright 1992
Pub. No. WBP 0582

Our cover picture shows morning coffee at the Congress - it is coincidental that this cover photo includes the Honorary Editor.
PRESIDENT’S COLUMN

A Call For Support

There are a number of items which deserve comment this month. First I am very pleased to extend congratulations on behalf of all our members to the Royal Australian Chemical Institute which is celebrating its 75th anniversary this month. Our links with RACI have been strengthened significantly in recent years. As well as sharing administrative staff at Clunies Ross House we have similar concerns over education and research funding. Members of RACI must also balance the twin roles of a learned society and a professional association. Our code of ethics was adapted from that which has been used by RACI for many years. There is clearly tremendous scope for continued close cooperation in future and I shall be pleased to do my part.

At long last the important task of finding a new editor for the Physicist seems to be nearing completion. I hope to be able to announce the new arrangements in the next issue. This will not only be a relief for your executive but also, I am sure, for Ron MacDonald. His selfless devotion to this Institute in keeping the Physicist going long after he had originally intended to stop, should be an inspiration to all of us. It also serves to introduce my next theme.

I have lost count of the number of people who over the past twelve months have made declarations like the following.

“As a member of the AIP I would encourage all of my colleagues to help with its activities, but as a senior member of my department/division/company I would have to discourage them. The demands of the job are now too great to allow time for voluntary work.”

This brave new world is not unique to our country. In the United States the government recently tried to forbid federal employees from participating in the activities of professional, non-profit societies (like the American Physical Society) on paid time. Under intense pressure from many societies including the APS, the initiative was dropped. However the issue will clearly raise its ugly head again in the future.

Perhaps it is time to remind ourselves just how important societies like the AIP are. I am continually impressed by the enormous amount of unpaid work carried out on behalf of our discipline by members of the AIP - all the way from education to science policy. Without that selfless dedication, our discipline would wither and this country would be a much less attractive place to work. I would like to ask all those reading this column to think very hard about what sort of society they want. If, as I suspect, it is not one where immediate gain is all that matters, then it might be time to ask how you can best contribute to the work of this Institute. Even in these hectic times we can all make the extra effort. It may even turn out to be a rewarding experience.

A.W.Thomas

ICPE

CONFERENCE ON REFORMING THE FUNDAMENTAL PHYSICS TEACHING

Southeast University Nanjing, China
25-29 MAY 1992

For further information and registration forms contact:

Professor Geoffrey L. Opat
School of Physics
The University of Melbourne
Parkville Victoria 3052 Australia
Phone (03) 344 5121 Fax (03) 347 4783

LOOKING FOR CREATIVE & PRECISE DESIGN?

Creative and precise accurately describes the driving force behind all the graphic design work carried out by Impress Studios.

Come to us for the design, layout, printing and binding of entire publications (annual reports, journals, monographs, magazines, technical manuals and books).

We also do design and artwork for advertisers, banners or logo design and creative or technical illustration work.

Australian & New Zealand Physicist Volume 29, Number 5, May 1992
Using Computers in Our Teaching

It is one of the ironies of our profession that we physicists, so innovative in some areas, can be so conservative in others. Take the use of computers, for example. In the last forty years we have been right at the forefront of their development, quick to take advantage of the benefits they bring to our research. But in the teaching of physics, many of us still use the methods that we ourselves experienced as undergraduates.

As a result there is a widening, and increasingly obvious, gap between physics as it is practiced and physics as it is taught. The professional physicist studies processes in the real world with computer models that take account of unpredictable and chaotic influences. The student models idealized situations with the aid of esoteric functions named after 19th century mathematicians. In a working laboratory computers hang off every nook and cranny, taking care of the minutiae of control and collection of data, allowing the researcher time to think about what the results mean. In the teaching laboratory our students take repetitive, simplistic measurements with surly and scaling-wax, and we comfort ourselves with the knowledge that Lord Rutherford would have approved.

Is it any wonder that the most frequently voiced student complaint is that physics courses are useless? Why are we surprised that physics seems to be going the way of classical Greek, to become a subject of purely archival interest?

In the last decade powerful personal computers with good graphics capabilities became readily available. Particularly in the United States, some universities started training physics students to use computers as they will use them in their future professional careers. An influential conference was held in North Carolina in 1988 under the auspices of the American Association of Physics Teachers which gave exposure to a number of important initiatives (including the Maryland University Project for Physics Education Technology, M.U.P.P.E.T.; the Workshop Physics Project at Dickinson College; and the symbolic manipulation package Mathematica) and provided impetus for later developments (the Computers for Undergraduate Physics Learning Environment, CPULE, based at Maryland University; and the Consortium for Upper-level Physics Software, CUPS, based at George Mason university being just a few which we are acquainted with). In the UK, an interesting initiative is the CTI (Computers in Teaching Initiative) project, linking a number of centres responsible for the dissemination of information and software.

It seems reasonable to sum up the scene in the US and Europe by saying that, while computers are not yet everywhere a firmly entrenched part of university physics teaching, they soon will be.

In Australia we are not nearly so far advanced along this road. We are not often represented at the important conferences, for example. Yet much good work is being done in our universities. We have a couple of departments where important work has been done on the computer management of student tutorials; several which offer courses in programming, numerical techniques and the like, mainly at second and third year level; and in quite a few first year teaching laboratories, imaginative computer-based experiments are being introduced. Unfortunately all too often these innovations come from one or two academics, working in isolation.

It is time to gather together all these individuals to share ideas and experiences. To make that possible, we at Sydney University are organising a scientific conference, the first in this country to be devoted specifically to the use of computers in university physics teaching. Its aims will be to bring to Australia certain key people who can tell us about the most important overseas experiences, to promote cooperation and sharing of the work that is already being done in this country, and to start thinking about future innovations, particularly the introduction of supercomputers into widespread use.

The enterprise is large enough that there is a pool of local experience to be shared, early enough that better practices can easily be adopted: late enough that there are plenty of overseas developments to be emulated, early enough that we can still make internationally important contributions.

If we do not make some move in this direction soon we will surely be in trouble. It cannot be long before all our students own their own personal computers, as powerful as Crays are today. They will need us to teach them to use these exquisitely powerful tools to solve their own problems. We must start adapting to that need. We cannot in conscience simply continue to teach what we like and are comfortable with. Physics teaching has got to change and we are the ones who must change it.

Ian D. Johnston
School of Physics
The University of Sydney

OzcUPED

the first Australian conference on

Computers in University Physics Education

University of Sydney
Sydney, Australia
14-16 April 1993

Further details can be found in the first circular obtainable from

Dr. I.D. Johnston
School of Physics, University of Sydney
NSW 2006 Australia
Phone: (02) 692 2637, 2537
Fax: (02) 660 2903
Email:idj@physics.su.oz.au

or

Dr. M.A. Oldfield
School of Physics, University of Sydney
NSW 2006 Australia
Phone: (02) 692 4235
Fax: (02) 660 2903
Email:mac@physics.su.oz.au
OBITUARY

Janice Thelma Powe
MScSoc UNSW, BA Macquarie, TC Sydney, ANU Fellow, MAIP

1939 - 1992

Jan Powe, well known Member of the Institute’s NSW Branch, died on Tuesday the 7th of April after a year-long struggle against cancer, cutting short her significant contribution to secondary schooling, science education, and the Australian Institute of Physics.

Jan was born at Ryde in February 1939, and spent her childhood in Parramatta. Educated at Macarthur Girls’ High School, from which she graduated as Dux, Jan demonstrated strong academic and sporting abilities, and always remained proud of her horse-riding skills. The results attained in her Leaving Certificate gave Jan free choice of the scholarships and bursaries then on offer to support attendance at tertiary institutions, but opted to undertake the Teaching Certificate for NSW high schools, marking the beginning of her devotion to education and its promotion.

Those who only met her later in life would be surprised to learn that despite majors in mathematics and biology Jan initially taught Social Science and Home Economics. Her first postings with the then Department of Education were at Burwood and Macarthur Girls’ High Schools, but her early career was interrupted by the birth of her two sons in 1960 and 1963. Jan returned to work full-time (as a secular teacher in the Catholic system) in 1985, extending herself by teaching geography and later geology, completing a course in conversational Indonesian in order to teach that language.

It was the teaching of geology that rekindled Jan’s interest in science, and she was sufficiently inspired to return to tertiary education, successfully undertaking a part-time Bachelor’s Degree in Geology and Paleontology at the new Macquarie University (1970–1974). In a typical display of her capability and determination, Jan completed the course in five years - a year faster than the normal programme and it gave her great pleasure to recount her success in passing a Statistics exam with high distinction while suffering from (it was later discovered) encephalitis.

The commencement of this Degree was Jan’s stepping stone into formal science teaching, and she returned to the State system as a member of the science staff at Parramatta High School. There, and later at Baulkham Hills, she taught geology and chemistry. In 1978 Jan was promoted to the position of Head Teacher (Science) at James Ruse AHS, one of NSW’s most prestigious selective secondary State schools: There she was personally responsible for raising the average marks to the point where Ruse students regularly appeared in the HSC top 10. Her skill and competence was recognised by the Department’s appointment of her as the Metropolitan West Regional Science Advisor, supporting some 60 State schools.

In the spirit of innovation she had shown in developing her teaching skills, it was during Jan’s tenure at Ruse that she decided to increase her knowledge by teaching herself physics. Despite not having been taught that subject (or even calculus) at school, she achieved considerable success in this endeavour - a fact that was recognised by her nomination as the first Visiting Teacher Fellow at the Australian National University. The resulting research project - A Communication Interface between Secondary and Tertiary Educational Institutions - paved the way for her increasing involvement in the promotion of careers in science to her students, particularly the gifts (for whom she was a powerful and inspiring role model).

In the same period, Jan was a regional president and later councillor of the Science Teachers’ Association (STA) of NSW, for whom she initiated and coordinated the STA’s Science Talent Search competitions. She was also state convenor of the BHP Science Research Prize, and worked to promote the original AMP-Beyond 2000 Science Competitions. In addition, several of Jan’s students enjoyed success in the international Physics and Chemistry Olympiads.

Professor Barry Ninham of ANU, amongst other members, pointed Jan towards involvement with the Australian Institute of Physics, and in 1981 she was invited to join the AIP (as a secondary teacher, she received the then rare accolade of full membership), and to address its National Congress - the first school teacher (and woman) to be so asked. Her participation was so well received that Jan want on to make presentations of various sorts at every Congress up to and including that held during the Australian Bicentennial year, but she was too ill to go to Melbourne this year.

In parallel with her completion of a Master’s Degree in Science and Society at the University of NSW, Jan was a member of the Institute’s Science Policy Committee (1983-1988), from which platform she expanded her contacts with physicists throughout the eastern states of Australia and even overseas.

Overlapping this involvement, and continuing until her death, Jan was the Associate Editor (Education) for The Australian Physicist, and also held the position of National Education...
OBITUARY

Tribute to a Teacher, Physicist and Friend

"So year twelve, what do I have to do to get your attention ...tap dance on the table?" Dead silence. All eyes turn to the front, to our teacher. Would she? It was an unspoken dare. A nanosecond later, there she was - arms flying, feet tapping,...and she had everyone's attention.

Who was this strong character, this powerful personality, who would not give in?

Many of you knew her as a special colleague, as Education Editor for this very publication, but my memories of Jan Powe are centred on the classroom where, as a senior high-school student, I was first introduced to the exciting world of Physics.

I had the fortune of attending one of the most truly non-sexist schools in Australia, where it was not only assumed that female students would study Physics along with their male fellow-students, but that they would excel in this subject also. They fulfilled this expectation. What gave this school its non-sexist environment? Surely the presence of such a dynamic, and successful role-model, in the form of Jan, our Head Teacher of Science, was an inspiration to the women students of the school.

Jan's enthusiasm about even the most basic areas of Physics was highly infectious. Many were the lessons, however, where the H.S.C. syllabus became a mere stepping-stone to more fascinating topics. Not only concentrating on Physics we discussed plate-tectonics and the reversal of the Earth's magnetic field. Quarks, neutrinos, evolution, relativity; there seemed no topic she was not willing and capable of addressing.

A vivacious mind, an inspirational educator, but that was not all of what Jan was to me. She cared about the students who were her responsibility, breaking through the traditional teacher-student barrier, to become a mentor and a friend.

There is one class in particular which I will always remember. Our investigations in the Nuclear Physics elective had led to a discussion of some ideas of Quantum Mechanics and current research in Particle Physics. I was spellbound. The rest of the class returned to their H.S.C. topic, but not me. My mind was mulling over, with the naivety of one not highly trained, the implications of some, as yet unexplained phenomena we had been discussing. An idea slowly formed in my mind. There were new, exciting, unsolved problems in Physics waiting to be investigated. I could be part of their discovery.

Jan Powe was a powerful inspiration to many through her years of teaching. Her influence will not die, but lives on through those students, like myself, who had the privilege of witnessing her incredible enthusiasm.

Sue Byleveld

Jan's funeral was attended by some 250 mourners, including many members of the AIP, with representatives from ANSTO, CSIRO Applied Physics, Sydney and Macquarie Universities, and UTS particularly prominent. The Institute has lost a valuable member and promoter, and worse, future generations of students have been denied the chance to be inspired and enthused by her: the premature passing of Jan Powe will be mourned by many, and the memory of her life and endeavours rightly cherished by us all.

Bradley James Powe
NSW Branch Treasurer
The Congress of the Australian Institute of Physics was held in Melbourne from February 10 to February 14, 1992. This meeting was a resounding success and the organisers are to be congratulated. Reports on the various sessions of the Congress, with particular emphasis on the plenary and invited speakers are presented in this issue of The Physicist. The talks themselves will be reproduced in later editions of The Physicist or in The Australian Journal of Physics. For those who did not attend this Congress, make plans to attend the next, which will be in Brisbane in 1994. The Asia-Pacific Physics Congress will be held in conjunction with that Congress.

PLENARY LECTURE
Symmetry and Physics

By Professor Chen Ning Yang
Chinese University of Hong Kong

Mankind is fascinated with symmetry. This is the basic reason why geometrical constructions have played such an important role in the Arts. Symmetry also plays a fundamental role in the laws of physics, although the precise reasons for this are not really clear.

Nature manifests itself in beautiful symmetrical forms, such as the biological structures like skeletons of radiolarians and snowflakes.

Symmetries have also played a dominant role in more creative fields such as painting, sculpture, music and literature. A poem written by the great poet of the Sung Dynasty, Su Dongpo exhibits a remarkable forward-backward symmetry. It can be read both ways, as seen below.

Schematic diagram illustrating the use of symmetry in fundamental physics

In the 19th century, Group theory was introduced simply to study the concept of symmetry in crystallography. However, in the 20th century symmetries have played a more profound role. For example, (i) special relativity and the concept of space-time symmetry and (ii) symmetries and conservation laws. The following diagram made in 1957, describes the role of symmetry at that time.

In 1956-57 it was realised that left-right symmetry was violated in nature. This was a great surprise to physicists. The studies of the violation of the discrete symmetries have continued in many directions. The two most important conceptual developments resulting from these investigations are firstly, the reaffirmation of the 2-component theory of the neutrino and secondly, the truly remarkable formulation of Kobayashi and Maskawa in 1973 that to incorporate CP-violation we require three generations of quarks. The fundamental reasons for the violation of the discrete symmetries remain a mystery. In fact, there does not even seem to be a hint of a possible solution for these violations. Theoretical structure of the physical world always has a reason and, therefore, such a solution must exist.

Continuous symmetries can be divided into two parts: ▲
(i) the kinematic symmetries like the quark model, which describe the spectrum of elementary particles. These symmetries have played a very important role in establishing the fundamental spectrum of the mesons and baryons. The following diagram exhibits the systematics of particles in SU(3) classification.

(ii) The dynamical symmetries. These symmetries have their origin in gauge theories. This is a subject developed by Hermann Weyl. He made an effort to unify electromagnetism and gravitation. He called it “Masstab Invarianz” which is translated as “Calibration Invariance”. Later, the German became “Eich Invarianz” and the English term became “Gauge Invariance”. His idea was the scale invariance. Consider two space-time points $x^\mu$ and $x^\mu + dx^\mu$ close to each other. Some physical quantity $f$ is such that it is $f$ at $x^\mu$ and $f + \frac{df}{dx^\mu} dx^\mu$ at $x^\mu + dx^\mu$. Weyl proposed a spacetime dependent rescaling of $f$ by a scale factor that is given by:

$$f + \frac{df}{dx^\mu} dx^\mu$$

at $x^\mu + dx^\mu$. Weyl called this a spacetime dependent rescaling of $f$ by a scale factor that is given by:

Now Weyl observed two interesting features. Firstly $S^\mu$ has the same number of components as the electromagnetic potential $A^\mu$, and secondly only the curl of $S$ appeared in the scale change. He set $S^\mu = A^\mu$. This scheme did not succeed. However, the idea re-emerged when Quantum Mechanics was formulated.

Following the work of Fock (Z. F. 39, 226 (1927)) and London (Z. F. Physics 42, 375 (1927)) $S^\mu$ is identified with $-i e A^\mu$ and not with $A^\mu$. This has profound consequences.

1. $\frac{ie}{\hbar c} A^\mu dx^\mu = \exp \left( -i \frac{e}{\hbar c} A^\mu dx^\mu \right)$

So that instead of investigating invariance under a scale-change, we now require invariance under a phase change. This phase invariance requires the existence of massless gauge bosons and restricts the interaction of radiation with matter. Consequently the idea of local phase invariance leads to Quantum Electro Dynamics.

These ideas of local phase invariance have been extended to more complicated groups to accommodate interactions among the gauge bosons, which is a consequence of the non-Abelian nature of the phase invariance.

A remarkable feature of present non-Abelian gauge theories is related directly to the fact that it allows one to formulate interactions with one coupling. This is the main theme today of attempts to unify all interactions and one expects profound future developments in directions such as Supersymmetry, Supergravity and Superstrings.

The schematic diagram below shows the role of symmetry in fundamental physics.

Girish Joshi
School of Physics
University of Melbourne
Professor Michael Berry FRS, (Bristol)

rather is rotated by an angle which is the solid angle enclosed by the path swept out in orientation space by the tangent vector. In 1986 Chiao, Wu and Tomita applied the Berry phase for a spinning particle to states of circular polarisation to derive the same result for the rotation of linear polarisation. Experiments with coiled optical fibres have demonstrated the effect. The monomode nature of these fibres suggests that Maxwell's equations should be employed rather than geometrical optics, and Berry progressed to discuss whether the phase in this case is a classical or quantum phenomenon. He promoted the latter viewpoint, but declared it to be a pseudoproblem, quoting Feynman that 'the photon equation is just the same as Maxwell's equations'. He then gave a brief overview of the derivation of the polarisation rotation for Maxwell's equations.

The next stream of anticipations began with Pancharatnam's research in the 1950's on interference patterns in polarised light passing through crystals of the most complicated types. In this situation the anholonometry involves the phase shift in the electromagnetic wave after passage through various materials has taken the state of polarisation through a closed cycle. With the description of the state of polarisation in terms of the Poincare sphere, the phase shift is found to be half the solid angle enclosed by the circuit executed by the polarisation state. (The factor of a half is due to the usual complications involved in representing the polarisation, a two state system for a spin-one field, in terms of a three-vector with its tip on the Poincare sphere). This part of the lecture was further enlivened by a digression to mention an exotic polarising crystal - Herapathite - which involved Herapath, Phelp's dog and a quinine treatment, in a manner that is best left as an exercise for the reader. In 1975 Budden and Smith displayed this phase shift as a general wave propagation phenomenon, in their analysis of geometric optics of an N-component wave field in inhomogeneous media.

In an adiabatic (WKB) treatment the wave is treated as staying in a "local" mode, which varies smoothly with the medium parameters along the ray, with two phase factors. The first is the phase memory which is the integral along the path of the WKB phase, while the second factor involves the variation of the eigenvalues of the local modes along the path. This second geometric memory reduces to the geometric phase if the system is hermitian. In recent work by Garrison and Wright (1988) the extension to systems with absorption was also analysed. This led to discussion of a geometric contribution to the phenomenon of adiabatic transition probabilities, or exponentially weak transitions. These transitions, for example between the different states of a quantum spin interacting with an adiabatically varying magnetic field arise when the field has a complex degeneracy. The transition probability is an exponentially suppressed one involving an integral over the time history of the magnetic field, and an additional geometric exponent (essentially this is the analytic continuation of geometric phase factors). In fact it turns out to be hard to find a field configuration which produces a non zero geometric phase and a rather complicated field is required. In 1991 Zwaniger, Rucher and Chingas reported NMR experiments where the geometric exponent contribution to the transition probability was extracted by exploiting time reversal to undo the dynamical part.

The final anticipatory thread was a brief mention of the role of the geometric phase or its classical limit, in classically integrable systems and the extension of this by Robbins and Berry to the chaotic case.

The second part of the lecture returned to the role of analogies and presented the geometric phase as the latest of a series of physics developments associated with circuits or cycles that occurred at Bristol University under the inspiration of Sir Charles Frank. The examples in this chronology of anholonometry included Frank's 1951 characterization of crystal dislocations as anholonony - the mismatch in transporting a vector around the defect, as compared to a perfect crystal, being the Burger's vector. These ideas were extended in 1959 to liquid crystal disclinations. Anholonometry appeared too in the work of Longuet-Higgins, Opik, Pryce and Sack (1958) on electronic sign changes near molecular electronic degeneracies - here the circuits are in shape space. The discussion of the Aharonov-Bohm effect in various manifestations was particularly interesting, as a catalogue of all possible variants of the classical and quantum nature of both the flux producing the phase shift and the system in which the interference was observed were briefly covered. In particular interference in a classical wave scattering off a quantum source of flux occurs in Steinberg's experiments with sound waves in liquid helium interacting with vortices, while the case of classical waves phase-shifted by a classical flux source can be found in the 'bathtub' experiment of Berry et al (1980) where ripple waves interact with an irrotational flow (vortex).

Another example of anholonometry mentioned was dislocations in waves, with line dislocations (e.g. threads of silence) where the phase of the wave has a 2x holonomy and the amplitude vanishes. This 1974 work of Nye and Berry has an anticipation too, in the study of tides by Whewell in 1833, and the identification of amphidromic points on the globe.

This was an informative and entertaining lecture; at times at breakneck speed. Along the way various sides, on regarding work as anholonony - the area enclosed by the heat engine cycle in the phase diagram, on the relation between Von Neumann and Wigner on electronic states and wheel balancing (in each case you need two control parameters to get degeneracies), and on Phelp's dog, kept the audience mentally on their toes. With a final reference to Charles Frank's observation that physics is not just about the nature of things, but also the interconnectedness of the nature of things, Michael Berry exhorted us to forget the things and only consider the relations between things.

Roland Warne
University of Tasmania

PLENARY LECTURE

Solar Flares: Current Dissipation or Magnetic Annihilation?

By Professor D. B. Melrose
University of Sydney

Professor Don Melrose, now heading the Research Centre for Theoretical Astrophysics at the School of Physics, University of Sydney, has been active for many years in the development of theoretical understanding for solar flare phenomena. Numerous research papers and an extensive section of his well known two volume monograph on plasma astrophysics testify to his impressive...
contribution in applying the standard plasma physics ideas (instabilities, non-linear wave-particle and wave-wave interactions) to the massive accumulation of astronomical data on solar flares and solar radio bursts.

Professor Melrose began his lecture by pointing out that solar flares are more energetic than any other processes occurring in the solar system. They involve an explosive release of $10^{24}$ to $10^{26}$ J of energy over a period of $10^{22}$ to $10^{25}$s in the solar corona.

Following a brief survey of observations on solar flares and their classification it was pointed out that the sudden onset of a flare tends to occur near neutral lines in magnetically active regions, particularly where the magnetic field is strongly sheared.

The lecturer then summarised the electric current models espoused by Giovanelli, Dungey and others, according to which relative fluid motions lead to electric fields large enough to give rise to runaway acceleration of electrons. The major difficulty with these models is their incompatibility with magnetohydrodynamics due to the magnetic energy being unable to propagate at the Alfvén velocity.

There followed a discussion of the alternative but yet complementary magnetic annihilation models, typically involving a magnetic interaction between two different current-carrying magnetic loops, magnetic reconnection being the actual mechanism for energy release. The most favoured of such models at present are the coronal storage models associated amongst others with the name of Sturrock. Like the electric current models, however, these suffer too from unsatisfactory features such as the possibility that magnetic stresses can be relaxed at the Alfvén speed rather than stored. In general the magnetic models neglect the global current system when it is precisely this system which must provide the essential coupling mechanism between the magnetic components of the model.

Professor Melrose concluded his talk by outlining a promising new approach of his own which through an idealized model for energy propagation, seems able to avoid the main objections to the electric current and magnetic reconnection models referred to above whilst including essential facets of both. It will be interesting to see how the future development of this approach can lead to an improvement in the present unsatisfactory state of theoretical knowledge about solar flares.

"demolishes" the photons being recorded, but is it possible to get information on light fields in a way that doesn't modify them? Professor Walls described a scheme for such a QND measurement involving the deflection of ground state atoms with well defined initial momentum as they traverse a standing wave light field (in a cavity). The deflection arises from the transfer of momentum between the atom and the light field when they interact. The light field is detuned from atomic resonance so that the probability of the atom making a transition to an excited state is negligible. Instead, the atom can absorb a photon to go to a virtual level, then quickly undergo a stimulated emission process to return it to the ground state with its momentum changed by zero or by plus or minus twice the photon momentum, depending on the directions of the emitted and absorbed photons.

Measurement of the output momentum distribution of the atoms gives information on the state of the field; for example, depending on whether the light field is a thermal field, a coherent state or a number state, very different momentum distributions can result. If the output momenta of sufficiently many atoms is measured, then the intracavity photon statistics becomes completely determined without having probed the light field directly at all. Because of stringent constraints on cavity lifetime and the need for negligible spontaneous emission.

Professor Walls believes that Rydberg atoms in high-Q microwave cavities are the most promising candidates for such an experiment with current technology.

Professor Walls then went on to discuss experiments in which the position of an atom might be localised to much better than an optical wavelength and some intriguing consequences of doing so. In a

Professor Dan Walls, President of NZIP

Ken Hines
University of Melbourne

Australian & New Zealand Physicist Volume 29, Number 5, May 1992 89
similar experimental arrangement to that of the previous paragraph, interaction between a two-level atom and a standing wave optical field through which it passes will give a phase shift to the field that will be different depending on whether the atom for instance passes through a node or an antinode. If the atom is initially localised to somewhat better than a wavelength of the light then measurement of the quadrature phase of the field gives a much more accurate localisation. Such a situation is equivalent to the atom having passed through a virtual slit whose width is determined by the precision of the localisation resulting from the measurement. Although such a slit is not a real slit Professor Walls and his coworkers have been able to show that diffraction will still occur from it as if it was real. He showed examples of far field diffraction patterns whose shape depended on the result of the measurement of the phase. The better the localisation of the atom implied by the phase measurement, the broader the far-field diffraction pattern, just as would be expected if the atom had passed through a real slit.

Even less intuitive is the concept of atomic focussing resulting from such a measurement of the phase of the standing wave field. If the result of the measurement is such that the atom is localised at an antinode of the field then it turns out that the measurement can leave the atom in a state in which there is a negative correlation between its position and momentum and its position distribution actually contracts with time, that is, the atom is focussed.

Professor Walls then went on to show that if the position distribution of the incoming atom is a little wider than in the previous two examples then it is possible for the quadrature phase measurement to cause the position distribution to have peaks in more than one position in such a way that interference can occur as a result of the atom having more than one possible path through the standing wave field to its final position.

Two recent papers from Professor Walls’ group, Phys. Rev. Lett. 67 1716 (1991) and Phys. Rev. Lett. 68 472 (1992) describe in detail the QND photon number measurement and the measurement-induced atomic diffraction and interference experiments discussed in his lecture. Although resigned never to trust intuition again, the congress audience received the lecture warmly. Such experiments are quickly becoming feasible and such tests of basic quantum physics are exciting to all physicists.

Russell McLean
CSIRO Division of Material Science & Technology

---

**PLENARY LECTURE**

The One-Atom Maser and Tests of Basic Quantum Physics

By Professor Herbert Walther

Sektion Physik der Universität München and Max-Planck-Institut für Quantenoptik, 8046 Garching, Fed. Rep. of Germany

‘An experimental tour de force’ and ‘a theorist’s dream’ have been used (Physics World, October, 1990) to describe Professor Herbert Walther’s exquisite little quantum device – the one-atom maser. In his latest model, a sequence of highly excited (n=63), velocity-selected atoms are injected one at a time into an ultrahigh-Q (3x10^{10}) superconducting niobium cavity at a temperature of just 0.1 K where they interact with a single quantized mode of a resonant electromagnetic field. Such a device permits the testing of detailed aspects of the coherent interaction between quantized electromagnetic fields and atoms.

Professor Walther commenced his lecture by discussing the modifications that can occur when an excited atom is confined in space within a cavity. Inside a cavity, the vacuum fluctuations are altered and the continuous radiation density distribution in free space is replaced by a discrete distribution corresponding to the discrete resonances or modes of the cavity. Thus, when the cavity modes are displaced from the resonance frequency of the atom, there are no vacuum fluctuations available to the atom and spontaneous emission of a photon is inhibited (the excited atom no longer decays), whereas when a cavity mode coincides with the atomic resonance frequency the vacuum fluctuations are enhanced and this enhances the spontaneous emission. In addition to the modification of the real emission of a photon, the proximity of the cavity walls also causes a modification of the virtual emission of a photon (Casimir force), i.e., a modification of QED effects, which is manifested as a slight modification of the Lamb shift. Professor Walther described an extremely sensitive experiment based on the Ramsey interference technique to search for these minute cavity level shifts. A beam of rubidium atoms is excited by a laser beam into a superposition state between the ground state and a highly excited n=30 (Rydberg) state, and these atoms are then allowed to process freely as they traverse a parallel-plate waveguide cavity. Although the Lamb shift scales as 1/n^2, highly excited Rydberg atoms are nevertheless very suitable for such an experiment since the probability of induced transitions between adjacent states is very large (scaling as n^4) and hence the radiation coupling is very strong. Since the frequency of precession depends on the energy difference between the ground and excited states, any modification of the Lamb shift due to interaction with the walls of the waveguide are detected as a shift in the phase of the precession by probing the atoms with a second laser beam as they exit the waveguide. It turns out that the modification of the Lamb shift is strongly enhanced when the plate separation is adjusted to 2λ, where λ is the wavelength of a transition between adjacent Rydberg states. Thus, using a highly stabilised laser having a bandwidth of 10 Hz, Wegener, Dirsche, Neizert and Walther have recently succeeded in measuring cavity level shifts of about 50 Hz in a transition frequency of 10^{13} Hz.

Professor Walther then went on to describe the one-atom maser and its application to the investigation of the dynamics of the oscillatory photon exchange between an atom and a single mode of electromagnetic radiation (Phys. Scripta T34, 5 (1991)). In the one-atom maser, highly excited (63P_{3/2}) Rydberg atoms of rubidium are injected one at a time into an ultrahigh-Q (3x10^{10}) superconducting niobium cavity, which is tuned to resonance with the 21.50658 GHz 63P_{3/2} - 61D_{3/2} transition and cooled to 0.5 K (more recently, to about 0.1 K) to exclude thermal photons from the cavity. Upon entering the cavity, a Rydberg atom in the upper state experiences the enhanced vacuum fluctuations and immediately emits a photon and falls to the lower state, whereupon it rapidly absorbs a photon and returns to the upper...
state, and so on. Thus a multiple exchange of photons (and energy) takes place between the cavity mode and the Rydberg atom as it transits the cavity. To demonstrate maser operation, the frequency of the cavity is tuned by slightly squeezing the Rydberg atoms with a piezoelectric transducer until a resonance appears in the population of the upper state corresponding to where the cavity frequency matches the atomic transition frequency, thereby allowing energy to be deposited by the atoms into the cavity. Resonances can be clearly seen for atomic fluxes as low as 50 atoms s\(^{-1}\), which corresponds to an average of just 0.004 atoms and 7 photons in the cavity at any one time. Such an experiment can be considered to be a microwave resonance experiment without any microwaves and with the vacuum fluctuations taking the place of the microwaves.

In order to observe the oscillatory photon exchange in the one-atom maser cavity, it is necessary to control the interaction times of the Rydberg atoms in the cavity by selecting just a single velocity subgroup of atoms from the Maxwellian distribution in the incident atomic beam. The oscillatory exchange, or “Rabi oscillations”, are then detected by selectively monitoring the populations of the two maser states with separate field-ionization detectors as the atoms exit the cavity. In such a one-atom maser, the Rabi oscillations are no longer periodic as in standard lasers and masers, but instead exhibit a complicated dynamical behaviour that depends on the photon statistics produced in the cavity. If there is no close to a coherent state in the cavity so that the photon distribution as a Poissonian distribution, the discrete, statistical nature of the photon field leads to a Rabi oscillation that initially collapses and then revives again some time later. Such collapse and revivals in the Rabi nutation, predicted by the Jaynes-Cummings model, are an explicit signature of the quantum nature of the electromagnetic field and were demonstrated experimentally for the first time by Walther and co-workers using the one-atom maser (Phys. Rev. Lett. 58, 335 (1987)).

Professor Walther went on to discuss some novel, nonclassical aspects of the photon statistics in the one-atom maser when almost all sources of noise, including spontaneous emission, thermal photons and velocity-smearing, have been excluded from the cavity. He started by showing some theoretical results of Meystre and co-workers (Opt. Commun. 58, 327 (1986)), in which the normalized standard deviation of the photon distribution, \(\sigma = \langle n - \mu\rangle /\sqrt{\mu}\), was calculated as a function of a scaled atomic interaction time \(\theta\), which is equal to \(2\pi\) when a atom enters the cavity in the upper state exists the cavity in the (same) upper state. The calculated curves of \(\sigma\) versus \(\theta\) show a familiar peak at \(\theta = 1\), corresponding to strong fluctuations at the masing threshold, but then, instead of \(\sigma\) reaching a steady value of unity as with Poissonian statistics in standard lasers and masers, it appears at values of \(\theta = 2\pi (q = 1, 2, 3, \ldots)\) a number of sharp maxima with \(\sigma > 5\) corresponding to nonclassical “sub-Poissonian” statistics, whilst in between the strong peaks there are broad minima with \(\sigma < 0.4\) corresponding to “super-Poissonian” statistics. If there were no velocity selection of the incoming atoms, these features would smear out and yield a value of \(\sigma = 1\). The sharp maxima at \(\theta = 2\pi, 4\pi, \ldots\) are a consequence of the back-action of the intracavity radiation field generated by upper-state Rydberg atoms that have previously passed through the cavity. Thus these maxima permit a measurement of the photon number in the cavity without altering the photon number - a quantum nondemolition-like measurement. Both sub-Poissonian and super-Poissonian statistics have recently been observed in the one-atom maser by Walther and his group by inferring the photon statistics from the populations of the upper- and lower-state Rydberg atoms as they exit the cavity (Phys. Rev. Lett. 64, 23 (1990)). The sub-Poissonian statistics observed in the region between the sharp maxima are found to correspond to a photon field with a variance 70% below the shot-noise level. The statistics turn out to be sub-Poissonian because the Rydberg atoms which traverse the cavity one after the other are correlated via the common intracavity field, which experiences only very small damping between consecutive atoms. This correlation has recently been studied in detail by Walther’s group by measuring the probability \(P(n)\) of finding an atom in the lower level at a time \(t\) after a first atom has been detected in the lower level at \(t=0\). When an atom leaves the cavity in the lower state, it has deposited energy in the cavity and so the next atom will tend not to be in the lower state, with the result that the lower-state atoms are more evenly distributed in time than the upper-state atoms, which have a Poissonian distribution. Thus there is an anticorrelation, or antibunching, of the lower-state atoms leaving the cavity and a sub-Poissonian distribution of atoms is generated in the lower state.

When the temperature of the cavity is lowered still further, to about 100 mK, so that essentially all thermal photons are excluded from the cavity, the theory predicts that additional structure, consisting of very sharp, deep minima, should appear on each of the \(\theta = 2\pi, 4\pi, \ldots\) maxima (Opt. Lett. 13, 1078 (1988)). At such low temperatures the whole system now becomes a quantum system and these sharp features, called trapping states, are the quantum eigenstates of the cavity: they are photon number states \(|n\rangle\) such that successive atoms now undergo an evolution of exactly \(2\pi\), or multiples thereof, as they transit the cavity. For example, the trap states in Fig. 2 correspond to 10 photons in the cavity with an evolution of \(2\pi n (q = 1)\); 9 photons \(q = 1\); 8 photons \(q = 1\); and so on. In this way, a certain flux of atoms passing through the cavity can now stabilise the photon number in the cavity. Professor Walther and his team have recently constructed a system incorporating a dilution refrigerator in order to achieve the very low temperatures required to detect these quantum states. By controlling the flux and speed of atoms passing through the cavity it should then be possible to lock the maser cavity to a particular photon number state.

Professor Walther then discussed the possible application of the one-atom maser to study the quantum measurement process and the question of complementarity. In a traditional Young's double-slit gedanken experiment, one normally determines which path the particle takes by precisely determining the linear momentum of the particle and, because of the position-momentum uncertainty relation \((\Delta x \Delta p \geq \hbar / 2)\), the determination of the position is then less well defined and the wave-like interference fringes are washed out (i.e., particle-like behaviour). Thus complementarity, or the prohibition of the simultaneous observation of wave and particle behaviour, is normally always connected with the Uncertainty Principle. Scully, Englert and Walther (Nature 351, 111 (1991)) have recently proposed an experiment to show that this is not the case and that complementarity actually goes beyond the Uncertainty Principle. If the interference particle is now an upper-state Rydberg atom and if a one-atom maser cavity in a number state is placed in each of the two paths in front of the slits, it is possible to study the photon exchange in the two cavities, i.e., to obtain which-path information without actually changing the linear momentum of the particle. When the cavities are in a number state it can be shown that the interference term which gives rise to the interference fringes disappears, but in this case the disappearance of the fringes is not a consequence of the uncertainty principle but rather a consequence of correlations between the measuring apparatus and the outcome of the experiment, viz., it is the information contained in the measuring apparatus that changes the outcome of the experiment.

The final topic of Professor Walther’s lecture concerned the laser-cooling of ions confined in a radiofrequency quadrupole trap (Phys. Rev. Lett. 59, 2931 (1987)).
ions in the trap are excited with a laser beam, it is relatively easy to generate sufficient photons ($\sim 10^4$ s$^{-1}$ in the case of strong resonance lines) to see just a single, trapped ion with the naked eye. Now when the laser frequency is tuned to just below the atomic resonance frequency, only ions moving towards the laser beam absorb photons and, by the exchange of linear momentum from the photons to the ions, the ions can be slowed and thus cooled to low temperatures. Professor Walther showed a fascinating photograph, taken with a microchannel plate attached to a television camera, of the fluorescence from just three Mg$^+$ ions cooled in a radiofrequency Paul trap and "crystallized" in an ordered arrangement, corresponding to the minimum energy configuration between the Coulomb repulsion of the ions and the trap potential. In the case of a Paul trap, ions that are not exactly in the centre of the trap experience a micromotion associated with the applied radiofrequency field and this limits the temperature of the ions to a few millikelvin. To overcome this problem, Professor Walther and his team have recently constructed a doughnut-shaped ion storage ring in which the cooled ions align exactly along the axis of the ring in a one-dimensional arrangement like a "string of pearls" (Phys. Rev. Lett. 69, 2007(1992)). In this way it is possible to cool the ions to microkelvin temperatures, where the de Broglie wavelength of the ions is now comparable to the separation ($\sim$ few microns) of the ions in the trap, and so it should be possible to generate a Wigner crystal. Professor Walther concluded his lecture by showing some very spectacular photographs of the fluorescence from some one-dimensional, ordered 'crystals' of ions condensed in the ring trap.

Hari began by acknowledged help from, and collaboration with, his many colleagues and pointing out that his association with suspension instrumentation began prior to his birth with a contribution by Hari's father to the first issue of the Journal of Scientific Instruments some 70 years ago.

Interferometry has a very long and distinguished history and the field was dominated by Michelson late last century and in the early part of this century. This domination was so great that there was a serious concern as to whether there was anything left to be done. Hari's aim in this talk was to show that there was indeed much left to be done. The lecture left the audience in no doubt of this. Indeed, it was clear that there is still much to be done more than sixty years after Michelson's death.

The developments in interferometry following Michelson were largely, but not entirely, stimulated by developments in the fields of lasers and fibre optics. Hari presented a systematic exploration of these developments.

First of all, there were some important developments in the pre-laser era. Three of the most important developments were shear interferometry which eliminated the need for a reference plane, the introduction of Zernike's three beam interferometer that could improve the measurement precision from $\lambda/20$ about $\lambda/2000$ and the development of double passed and confocal Fabry-Perot interferometry which gave a tremendous increase in throughput and contrast.

Following these developments, the next important phase followed the development of the laser. As we all know, the laser has the advantages of coherence and monochromaticity. This resulted in the possibility of observing optical beats and therefore of heterodyne interferometry. It is now possible to determine the phase of the beats using electronic detection. Heterodyne interferometry has a huge number of important applications. Three of those discussed in this lecture were:

(i) Length measurement: The metre is now defined in terms of the second by comparing stabilized lasers against a standard second from a Caesium clock.

(ii) Optical testing: A number of beautiful techniques were described. One example was a technique in which the phase of the output from a moveable detector was compared with that from a fixed reference detector. This allows the precision exploration of wavefront errors.

(iii) Laser-Doppler interferometry: Beat signals from the lasers are used to measure flow velocities and vibrating surfaces. It is now possible to measure oscillations with an amplitude of only a few thousandths of a nanometre.

The laser has also allowed the development of Laser feedback interferometry in which feedback of light back into the cavity of a laser causes the laser output to oscillate. This phenomenon allows the determination of velocities and can, for example allow the detection of speech inside a room by observing the vibrations of the window.

The developments of fibre optics has allowed the development of fibre interferometry. These techniques can be two orders of magnitude more sensitive than more conventional alternatives. The first application of fibre interferometry was to rotation measurement using the Sagnac technique. The latest versions are used in missile guidance systems and are able to get very close to the theoretical shot noise limit. Other applications of fibre interferometry include high resolution spectroscopy.

Hari then went on to describe the familiar principle of the Michelson Stellar interferometer. He pointed out that Michelson attempted to construct a large 15m version of this device, but had to abandon it due to stability problems. A technique designed to avoid the stability problems is the Intensity interferometer, which is close to the heart of every Australian physicist. The crucial limitations in intensity interferometry is its rather limited sensitivity. The path to increased sensitivity is to return to the original Michelson approach and it is this that is the basis of the new Sydney University Stellar Interferometer project. Hari briefly alluded to new possibilities using heterodyne techniques which are currently limited to work in the Infra-red but show promise of extension into the visible.

Interferometry continues to contribute to fundamental research connected with gravitation and relativity. The Michelson-Morley experiment has now been confirmed to very high precision using heterodyne techniques. A major current interest is in the problem of gravity wave detection. Hari pointed out that, if the correct interferometer is built, the required precision (one in $10^{21}$!) should be possible using 3km long arms. This possibility is being pursued by a group of Australian Universities.

Another interesting field is that of Phase conjugate interferometry. The use of
conjugate mirrors allows the interference of a wavefront with its mirror image. Phase conjugate techniques also allow for the possibility of detecting only transient events and greatly improved sensitivity.

Finally, Hari looked into the future in an attempt to foresee developments which will further push the boundaries of interferometry. Possibilities that are already apparent are greater use of solid state lasers, digital processing, non-linear materials, phase conjugation, fibre optics and squeezed light. The field of interferometry clearly has a lot of life left in it yet.

This plenary lecture was a stark warning to any who might feel moved to proclaim a field of science complete and was a marvellous testament to the role of creativity and ingenuity in science.

K. A. Nugent
University of Melbourne

MASSEY PRIZE LECTURE
Observations of Atmospheric Dynamics Using Radar Techniques

A History of One Technique

By Dr. B. H. Briggs
Department of Physics and Mathematical Physics
University of Adelaide

In 1931 J.L. Pawsley arrived in Cambridge to work under J.A. Ratcliffe, after graduating at Melbourne University. (Two years earlier H.S.W. Massey had also gone from Melbourne to Cambridge to work under Rutherford). Ratcliffe suggested that Pawsley should investigate the causes of the fading (temporal fluctuations) of radio echoes from the ionosphere. In order to do this, Pawsley set up two radio receivers whose separation could be varied, in order to find out over what horizontal distance the fluctuations were correlated. He found that this distance was several hundred metres. He also made a very important observation; sometimes the fading at the two receivers was similar but with a time difference. This, he suggested, was due to a horizontal wind in the upper atmosphere, causing a random diffraction pattern to move over the ground. Using diffraction theory, he showed that the pattern would move with twice the speed of the wind. (This later became known as the “point-source effect”). He also showed how to relate the scale of the pattern to the degree of angular spreading of the downcoming radio waves. These important results were described at a meeting of the Cambridge Philosophical Society in November 1934, and published in a seminal paper in 1935.

There the matter rested until Ratcliffe returned to Cambridge after the 2nd World War to rebuild his radio group. I joined his group as a research student in 1947. Ratcliffe wanted to develop Pawsley’s method to measure winds in the upper atmosphere, no other methods being available at that time. Several research students were involved. We soon realized that there was a problem in applying the method in its simple form because, unless the atmospheric motion is completely non-turbulent, the pattern will be changing in form as it moves. The effect of this is to make the derived wind speed too large; indeed, if the time changes are due entirely to turbulence, the fading records will match up best with zero time lag, leading to an apparently infinite horizontal velocitv! A model was needed, which included both wind and turbulence, by means of which the true velocity could be obtained. Such a model was described by Briggs, Phillips and Shinn in 1950 and further developed by Phillips and Spencer in 1955. Naturally some assumptions had to be made, and the model was not universally accepted.

In 1962 I moved from Cambridge to Adelaide. In the Physics Department at Adelaide, winds in the height range 60-100 km were being measured by Dr W.G. Elford using a meteor radar technique. The height range 60-90 km was suitable for observations by the spaced-antenna technique by making use of the weak partial reflections from these heights discovered by Gardner and Pawsley in 1953. However, the spaced-antenna method was controversial because of uncertainties about the applicability of the analysis technique, and about the validity of the point-source effect. It seemed to me that both these issues could be settled one way or the other by building a large array of receiving antennas so that the pattern motion could be directly observed. Graham Elford and I together designed such an array, to operate at 2 and 6 MHz. Situated about 40 km north of Adelaide, it has become known as the “Buckland Park array” We knew that the array would have to be at least 1 km x 1 km in order to encompass several maxima of the irregular diffraction pattern. We finally decided on a circular shape containing 89 pairs of crossed dipoles. Each of the dipoles had its own buried coaxial feeder line running to a central laboratory. There, the outputs of 89 radio receivers were digitized and recorded on magnetic tape. The output voltages were also used to control the brightness of 89 light globes, arranged in the same configuration as the antennas, so that the motion of the pattern over the ground was made visible. The moving pattern was also photographed with a cine-camera.

By applying a two-dimensional correlation technique to the 89 channels of data it was possible to get a good estimate of the distance moved by the pattern in a given time. The velocity obtained in this way required no assumptions to be made about the statistical properties of the pattern. It was compared with the velocity obtained simultaneously by the more controversial three-antenna technique, corrected for the effects of random changes. The agreement was good. The point-source effect was tested in the following way. A transmitter was switched rapidly from one antenna to another 91 metres away. The pattern was observed to move the same distance in the opposite direction. This geometrically equivalent to the point-source effect.

Having established the validity of the three-antenna method, it was then adopted as a standard method for wind measurement. It has been continuously developed and refined, largely due to the work of Dr R.A. Vincent, who joined the group in 1970. The analysis is now carried out in real time, and gives velocities every two minutes over the height range 60-96 km. This provides a valuable database which can be analysed to give information about prevailing winds, tides, atmospheric gravity waves, and other forms of wave activity in this height range.

Dr W.K. Hocking began to make measurements of upper-atmospheric turbulence at Adelaide in the early 1980’s. His method was based on the idea that the power returned to the radar will be spread in frequency because of the Doppler shifts imposed by the randomly-moving scatterers. The spreading can be used to...
estimate the root-mean-square velocities. This would be straight-forward were it not for the presence of Doppler shifts produced by the horizontal winds. The latter can be minimized by using a narrow antenna beam directed to the zenith. The Buckland Park array was ideal for this purpose, being the largest array in the world for work on medium frequencies. Nevertheless, a correction for the horizontal velocity, and some other corrections, still had to be made.

Also in the early 1980’s R.A. Vincent and I.M. Reid devised yet another use for the array which had not been envisaged when it was originally designed - the measurement of the vertical flux of horizontal momentum. This flux is believed to be important as one of the main driving forces for the general circulation of the upper atmosphere. Gravity waves generated in the denser lower atmosphere travel to the upper levels where they may deposit their energy and momentum in a region of much lower density. Vincent and Reid showed that the required flux can be determined by measuring the velocity fluctuations in two off-zenith directions. They used the Buckland Park antenna array to produce beams at ±11.6° from the zenith, and measured the fluctuating Doppler shifts in each direction.

The array at Buckland Park was originally designed, for economy reasons, to operate only as a receiving antenna. However, a much better radar performance can be achieved if the large array is also used for transmission. The necessary changes are now being implemented, under the guidance of Dr. I.M. Reid. The new system will have greater sensitivity and narrower beamwidth. Many other improvements will be incorporated, such as rapid computer-controlled beam swinging. Previous observations will be continued with greater precision, and new types of observation will become possible. The future of the work is bright.

Unfortunately there was no time in the lecture to say anything about the relation of the Adelaide work to that in progress elsewhere, in Australia and world-wide. Therefore, in conclusion, I would like to emphasize that atmospheric physics is a discipline in which close cooperation between groups is essential. This is being well fostered by the present leader of the Adelaide group, Dr. R.A. Vincent, who is active on many international committees, and is currently President of the International Commission for the Metrology of the Upper Atmosphere. I thank him, and my other colleagues and students, for their help over the years. I hope that they will all feel that they share the honour of the Harrie Massey prize.

Zwi Barnea
University of Melbourne

---

**PLenary Lecture**

**X-Ray Physics with Synchrotron Radiation**

By Professor Michael Hart, FRS
University of Manchester, UK

Electromagnetic radiation is central to our knowledge of the Universe. Hence a new source billions of times brighter in any part of the electromagnetic spectrum must excite considerable interest. This would be true even if the exploitation of synchrotron radiation did not include the extraordinarily broad range of disciplines that it does from biology to material science.

It is about 20 years since synchrotrons have come to be used as sources of electromagnetic radiation. Conventional x-ray tubes and rotating anode x-ray tubes delivered about 10⁶ units of brilliance. The first generation of synchrotrons, used in parasitic mode, increased this number to about 10¹². The second generation, dedicated to use as sources of electromagnetic radiation but of similar design, achieved values of about 10¹⁴. The European synchrotron (ESRF) had its funding fortunately delayed. Its design is therefore specifically planned for optimum output and constitutes thus a third-generation instrument which can reach with the use of undulators an output of 10¹⁹ units. Even this is not the foreseeable limit and free-electron lasers whose design remains to be achieved promise even higher intensities.

Third-generation synchrotrons will make it possible to investigate for the first time the in vivo behaviour of biological systems by real-time microsecond exposure of proteins using, for example, the Laue technique. In condensed matter studies they will offer new opportunities in the fields of nanotechnology, dilute systems, high-energy x-ray scattering, x-ray polarimetry and gamma-ray interferometry.

It is intriguing to compare the conventional x-ray tube in which the electrons are decelerated in the solid target with the deceleration of the electrons (or positrons) by the bending magnetic field of the synchrotron. It is noteworthy that in both instances the limitation on the intensity of the x-rays produced is the melting point of a solid of the tube target or of the synchrotron components.

It is therefore one of the first tasks to develop components, such as monochromators, which can perform successfully at an incident power of, say, 100 watts/mm². Monochromators satisfying these requirements must be cooled by water jets and the resultant distortion of the monochromator must then be corrected by the backpressure of helium at about 80 kPa.

The high construction costs of synchrotron facilities, beyond the reach of countries with populations below about 50 million, are of course notorious. Considerable insight and lively amusement was, therefore, generated by Professor Hart’s comparison of the price of photons from an x-ray tube advertised in a popular journal in 1914 at $4.30 and the price of a synchrotron in 1992. The conclusion was that while the source brilliance had increased in the course of the intervening 78 years by a factor of 10¹⁴, the cost increased only by a factor of 10⁸. If consideration were given to the relative number of photons actually delivered at the specimen, synchrotrons would in fact be found to be an even greater bargain.

Zwi Barnea
University of Melbourne

---

**Meeting Announcement**

**Recent Advances in Two-Dimensional and Nanostructure Electron Systems**

**20-21 July 1992**

School of Physics, University of New South Wales
Sydney, Australia

National and international speakers will discuss recent theoretical and experimental developments. It is hoped that there will also be a session of contributed papers.

For further information please contact D. Neilson
Phone: (02) 697 4564, Fax: (02) 663 3420
University of New South Wales, Kensington NSW 2033 Australia
Internet: neilson@newc.phys.unsw.edu.au
Dr. Alun Jones, Executive Officer IOP, Mrs. Jones, Dr. Rosemary Lee (GEC) and Professor Cyril Hilsen (IOP)

I N V I T E D P A P E R
Educating Physicists

Professor R. J. Blin-Stoyle
President of the Institute of Physics
United Kingdom

Problems With Current Science Education In the United Kingdom

i dominated by examination hurdles
ii inflexible
   a once a course is started, there is little scope for sideways movement for a year or more.
   b courses of one- or two-years duration are assessed by all-or-nothing exams at the end.
iii relatively small number of people studying Physics (very few studying Science Education). A small and decreasing percentage of people going on to study Physics at University.
iv a public perception that there is little career future in studying Physics. There needs to be better education of the general public to the fact that physics education is excellent training for a range of occupations.

Some Current Changes in Science Education

0 - 5 Years
there is a growing realization that these years are important in science education because it is at this time that gender bias towards Science and stereotypes of Science become established in children.

5 - 16 Years
i Science is becoming well established in U.K. primary schools
ii the National Curriculum has established Attainment Targets in Science relating to Investigation, Life and Living Processes, Materials, Physical Processes with 10 levels of attainment.
iii All students at age 14-16 years prepare for GCSE which deals with Balanced Science. This can mean either a Coordinated programme of studies in physics, chemistry, biology etc or an Integrated programme in which the individual disciplines have no separate existence. Either way the separate subject of Physics as such does not exist.

There are obvious fears that Physics will be lost or submerged in this new approach or that the physics will be over-simplified. On the other hand, most of the Attainment Targets are clearly physics-related and give physicists a good opportunity to spread the message. One need is for better cooperation with the mathematics teachers and also for greater emphasis on real-life applications of Physics.

16 - 19 Years
There is a widely held opinion that the present courses are overspecialised; that insufficient students take modern languages and that too small a percent-age of the population continue with education (presently 20% of the population continue to tertiary level study).

The choice facing such students presently is an academic stream (A-levels) or vocational training. A-levels involve a 2-year course of specialised subjects with no changes possible (the "tramline effect") and a guaranteed 25 failure rate.

Some suggestions at 16-19 Years
i integrate academic and vocational studies with balance, variety and flexibility (e.g. offer modules and short term targets). This approach poses the challenge of how to integrate the understanding gained in the various modules.
ii use differentiated assessment methods rather than just exams. Cater for a wide range single make-or-break hurdle at the end of the course.
iii provide varied teaching and learning experiences
iv give credit for achieving shorter-term goals e.g. award a Certificate after 1-year and a Diploma of Advanced Education after 2 years.

Implications For Tertiary Education

The government hopes to increase participation rates to 30%. Together with the changes to secondary education this will mean:

i university intake will be more varied in ability and background
ii departments will need to use new learning techniques and provide short preliminary courses.

The Structure of Degree Courses

B.Sc. Degree Course
This has become overloaded with material. There is an over-emphasis on facts and a lack of time for reflection. It is significant that 20 Universities are introducing 4-year B.Sc. courses.

Suggestions
i reduce the B.Sc. course content by 113
ii introduce more modern applications of physics

Masters Degree
For those who intend to continue with research after their B.Sc. there could be a need for a non-specialist Masters Degree. There should be provision for people to exit from higher education at various points (e.g after 1 year or 2 years) with appropriate credit.

Reporting should include several assessment modes not just a final grade.

Delivered by Dr. A. Jones
Chief Executive of IOP

Australian & New Zealand Physicist Volume 29, Number 5, May 1992
average energy dissipation of $k\log_2 k$. In such irreversible computers, the initial information is lost, being incapable of reconstruction from the output. Following Charles Bennett, Landauer introduced the idea of reversible computation, in which the output is not discarded, but is stored. Likharev showed, that with an appropriate choice of a set of logical functions, reversible computation could be achieved in principle. By way of example, Landauer pointed out that a "gedanken" realisation of such logic-performing elements is possible, based on deformable potential wells which change in time from a single minimum form to a double minimum form, or the reverse. As a result of each logical operation, the output bit, 0 or 1, is represented by the particular minimum into which the system settles in the double well. With slow enough computation based on these elements, it may be shown that the dissipation can be reduced below any desired amount.

Landauer now turned to quantum questions. Following Paul Benioff, it was shown that for slow enough computation, the requirements of the uncertainty principle of quantum mechanics could be satisfied by excitation energies, $\Delta E$, in the computer's memory elements, below any desired limit. In summary, neither thermal physics nor quantum physics places a lower bound on the energy required by a given computation.

Landauer's final remarks were addressed to the implications of dissipationless computing for physical theory. Are there no limits on computation imposed by physics? In a finite (or even infinite) universe, space alone will limit the size of the memory, which has to be huge, because information is never discarded in reversible computing. Large pieces of matter inevitably degrade or are affected by the rest of the universe, e.g. by split coffee, electrical noise, cosmic rays or matter diffusion. Nature will set her own limits.

On the other hand, the arguments and proofs of mathematics, assume that the number of operations is unlimited. This cannot be the case, as even the storage of $\pi$ requires an infinite number of memory cells. Mathematics has to be realised in matter, whether it be in computer memories or in human brains. Landauer believes that information handling is limited by the laws of physics and the size of the universe, and this will represent a limit, particularly to continuum mathematics, when it goes beyond the merely formal.

Geoffrey I. Opat
University of Melbourne

*For an extended account of this talk, see Physics Today p23, May 1991.
Optical Physics and Millimetre Waves - Day 1

The morning session commenced with an overview from John Davis of the newly-operational Sydney University Starfall Interferometer (SUSI) which will provide the opportunity to study stars with unprecedented angular resolution. A key element of SUSI is the optical path length compensation system which maintains equality of the optical paths via the two arms of the interferometer to within a small fraction of the coherence length of the starlight. One of the limiting factors of SUSI is the effect of diffraction in the long optical paths, and calculations of these effects were later presented in a post-deadline paper by Mark Hrynevych. In the second invited lecture, Keith Nugent (University of Melbourne) presented some new perspectives on optical coherence, in which the light propagation is described purely in terms of optical intensity and direction of propagation with no reference to the phase of the field. This permits wavefields in any state of coherence to be fully characterised using three-dimensional intensity information. The next two papers discussed the development of a Scanning Near-Field Optical Microscope at the University of Melbourne. Ann Roberts presented calculations which place constraints on the positions of the detector relative to the sample and Duncan Butler showed the first true near-field optical measurements of the optical intensity produced by an optical fibre.

After lunch Jesper Munch presented an overview of the new optics programme at the University of Adelaide. He described the use of real-time holography and phase-conjugation techniques to compensate for time-dependent optical aberrations, such as the effects of atmospheric turbulence on the resolution in telescopes and the effects of medium inhomogeneities on the beam quality in high power lasers. Brendan Allman (University of Melbourne) followed with a presentation of a method for determining refractive index profiles in planar media such as dielectric waveguides using an analogue of the Lloyd’s mirror experiment known as Lloyd’s mirage. Stewart Martin (University of S.A) described an electronically scanned white-light interferometer for measurement of displacements to within 3 microns and for use in fibre optic pressure sensors in medical applications. In the final paper of the session, Hans Bacher (ANU) discussed a new form of interferometry for optical depth measurements which involves detecting the Gross-Lindelof differential phase shift between several optical beams propagating through the sample.

The final session of the day was devoted to millimetre waves. The invited speaker, John Archer, presented details of recent progress in GaAs-based millimetre-wave integrated circuits at CSIRO Radiophysics. The group there have pushed the performance of HEMTs and schottky diodes well beyond 100 GHz and incorporated them into MMIC amplifiers, oscillators, mixers and frequency multipliers. Lew Whittbourn then reported a talk on recent millimetre wave and sub-millimetre wave research at the CSIRO National Measurement Laboratory involving lasers, grids and detectors. In the final two papers, Ross MacPhedran (University of Toronto) discussed the use of a simple equivalent circuit for modelling very thin grids and a rigorous electromagnetic theory for modelling thick, perfectly conducting capacitive grids.

Optical, Laser & Atomic and Molecular Physics - Day 2

The eminent Russian physicist, Vladilen Lisevich, began with a Keynote Lecture on his pioneering work in the exciting new field of atomic optics with laser beams. He described the use of laser light to manipulate atoms, including the deceleration, collimation and channeling of a thermal beam of atoms; the reflection of an atomic beam from an atomic mirror consisting of an evanescent travelling light wave; and a novel scheme for transporting a slow beam of atoms along a fibre. In the second invited lecture, Geoffrey Sedman described the He-Ne ring laser interferometer currently under construction at the University of Canterbury. In its final form the interferometer is mounted on a zedur table in a wind tunnel some 30 m underground in the hillsides of suburban Christchurch. The ring laser has a potential frequency resolution of 1 part in 10^13, corresponding to a beat frequency of less than one millihertz, and should be capable of measuring phase shifts between counter-circulating beams of 10^-10 radians and rotations down to about 10^-16 rad. s^-1. Thus such an facility offers the prospect of a wide range of new fundamental physics experiments, including novel tests of special relativity, obtaining an upper limit on the chirality induced in the vacuum by electromagnetic fields, precision tests of Fresnel drag in moving media and the search for exotic pseudo-particles, as well as having important applications in seismology and in monitoring Earth tides. A highlight of the lecture was the playing of an "audio" of the beat signal (bumped up by a factor of 4 in frequency) produced by the Earth's rotation. Bruce Stenlake (ANU) then described some of the conditions under which it should be possible to use an evanescent standing-wave light field as a reflection grating to diffract sodium atoms. In the final paper of the session, Murray Hamilton (University of Adelaide) reported high resolution two-photon absorption measurements of the sodium 1S-3S two-photon transition for the case where the exciting laser has random telegraph phase fluctuations.

The invited lecture after lunch, by Wes Sandle, described some new optical switching behaviour recently observed at the University of Otago. When an external (dye) laser tuned to the near 588.2 nm (1S2p^2-1S^2) wavelength is used to pump a commercial He-Ne laser, stimulated Raman emission at both 650.0 nm (1S-1P^2) and 659.9 nm (1P-1S^2) was observed and under certain conditions the Raman lines exhibit intriguing optical-bistable and polarization-flipping behaviour. Xiaowei Xia then went on to discuss details of the criteria for observation of the Raman emissions in the He-Ne laser. The final two papers described recent spectroscopic research at CSIRO Materials Science and Technology: David Gough reported the application of a frequency-doubled cw Ti:sapphire laser to Doppler-free spectroscopy in the near-ultraviolet (360-410 nm) in Yb I, Yb II and Pb I, and one Wayne Rowlands described an external-cavity diode laser system with smooth-scanning narrow-bandwidth operation for high resolution spectroscopy in Zr.

In the final session, Erich Weigold (Flinders) presented an invited lecture on the application of (e, 2e) spectroscopy to the study of the electronic structure of atoms, molecules and solids. He reported the first measurements of the momentum density profiles of both excited and oriented target atoms, which consisted of sodium atoms pumped to the 3p, M_{-1} state by circularly polarized laser light. Rod Tobin (Monash) then described investigations of an observed enhancement in the output power of a 780.8 nm copper hollow-anode-cathode laser caused by the application of a longitudinal magnetic field. The final paper of the session, by N.W. Mortarty (ADFA), described an investigation into the reliability of ab initio molecular orbital theory for calculations of molecules containing transition metal atoms.

Quantum Optics - Day 3

David Pegg ( Griffith) commenced the morning with an entertaining invited talk on wave function collapse in atomic physics. He showed examples of how the D-
concept of wavefunction collapse can be usefully employed in predicting the statistics of results in three well-known experiments (and also in some less familiar ones): photon anti-bunching in the fluorescence of a two-level atom, interrupted single-atom fluorescence from a laser-driven three-level atom, and single-photon phase difference states produced by the signal and idler modes in degenerate parametric down-conversion.

Pegg examined the question of whether or not wave function collapse is really a physical process and then, after surviving a flip-of-the-coin to decide whether he should remain in the room and continue his lecture, he went on to conclude that if physics is meant to be a description of the real world including the observer then the collapse concept would seem to preclude an accurate description and so should not be part of physics. In the following paper, Gerard Milburn (University of Queensland) presented model calculations of quantum coherence and classical chaos in a parametric amplifier driven by a periodically pulsed pump field inside a cavity containing a Kerr nonlinearity. Bryan Dalton (University of Queensland) then described the theory of the Hanle-effect correlated emission laser, in which the coherent excitation of three-level atoms in a cavity can produce a correlation between the two driven transitions, thereby leading to a reduction in quantum noise. Barry Sanders (Macquarie) went on to consider the case when a coherent light field is passed through a nonlinear interferometer and the output state is a superposition of two separated coherent fields, and concluded that this entanglement of the two coherent states leads to a violation of Bell's inequality and thus facilitates a test of local realism. M. Hall (ANU) then presented a paper in which the statistics of quantum observables are represented by "positive-operator-valued measures" (POVM's) and demonstrated that POVM's can be constructed to correspond to time and electromagnetic-phase observables. The morning session concluded with a paper by Mark Andrews (ANU) who reported that some recently published work on the suppression of quantum tunnelling by the application of a periodic force can be understood as a two-state phenomenon analogous to early theoretical studies of the Hanle effect with a transverse oscillating magnetic field.

The afternoon session was devoted to experimental papers on the suppression and reduction of optical noise. The invited talk, presented by Hans Bachor, gave a simple interpretation of squeezed light which was then used to describe two recent experiments in which noise suppression below the shot-noise limit had been observed at the Australian National University. In the first experiment, the coupling between the atoms and the surrounding cavity leads to a correlation between the amplitude and phase fluctuations, resulting in an observed noise suppression of 18%. In the second, the mechanism involves the charge correlation between the fluctuations of light emitted from a high efficiency source (an LED) and the sub-Poissonian statistics of the driving current. This was then followed by papers by Paul Edwards (University of Canberra) on "sub-Poissonian light, correlated light beams and the quantum watchdog effect"; Matthew Tuchman who described an experiment to measure the intensity fluctuations in the light transmitted by a cavity whose length is controlled by a current derived from the intracavity intensity; and Malcolm Gray (ANU) reported schemes to suppress the classical noise in devices such as electric field sensors in order to achieve quantum-noise limited sensitivity.

Peter Hannaford & Ann Roberts
CSIRO Division of Materials Science & Technology

SCIENTIFIC SESSION
Particle & Nuclear Physics

This section of the AIP Congress doubled as the AINSE Conference on Nuclear and Particle Physics, the 14th in that biennial series.

The Conference ran for four days with some 35 oral presentations plus a large, and lively, poster session. The program was diverse, representing the wide ranges of interests in both the Particle Physics and the Nuclear Physics communities in Australia.

Each oral session commenced with a review talk. We were able to attract a talented set of overseas speakers to complement the talks by an equally talented set of local speakers. For your rapporteur the highlights were Torrief Ericson (CERN) in his opening talk "Recent Developments in Nuclear Physics", Taka Kajino (Tokyo) on "Primordial Nucleosynthesis in the Early Universe", Gary Crawley (Michigan State University) "High Energy Heavy Ion Reactions" and Tony Thomas (Adelaide) "The Truth about the EMC Effect". Others would have their own selections; the talks were all good!

The shorter talks in each session, and the posters, quite naturally reflected the current research interests of Australian groups. Perhaps the best way to indicate the breadth and vitality of the field to our colleagues in other disciplines is to list the areas covered without attempting to single out individual talks.

The many talks, both theoretical and experimental, from physicists at the ANU indicated the scale of the program being undertaken there, in association with the University of Auckland, on Heavy Ion Physics.

From the University of Melbourne experimental data were presented on both Photonuclear Reactions and Nuclear Reactions of Astrophysical importance, while theoretical talks covered both Nuclear Reactions and Nuclear structure.

The Experimental Particle Physics group from Melbourne presented a wide range of activities, from analysis of existing data from CERN and TRIUMF to developing detectors for future accelerators.

High Energy Theory was well represented, with papers on fundamental concepts (from the Universities of D↓

L to R - Dr. Graeme Putt, Mr. Graham Sorell and Dr. Stuart Tovey
Tasmania and N.S.W.) and phenomenology (the University of Adelaide).

Accelerator Mass Spectrometry is a growing field and a talk from Anato reviewed work underway both there and at the ANU.

Finally, having said that I would not single out any talk, I will do just that. A very nice presentation (from Auckland) showed how a table-top experiment on Superallowed Beta Decay may help to improve knowledge on a fundamental constant, one of the elements in the Cabibbo-Kobayashi-Maskawa matrix which describes the mixing of quark flavours in the Standard Model of Particle Physics. A good illustration of the interrelationship of Nuclear and Particle Physics.

In conclusion the participants in the Particle and Nuclear Physics session of the Congress enjoyed the plenary talks and we profited also from our own varied program.

Stuart Tovey
Research Centre for High Energy Physics
University of Melbourne

**SCIENTIFIC SESSION**

**History of Physics in Australia and New Zealand**

A Section on the ‘History of Physics in Australia and New Zealand’ was held at the Congress for the first time. About 40 to 50 participants heard five excellent papers; it was especially pleasing to see Em. Prof. Bert Bolton in the audience after a serious illness had prevented him from bringing his organisation of the Section to its fruitful conclusion.

Richard Threlfall’s mature and pioneering career at Sydney University has been surveyed previously, but Jim McCaughan (U. of Sydney) gave us a fascinating new picture of Threlfall’s early life and formative years. Very early Threlfall was making scientific apparatus in his family’s farm workshop, undertaking chemical experiments, and learning from his mother’s teaching. Most remarkable of all was the science he enjoyed at Clifton College during the 1870s. In addition to extensive classroom science lessons, it had a Scientific Society to which students read papers and which published printed Transactions to which its students contributed - still a useful model 120 years later!

Peter Robertson (Aust. J. Phys., CSIRO) provided a taste of the large manuscript he is preparing on the history of the Parkes radio telescope. Unlike the UK and USA, Australia kept its war-time Radio Physics Laboratory intact, and by the early 1950s plans were developing for new, innovative facilities. Improved resolution required interferometric techniques, while larger aerials were needed to improve sensitivity. In the latter case, funding from the Carnegie and Rockefeller foundations and the Commonwealth government - and the cooperation of an outback farmer - eventually allowed the Parkes dish to go ahead. And made it such as it has been - for 30 years and still going strong.

Richard Payling (BHP Res. & Tech. Centre) outlined an intriguing piece of very recent history ‘The role of the Australian Institute of Physics in the foundations of FASTS’. He reminded us of the recession of 1983, of Barry Jones’ battle with CSIRO, his futile efforts to interest the Hawke government in science and technology, and of the disastrous 1983 and 1984 federal budgets. Science funding was slashed, Jones became agitated and then lashed out (scientists are whimp), and Geoff. Wilson and then Fred. Smith began a fightback by calling together six, then eight, and later many more of Australia’s science and technology societies. Payling’s paper concluded with the November 1985 foundation meeting of FASTS. It has achieved much, it will achieve more, and it began thanks to Geoff., Fred., and the AIP - a proud episode in the history of our small institute.

Anna Binnie’s paper (St. Aloysius College, Sydney) traced the historical development of an accurate value for the electronic charge. Millikan’s oil-drop experiment, she pointed out, was not conceived in isolation, but was a natural outgrowth of earlier experiments with water droplets and competing fields (electric, magnetic and gravitational).

Laby and Hopper in Melbourne contributed to a later chapter of the story, which could also be viewed as a history of the search for an accurate value of the viscosity of air.

John Mainstone’s contribution (U. of Queensland) seemed very remote in time and place for the history of physics in Australia and New Zealand. “A slow path to understanding: the case of the overblown pipe”. It concerned Newton’s struggle to comprehend the overtone/harmonic structure of organ pipe sounds and the higher octave note of the overblown pipe. Mainstone suggested that Newton made significant advances in understanding these phenomena, in part by watching Thomas Thambur build a new organ in Trinity College (Cambridge) chapel. Mainstone then related these problems to Neville Fletcher’s seminal research on organ pipe in the 1970s and 1980s. The loop had been closed, bringing to an end an excellent afternoon of physics history.

John Jenkin
La Trobe University

**SCIENTIFIC SESSION**

**Condensed Matter and Materials Physics**

The Condensed Matter and Materials Physics Section was well attended, with 58 contributions. Although the annual condensed matter meeting was held in New Zealand just two weeks earlier, interest at the congress was high and there was little overlap in the presentations.

Posters are a tradition in condensed matter. Three sessions at the congress provided ample time to scrutinise over 40 presentations. Seven speakers were invited, including four from overseas, and a further ten talks were contributed. The range of seniority of the speakers was unusually broad: Louise Mason (University of Melbourne) spoke confidently about her first research project, and Bob Street (U.W.A.) ably proved that there can be research life after high office.

Superconductivity remains the largest single area of activity, with significant contributions from both the CSIRO Division of Applied Physics and Monash University. In the continuing push towards fabrication of high-Tc thin-film and other devices, authors concentrated on the formation of grain boundaries and consequent effects. The emphasis is on preparative techniques such as micro lithography with modifications.

Ted Collings (Battelle Memorial Institute, Ohio) spoke about designing solenoids from high-Tc ceramics: the optimum wire dimensions and proportion of copper depend on cryophysical considerations; for example, a small number of laminations must either contract or rapidly expand to prevent permanent damage. Front velocities of up to 300 m/s are possible.

John Close (Berkley) described experiments to measure the quantum of circulation in superfluid $^4$He. A vibrating wire inside a vortex of fluid is “plucked” by a current pulse, and the beat frequency is measured and depends on the circulation via the Magnus force. Temperatures down to 150uK are required, and in order to circulate the fluid the entire refrigerator is rotated at a few rads/s. Cooper pairing is found to be present in the B-phase of $^3$He, and experiments on the A-phase are in progress.

Martin Speth (Paderborn) and Mark Smith (CSIRO) described high resolution multiple and mixed ESR and NMR spectroscopies. These techniques have been devised recently, and although they are complex they provide a significant

*Australian & New Zealand Physicist Volume 29, Number 5, May 1992*
improvement in the characterisation of structures and point defects.

Bob Street (U.W.A.) and Quentin
Pankhurst (Liverpool) presented results on
magnetic particles. Starting from his 40-
year old study with Wooley, Street
demonstrated the importance of viscosity
effects in modern permanent magnet
materials. Periods of over a minute can be
necessary for the magnetisation to
stabilise. Pankhurst debunked a number of
long-standing "anomalies" in magnetism
on the basis of high-field Mössbauer
spectroscopy.

Theoretical condensed matter was
represented by John Dobson, who
discussed the density functional approach
to the calculation of electronic properties.
Theory-only presentations in condensed
matter sometimes appear dry and obscure,
however in comparing his theory to a
chocolate covered ice cream with a mushy
interior, Dobson was successful in
providing an understandable and
entertaining account.

Robin Pollard
Monash University

**SCIENTIFIC SESSION**

**Astrophysics**

The Astrophysics sessions covered the
whole of Tuesday February 11 together
with the following Thursday morning
which was devoted to Antarctic
Astronomy.

The Tuesday morning began dramatically
with a lecture by Professor Don
Mathewson of Mt. Stromlo Observatory,
who spoke on the topic "Does Gravity
Rule the Universe?" This talk could also
have been entitled "I come to bury Caesar
not to praise him" as it contained the
evidence collected during an extensive
observational program by Mathewson,
Ford and Buchhorn for the demise of the
Great Attractor, a concept according to
which whole galaxies, clusters of galaxies
and superclusters of clustered galaxies
appeared to be streaming at speeds of
around 1000 kilometres a second towards
a point in the constellation Centaurus.

The 1987 analysis by the so-called 'Seven
Samurai' had resulted in the idea that an
immense mass was dominating the
peculiar velocities of galaxies in the
universe. The paradox was that nothing
which could conceivably be responsible
for this effect, was observable in the
region of the sky where the Great
Attractor should have been located. The
extensive observations reported at the
Congress constitute a survey of the
peculiar velocities for upward of 1300
galaxies so allowing a determination of
the signature for the bulk flow of these
southern hemisphere galaxies. The failure
of the survey to detect a backside infall
into the Great Attractor (no observed blue
shift for galaxies on the far side of the
GA) leads to the conclusion that the
motion of the galaxies towards the GA is
probably not real.

The measured bulk flows of 600 km/sec
found on scales greater than 150Mpc in
the Supergalactic Plane falsify the
standard cold dark matter models and
seem to imply the heretical view that there
exist weak anisotropies in radiation and
matter densities which must have a
cosmological origin.

Continuing the morning session, Dr.
Rachel Webster gave a lucid account of
the difficulties with the Hubble Space
Telescope with particular emphasis on
details of the famous spherical aberration
problem. She discussed the plans for the
improvement of the telescope's
performance with long term corrective
optics likely to involve in early 1994 the
most ambitious use ever of the shuttle
program. The hope would be to move
from the present 17 per cent of light
utilization to an impressive 97 percent.

Dr. Andrew Prentice then recounted in his
own inimitable style another of the
impressive successes of his Modern
Laplacian theory, this time his detailed
predictions about the satellite system of
Neptune. The recent discovery of large
quantities of pure dry ice on Neptune's
satellite Triton is in complete conformity
with earlier analyses of the carbon
chemistry in the outer solar system made
by Dr. Prentice.

In later talks a variety of topics was
presented covering the solar abundance of
iron, stellar nucleosynthesis, gamma ray
astronomy, galactic magnetic fields and
black holes.

The remainder of the Astrophysics session
reviewed impressive plans for the
development of a wide ranging program of
Antarctic astronomy. Some interesting
results obtained with already existing
equipment was also presented by workers
at the University of Tasmania and the
Australian Antarctic Division.

Ken Hines
University of Melbourne

**SCIENTIFIC SESSION**

**Third Australasian Conference on the
Physics of Remote Sensing of Atmosphere
and Oceans**

This was the third Conference in a series
which aimed to concentrate on the
physical interactions which enable the
science of Remote Sensing to be viable
and on the interpretation of the data
obtained.

Remote Sensing provides in many cases
the most economical way of obtaining
data at one surface location over a long
period of time, as from a ground based
location, or data over a large area at one
instant, such as obtained from a satellite
radiometer.

Ground based active and passive remote
sensors have now reached a level of
sophistication where they can measure for
example, temperature, water vapour,
aerosol, cloud particle and ozone profiles
through the troposphere and stratosphere
and to an accuracy which has been
unobtainable hitherto. These sensors are
now being used in integral experiments to
sound a column of the atmosphere in
great detail. Such observations are vital
for proper validation and subsequent
improvement in the representation of
physical processes in numerical models.
Such improvements are the only way that
numerical models of climate and climate
change will be improved.

In a similar manner, multi-sensor
instrumentation of satellites is leading to
much more detailed information of the
earth's surface and atmosphere on a
global scale.

The Conference was divided into sections
which covered the different topics of
Ocean and Land Surface; Radiation
Budget and Clouds; Stratosphere and
Troposphere; General Soundings of
Atmospheric Properties; Clouds and
Aerosols; Tropospheric Turbulence,
Convection and Rain; Tropospheric
Dynamics. These sessions therefore
covered a broad brush and occupied the
whole week of the Congress. It also put a
different interpretation on the term
Remote Sensing which is sometimes
interpreted in the narrower sense of the
study of earth surface properties.

There were eight invited speakers, six of
whom were experts from overseas.

There was also a joint day session with the
South Pacific STEP Workshop. There was
a small poster session during one lunch-
hour when refreshments were provided.

The measurement of accurate sea surface
temperature for climate research has been
the aim of satellite radiometry during the
past few decades. According to reports at
the Conference this is likely to be
achieved now with a new radiometric
technique (the ATSR-1) aboard the ERS-1
European Satellite, which takes a very
careful account of atmospheric absorption
and has a very high instrumental
accuracy. Australian scientists have been
involved from the first conceptual and
design stages of the radiometer and
recently in the very careful validation of
data from shipboard measurements.
The remote sensing of land surface temperature is harder due to varying surface emissivity, but considerable progress has been achieved with recent work on the split window (10 - 12 micrometre) satellite AVHRR technique together with large-area surface instrumented sites.

The remote sensing of minerals through laser backscatter at their Raman wavelength has provided a potentially powerful tool for the survey of mineral deposits from the air, and an Australian project is near to full technical success.

High-frequency radar continues to be used to sense ocean wave and wind characteristics, and reports concentrated on recent investigations around the Australian coastline, as well as on radar altimeters on recent polar orbiting satellites. The physics of Bragg wave reflection and diffraction has been applied to measurement of shallow ocean depths and to the measurement of ocean wave directions (which may be different from the prevailing wind direction). Radar satellite altimetry has yielded useful information on wave height and its climatology, particularly in data-sparse areas of the southern oceans.

The atmosphere causes errors in satellite visual imagery due to scattering by molecules and aerosols. New techniques are being applied to minimise these effects, with detailed information on scattering phase functions and the achievement of computationally efficient schemes.

An area where remote sensing is having a large impact is in the study of the earth's climate, particularly with use of the global coverage of earth orbiting satellites. The use of multiple channels from microwaves to the visible has recently given new results on clouds, liquid water and water vapour, which is influencing our understanding of the earth's hydrological cycle. For instance, it is found that solar and infrared fluxes are nearly balanced in tropical clouds but have large differences in midlatitudes. The cloud liquid water and water vapour mirror closely the sea surface temperature. Furthermore, there are large changes in cloud characteristics from Northern to Southern Hemispheres.

Aerosol optical depth, which is important climatically, has also been sensed from the surface using a multiwavelength spectral radiometer. Inversion of the data using the Mellin transform of the kernel of the Fredholm integral gives the aerosol distribution.

Using satellite AVHRR data and the various correction techniques also reported, products of normalised vegetation index (to assist in plotting drying vegetation in the summer) and sea surface temperature (to assist the fishing industry) are produced on a routine basis at Aspendale.

Some other novel methods to probe the earth's climate were reported. Perturbation methods can be used to study how small changes in atmospheric structure (temperature, moisture, etc.) can impact on the radiative fluxes at the earth's surface and the top of the atmosphere, that is, the equilibrium climate. Similarly, the consideration of the entropy production of the planet can be used as a constraint on climate models in addition to energy, momentum and mass balance. The impact of clouds on entropy production has been assessed from Earth Radiation Budget (ERB) satellite data. To assist in these studies and to provide validation, highresolution cloud climatologies for numerical model grid squares in the Australian region are being generated using NOAA polar orbiter AVHRR data.

High resolution infrared interferometer spectrometers are now being used to probe many aspects of the atmosphere. Recently, the technique has shown its power in the excellent temporal and height sampling of boundary-layer temperature, based on the results from two recent US field experiments, SPECTRE and STORMFEST. Results showing the formation and erosion of the boundary layer were impressive.

NASA airborne lidar measurements in both the Antarctic and Arctic were made in 1987 and 1988 as part of a programme to study the links between polar stratospheric clouds and ozone depletion. The lidars could measure both constituents, showing the close correlation one with the other. The recent appearance of ozone depletion in the Arctic was highlighted.

Both temporal and spatial characteristics of the Philippines Mt. Pinatubo volcanic eruption as determined by lidar and satellite measurements were reported. Lidar observations at Aspendale, Victoria indicated the rapid spread of volcanic haze in the Australian region, plus a secondary volcanic veil from Mt. Hudson in the Andes. Scattering of solar radiation by the Pinatubo veil will cause a significant drop in global temperature of approximately 0.5 to 1.0°C, particularly in the tropics, during the next two to three years.

The importance of clouds in the radiative balance of the atmosphere was reviewed. The contribution that lidars can make to determining cloud height, structure and evolution as well as optical extinction and infrared emissivity was illustrated from examples taken at Aspendale, Victoria, as part of the international ECLIPS programme.

The use of satellite data in operational weather forecasting is a powerful new tool. Australia is now one of only five countries that routinely calculate and use mass and wind data estimated from satellite observations. Data from three polar orbiting satellites and one geostationary satellite including microwave sounding of humidity are used. A recent addition has been the generation of high resolution cloud-drift winds from successive images of the Geostationary GMSA satellite.

There are now many powerful surface-based techniques for studying the atmospheric constituents of the atmosphere. In the US Atmospheric Radiation Measurement (ARM) programme which aims to set up large surface observing stations, four laser-based systems are being developed: Raman lidar for the measurement of the vertical distribution of water vapour density, polarisation diversity lidar for estimation of hydrometeor phase and density, high-resolution lidar for aerosol properties and an eye-safe cloud profiometer. Raman lidar has also been extended to look at the backscatter ratio of clouds and aerosols, which gives valuable information on ice crystal type as well as cloud humidity.

Satellite techniques are also being developed to measure methane column density from space using infrared interferometry. The angular distribution of reflected solar radiation measured at a satellite is affected by cloud inhomogeneities and microphysics, and the data could be inverted to obtain the cloud inhomogeneities. These techniques are being extended in another satellite instrument a multi-imaging spectro-radiometer, which will give information on optically thick clouds and also the cloud altitude and cloud inhomogeneity.

A rather similar surface-based technique which measures whole-sky images has been used successfully in the ECLIPS experiment to discriminate clear and cloudy areas by threshold techniques.

Methods of measuring cirrus clouds with a novel scanning radiometer (ATSR) on the ERS-1 satellite are being developed, making use of the multiple paths through cirrus. Aerosol optical depths are similarly being measured from AVHRR NOAA satellite data over the sea, and the arrival of the volcanic veil from the eruption of Mt. Pinatubo was identified.

Infrared CO2 doppler lidar has been applied to probing the dynamics of winds associated with mesoscale processes, for example, the 3-dimensional aerosol and cloud structure below the rim of the Grand Canyon, to determine what sources of particles were contributing to pollution in winter. The use of the lidar to probe clouds in association with a
millimeterwave radar shows the potential to measure particle sizes in clouds, a very important quantity climatically.

The acoustic sounder continues to develop as a valuable technique for sounding the atmospheric boundary layer. A current review covered applications to wind and turbulence and integrated fluxes and energy budget estimates, recently in forested complex terrain. Possible new applications are use of the acoustic technique to describe air-sea interactions, planetary surface interactions and investigation of particle velocities in volcanic explosions.

In another application solitary waves in the lower atmosphere have been studied in the Northern Territory, where the waves were produced by thunderstorms. Solitary atmospheric waves are usually highly non-linear in nature with properties which differ significantly from those described by small-amplitude wave theory.

The use of radar techniques in the observation of tropospheric turbulence, convection and rainfall has continued to expand. Deep tropical thunderstorm activity in the Indonesian region constitutes one of the major areas of latent heat release within the globe. A Doppler wind profiler has been used recently to understand in detail the structure, evolution and rainfall production of these systems. Doppler radar has also been utilised in the same tropical area to sense important information on microphysical cloud structure. In fact, a relatively simple technique can yield the raindrop size distributions. Wind profilers at frequencies of about 50 MHz have the unique capability of obtaining continuous time and height measurements of the vertical wind component. These systems have been used at two tropical stations in conjunction with Doppler weather radars and satellite observations to study the vertical circulations in convective storms.

The VHF radar technique continues to find wide applications with a report on the observation of coldfronts, in conjunction with Marwinsonde balloons and modelling. These techniques are shown to have the potential of observing gravity waves at their source. Application to the measurement of momentum flux was reported in an experiment adjacent to the Hartz mountains in Germany. The VHF radar also responds to temperatures and temperature gradients in the vertical which has been demonstrated by application to observing the height of the tropopause.

The use of GHz radar to observe swarms of migrating insects provides entomological data but also offers insights into micrometeorology. Spaced-antenna techniques have long been used in conjunction with atmospheric radars to determine horizontal winds. A review reported that a "full correlation analysis" will also give other information such as the r.m.s. turbulent velocity of the scatterers.

Martin Platt
CSIRO Division of Atmospheric Research
Melbourne

SCIENTIFIC SESSION

X-Ray and Synchrotron Physics

The session commenced with a report of the progress and plans for the Australian National Beamline at Tsukuba.

D.C.Creagh summarized the beam and monochromator characteristics. Initially a water-jet cooled silicon monochromator designed by M.Hart will be used. An overview of the committee structure directing the beamline project and of funding application procedures was provided. S.W.Wilkins described the design of the Australian diffractometer and its various modes, such as powder diffraction, protein crystallography, small-angle scattering, white-beam topography, in which it will be used in conjunction with a choice of recording with image plates or analyzer crystal and counter. A secondary monochromator for conditioning the beam is also planned. A table was placed behind the diffractometer will serve as a platform for the mounting of instruments for other experiments for which proposals were invited.

M.Ando reviewed the Tristan High-Energy Program at Tsukuba, Japan. The production of the world's highest flux of Mössbauer photons holds the promise of a host of applications in topographical contrast, magnetic studies, very high resolution spectroscopy, X-ray interference, as well as studies of the phase problem and of the gravitational red shift.

K.Ohsumi reviewed the potential of the Laue method with white synchrotron radiation to investigate the structure of submicron-sized single crystals, illustrating his discussion with a study of CVD diamonds in which image plates were used to collect the data.

T.J.Davis reported work on the X-ray diffraction from stoichiometrically described imperfect crystals. While no analytic solution of the Takagi-Taupin equation was known, an approach via the complex reflectance plane, illustrated by an intriguing video of a computer simulation, held considerable promise.

The high X-ray flux of synchrotrons and the subtraction of images taken simultaneously above and below the K absorption edge of a contract agent makes it possible to obtain clinically useful coronary angiograms with decreased risk to patients. R.F.Garrett reviewed the work carried out in this area at the National Synchrotron Light Source in Brookhaven and illustrated it with actual images from patients.

H.N.Chapman gave a lucid account of the x-ray optics of capillary arrays which promise to make available achromatic, compact, robust, cheap and easy-to-use x-ray focusing components.

D.X.Ballic discussed the complex interplay of extinction and binding effects in noncentrosymmetric crystals.

Other talks covered a variety of topics: a locally designed and constructed image plate scanner (T.I.Davis), x-ray microtomography (J.A.Grant), the calculation of axial divergence profiles for powder pattern (R.A.Coyle), and a review of the study of composites, engineering ceramics by neutron powder diffraction (C.J.Howard).

Zwi Barnea
University of Melbourne

SCIENTIFIC SESSION

Gravitation

The field of experimental, theoretical, mathematical and astrophysical gravitation is expanding in Australia, and the sessions were oversubscribed. In spite of this, there were few papers from workers in mathematics departments, mainly because these people are not members of AIP, and did not consider the Congress to be "their" meeting. The recently formed Australian Gravitation and Relativistic Astrophysics Network (AGRAN) is attempting to put all workers in the field in touch with each other, and will hopefully ensure cross-fertilisation in the future. Possibly AGRAN should affiliate in some way with the AIP, the Australian Mathematical Society and the astronomers.

The gravity sessions had some 16 papers in all, of which 5 were by invitation.

One of the invited papers and a number of the subsidiary papers were devoted to the Australian International Gravitational Observatory (AIGO). Funded AIGO pilot research on an optical gravitational antenna is proceeding, based on David Blair's gravitation group at the UWA and John Sandeman's optical group at the ANU. As the physical, astrophysical, technological, and industrial consequences of the creation of AIGO are of great importance to Australian Physics, it was pleasing that the prospects for AIGO were again placed before the Australian Physics Community.
The Solar-Terrestrial and Space Physics Group of the AIP conducted the South Pacific STEP Workshop in conjunction with the AIP Tenth Congress. The Solar-Terrestrial Energy Program, operating from 1990-97 is providing exciting new opportunities for research into solar-terrestrial phenomena which determine the "weather and climate in space". STEP's main scientific aim is to advance the quantitative understanding of the coupling mechanisms that are responsible for the transfer of energy and mass from one region of the solar-terrestrial system to another. It also has a practical goal to improve the predictability of the effects of the variable components of solar energy and disturbance on the terrestrial environment and on technological systems in space and on earth. These aims cannot be achieved without extensive international co-operation, and across, the sub-disciplines of solar-terrestrial physics.

The South Pacific STEP Workshop provided an excellent opportunity to discuss the latest results from research being conducted in our geographic region, and to plan new initiatives for cooperative research programs. The workshop was not confined to regional research and it has a strong emphasis on global research programs as well. Some 109 papers were presented, including 16 from overseas.

Sessions were held over the whole week on the following topics: Magnetosphere, Geomagnetism, Middle Atmosphere, Aeronomy, Ionosphere, Propagation and Modelling. A poster session consisting of 24 papers was held on Wednesday afternoon. The Middle Atmosphere sessions were held jointly with the Third Australasian Conference on the Physics of Remote Sensing of Atmosphere and Oceans.

Magnetosphere and Geomagnetism - Day 1

This section comprised 18 oral papers presented at three sessions and 11 poster papers, representing 13 different research groups. Five speakers were from overseas. The morning session featured invited reviews on issues relating to STEP and activities and opportunities resulting from associated programs. First, Yumoto (Nagoya University) outlined the STEP 210° longitude ground magnetometer campaign which involves a co-ordinated global instrument array between Siberia and Southern Australia. Fraser (Newcastle) then described the aims and objectives of the US Geospace Environment Modelling (GEM) Program. A problem-based approach is used to tackle outstanding problems in solarterrestrial physics. The first of these, focusing on physics of the cusp and boundary layer, commenced a few years ago. The Japanese GEOTAIL spacecraft program (Nishida, ISAS), with its first launch in July 1992, is another significant joint venture to study magnetospheric processes. In particular it will explore the distant tail region as well as travel a unique orbit parallel to the magnetopause.

Close to the ground, Chamalaun and Ziesolleck (Flinders) presented major results from the Australia side Array of Geomagnetic Stations (AWAGS) which consists of 97 3-component digital magnetometers across Australia, with an average spacing of 275 km, and field resolution of 1 nT. The AWAGS data set will provide the first systematic survey of electrical conductivity of the Australian crust, as well as furnish new questions and answers on important topics in ionospheric and magnetospheric physics. Several papers from the Newcastle and Antarctic Division groups presented new results from studies of space plasma waves in Antarctica. These programs are another example of an area in which Australia makes unique international contributions based on access to unique geographic locations. Phenomena studied included Pci-2 sources and propagation; long period pulsations near the cusp; and magnetic reconnection and flux transfer processes.

It is not generally known that geomagnetism in Australia celebrates its bicentenary in 1992. Is this our oldest science? Lilley (ANU) described the scientific methods used in Australia's first magnetic measurements by D'entrecasteaux and their significance in showing that the earth's field was dipole-like.

Turning to specific results of recent new projects, Singer (USA), outlined preliminary findings from the CRRES (Combined Release and Radiation Effects Satellite) which featured the study of magnetospheric plasma convection using lithium and barium releases. A major discovery has been a low altitude (L=1.6) proton belt analogous to the ring current, presumably associated with substorm injection processes. The Newcastle group's presentations included the use of CRRES to study the generation and propagation of ion cyclotron waves (ICWs); the radial event of ICW source regions; a ground-satellite experiment to determine field line resonance characteristics, and an interesting...
experiment relating magnetic pulsations to corresponding ionospheric oscillations.

Other papers concerned modelling ULF plasma waves in the magnetosphere. Allen (DSIR) found that the ponderomotive force distorts the plasma density distribution, resulting in temporal evolution of the wave's spectral and phase properties. Waters (Newcastle) showed how a relatively simple experiment based on comparison of ULF resonances at nearby stations, can be used to monitor the evolution of magnetospheric plasma characteristics. Peake and Peake (Wales) modelled the response of the geomagnetic cavity to external compression, finding that nighttime P12 pulsations at low latitudes may be associated with magnetospheric cavity resonances, a topic also developed by Li (Newcastle).

The final group of papers examined long term variations in ionospheric current systems. Butcher (La Trobe) presented evidence of an annual variation in the geomagnetic K component which includes a ring/solar wind component, and another component, possibly associated with cross-tail current. Hibbert (New England), in a controversial paper, presented a close correlation between the daily Sq variation and the 10.7 cm solar flux, which by extrapolation implies a substantial Sq effect in the absence of an ionosphere and so raises questions about the general validity of the dynamic theory of Sq.

Stening (NSW) specifically examined seasonal and latitudinal variations in the strength of Sq effects at the ground, finding that seasonal effects, for instance, are local time dependent.

**Middle Atmosphere - Day 2**

The Middle Atmosphere covers the height region between 10 and 100 km. It falls between the main region of interest of Solar Terrestrial and Space Physicists and that of many Australian atmospheric scientists and researchers. However, amongst other things, it contains the ozone layer and transport processes that carry pollutants from low and middle latitudes to high latitudes. It is consequently of very great interest and these joint sessions aimed to bring together the different groups working on middle atmosphere problems in Australia, as well as those working in the regions 0-10 km and above 100 km altitude. There were three invited speakers.

Boyd (ASO) gave an excellent overview of the Australian Space Office, the economic and social "drivers" of space research policy, and those specific to remote sensing. He emphasised the need for Australia to acquire a stake in those space-based remote sensing systems on which many of our vital services depend. Taylor (Oxford) spoke about infrared sensing of the middle atmosphere from space. He emphasised the complexity of interactions between the temperature, chemistry and dynamics of the region. He discussed two instruments: SAMS (Stratosphere and Mesosphere Sounder), which operated from 1978-83, and ISAMS (Improved SAMS) launched aboard UARS (Upper Atmosphere Research Satellite) in 1991. The instruments utilise radiometry on pressure modulated gas cells to measure height profiles of many minor constituents including CO2, C0, CH4, O3, and N2Ox and promising early results were presented. Tsuda (Kyoto) described a wide variety of measurements of winds in the 20-60 and 60-100 km height regions, obtained with the powerful Middle and Upper (MU) Atmospheric VHF-radar operated by Kyoto University. Of great future importance to Australia is the Japanese plan, which Tsuda described, to build a new equatorial radar, 10 times as large as the MU radar, as an international observatory in Indonesia.

The members of the Atmospheric Dynamics Group, University of Adelaide presented 12 papers, including observations obtained with radars at Adelaide, Mawson Base Antarctic, and Christmas Island. Three-field photometer airglow observations of emissions from near 97 km altitude and VHF meteor observations at Adelaide were described. Greer (Antarctic Division) presented observations of mesospheric Na emission profiles over Mawson Base and Hernandez (Washington) presented new results of mesospheric OH airglow over Amundsen-Scott Base, South Pole. Von Biel (Canterbury) presented results suggesting the existence of a layer of ionization at 40-55 km altitude, and Stening (NSW) discussed observations of lunar tide obtained using Adelaide and Sackson MR radars.

**Aeronomy - Day 3**

The morning session concentrated on High Latitude phenomena. Two invited speakers presented papers. Greenwald (Johns Hopkins) discussed the development of HF radars and future research prospects, including the need for an Australian radar to study Antarctic phenomena. HF radars, looking obliquely over high latitudes, can provide a snapshot of ionospheric convection over wide areas. Recent success has been the mapping of the dynamics of conjugate regions. An extensive Northern Hemisphere radar network is being set up to give coverage of the entire Arctic polar cap.

McEwen (Saskatoon) reviewed new Canadian initiatives in polar science, including the CANOPUS system, consisting of an all-sky imager, a bistatic auroral radar, a 13 magnetometer and riometer array, and 4 meridional scanning photometers. The CANOPUS system will operate for at least the duration of STEP. Initial results on bright aurora (>10k), from the Canadian Polar Observatory at Eureka (within 20 latitude of the invariant pole), were also presented.

Researchers from Antarctic Division reported on photometric and riometer observations at Mawson during 1991 (Burns); and TEC (Total Electron Content) observations in the polar cap which show a persistent electron concentration enhancement of over 2 hours duration at around 85° invariant (Beggis). Essex (La Trobe) presented work on quasi-periodic satellite scintillations, included a rare form not previously observed. The paper by Price (Alaska) presented the first simultaneous measurements of vertical winds at two latitudes in the upper and lower thermosphere (40 m/s at 120 km, 150 m/s at 290 km). These were recorded at high latitude near a region of increased auroral activity, but the source of energy to drive such substantial movements of the upper atmosphere is still not identified.

Post papers included Antarctic Division work on excitation processes of the auroral 5579 Å emission and methods of removing local influences from ground-based vertical electric field data collected at Davis Base (with La Trobe).

The afternoon session spanned high latitude aeronomy to low latitude clear air electric fields. Breed (SA) showed that TEC enhancements south of Adelaide could be due to the equatorward edge of the polar convection region. Burns (Antarctic) then argued that the variable time constants for rapid changes in auroral activity, but the source of energy to drive such substantial movements of the upper atmosphere is still not identified.

**Ionosphere - Day 4**

The morning session began with Yeh (Illinois) reviewing computerized tomography, widely used in medicine, applied to determining ionospheric structure from TEC data. The trick is to overcome the shortage of data since only
a limited number of ground stations could ever be used, and to devise alternative methods which converge. Only limited experimental results are available but these show considerable promise. Goodwin (SA) described TEC and equivalent slab thickness measurements made by a large team using GPS and NSS satellites. Some slab thicknesses are much thinner than expected from modelling.

Medium scale TID analysis by Wilson (QLD) showed that a wide spectrum of waves are observed, including two waves higher than the Brunt frequency and travelling in opposite directions. Bowman (Qld) described time differences between magnetic activity and associated spread-F observed on successive days following each initiating geomagnetic event. Spread-F events, observed to come from Antarctica, were reported by Quach (La Trobe) and in related work, Johnstone (La Trobe) showed how Doppler sorting enables the angles of arrival of spread-F echoes to be determined. Spread-F causes the ionosphere to be rough and echoes first appeared from the poleward direction then from the whole sky, and finally equatorwards. Vertical velocities determined from Doppler shift, are related to Kp.

In summary, there are now available in Australia several ground-based methods for detailed study of the entire range of ionospheric irregularities which have profound effects on radio wave propagation.

The afternoon session began with Jones (Leicester) presenting an invited paper discussing changes in the direction of arrival of HF radio signals caused by large ionospheric irregularities convecting across the polar cap. Localized regions of electron density, 2-3 times greater than normal, form in the dayside oval. Large changes in bearing and elevation of radio signals are explained by reflections from these regions as they drift from the day to night side of the auroral oval.

Barnes (DSTO) described radar observations of spread-Es layers showing that the spread is not due to changing obliquity, but to irregularities at arange of heights moving with velocities of ~100m/s. Whitehead (Qld) discussed the formation of sporadic E. Current theories do not satisfactorily explain the height, thickness or occurrence of Es layers. Interactions of metallic ions with small dust particles may cause large enhancements in the density of Es layers, giving height and time distributions in better agreement with observations. He also presented a paper investigating the necessary conditions for gradient instability to occur in the ionosphere. When practical boundary conditions are applied, multi-slab solutions give an upper horizontal scale of a few hundred metres for growing irregularities. A detailed one-dimensional analysis predicts maximum perturbations about 10° off field alignment.

Ionospheric Propagation and Modelling - Day 4 and 5

Three sessions were held on this topic. The first four papers presented work from HFRD, DSTO on propagation phenomena observed with the Jinadalee Frequency Management System. Doppler measurements show broadening associated with spread F and interesting variations during sunrise and sunset which are not yet completely understood. Problems of range folded clutter and progress in automated radar frequency management were also discussed. Five papers from ERI, DSTO spaced through the three sessions, presented interesting new results on the variability of F2 and its application to real time management of communication methods of determining angles of arrival of coincident signals, adaptive null steering, conversion of vertical incidence measurements to oblique propagation characteristics, and a comparison of predicted and observed one-hop propagation characteristics at 30 MHz.

The second session concentrated on the application of ray tracing techniques to the modelling of ionospheric radio propagation with seven papers presented by the La Trobe/Imani and HFRD, DSTO groups. Applications considered included point-to-point communications and over-the-horizon radar. Ray tracing in this context covers a vast range of approaches, from representing the ionosphere as a simple mirror to full numerical ray tracing in a three-dimensional iono-earth medium. It was shown that the appropriate technique in a particular situation depends on the time and computer power available, as well as on the desired output. The techniques described by the various authors were shown capable of reproducing many of the features observed in the experimental records. Particular attention was paid to the database of the Jinadalee radar and its associated frequency management system.

The final session included a critical review of the methods of calculating ionospheric absorption (Monash/ La Trobe); and comparison of sequential sporadic E with the NCAR thermosphere-ionosphere general circulation model and modelling of the Australian ionosphere (IPS Radio & Space services). Two papers on true-height profile analysis were presented, the one by Ward (DSTO) highlighting problems with the incoherent scatter method and the other by Qld (U of Qld) presenting a novel attempt to assess errors in true-height profiles using Doppler measurements. Finally Titheridge (U of Auckland) discussed the derivation of neutral winds by modelling total electron content of the ionosphere. This is an important technique because of the general sparsity of neutral wind measurements.

Overall, it is clear that there exists a great diversity of experimental and theoretical work performed in Australia, ranging from modelling of plasma instabilities in the distant magnetosphere, radio and optical studies of the ionosphere, thermosphere and middle atmosphere, to determination of electric fields at the earth's surface and conductivity of the crust. As well as interest in the basic physics, this session indicate very strong development in Australia of application of the basic physics to practical problems such as ozone, over-the-horizon radar and HP communications.

The Workshop was supported by a grant from DITAC and was held as part of Australia's International Space Year activities. This report was compiled using contributions from J.A. Bennett, G.B. Burns, F.W. Menk, I.N. Reid, J.E. Titheridge, J.D. Whitehead and P.J. Wilkinson.

Peter Dyson
La Trobe University

SCIENTIFIC SESSION
Medical Physics and Radiation Protection

A joint one-day session for Medical Physics and Radiation Protection was organized on Tuesday the 11th of February and attended by around 40 active participants.

The scientific programme started soon after the two plenary lectures, and filled the whole day with the exception of a short lunch break.

Radiation Protection Session

The morning session was devoted mainly to radiation protection and related activities. The only invited lecture in this session was jointly given by Drs. Mason and Roy, both from the Australian Radiation Laboratory. Dr. Mason mentioned the important development in the measurement of radiation safety over the past year had been the adoption by the International Commission on Radiological Protection (ICRP) of the new recommendations for protection from radiation. Accordingly the recommended occupational dose limit had been reduced from 50mSv per year to 20mSv per year, averaged over 5 years. He outlined the implications of the new ICRP recommendations to radiation
AIP CONGRESS REPORTS ON MEDICAL SESSIONS

protection activities in Australia. The other half of this paper by Drs. Roy and Gies was delivered by Dr. Roy who discussed current issues in measurement, effect and protection, especially solar ultraviolet radiation (UVR) and extremely low frequency radiations (ELF). He discussed the possible causes of the increase in the ozone hole on the Antarctic and mentioned that, according to their modeling and measurements, the actual ozone loss was greater than predicted, which would increase the ambient UVR.

However, he also pointed out that our knowledge of the implications of this increased UVR for human health and ecosystem was still scant.

On the ELF side he pointed out that even 12 years after the publication of the first epidemiological study raising the hypothesis that exposure to ELF magnetic fields may be responsible for the increase in the incidence of some or all cancers, the issue remained unresolved. He discussed the inadequacies of the existing theories to explain this phenomena and pointed out that the major challenge in these studies was that of assessing "exposure" to ELF magnetic fields, and perhaps even to define the "exposure".

The remaining part of the radiation protection session was filled with Contributed papers. Drs. Jenks and O'Donovan of MRL discussed the limitations of physical dosimetry for victims of acute exposure to ionizing radiation. The calibration of radiation therapy equipment at high energies was described by Drs. Webb and Hargrave (both from ARL).

Dr. Ali Shah of the University of Newcastle, pointed out some shortcomings in the way Australian average occupational exposures to ionizing radiation was being calculated. He highlighted that occupational exposures from internal sources was apparently not included in the calculation, this figure was derived only from data collected by the Personnel Monitoring Service of the ARL, and that the data collected by the Department of Health in N.S.W., Queensland and W.A. as well as by ANITIO was not taken into consideration.

In this way he concluded that about 45% of the data collected in Australia was ignored in calculating the national average figures. To say that the occupational exposures with personnel monitoring services are normally not measured below a minimum reportable dose (MRD) which is 2000 µSv per year in N.S.W. According to him some workers needed 4 films/year while others as many as 12 films/year.

Thus, he concluded, the corresponding annual MRD would be 800 µSv/year 2400 µSv/year respectively, which could be completely ignored in the ARL assessment, as exposures below MRD are assumed to be zero.

Medical Physics Session

The afternoon was devoted to medical physics and related activities of physics as applied to medicine, biology and dentistry. While opening the afternoon session Dr. Chaudhri, the Co-chairman of the Session, who organized the medical physics programme, gave the logic behind the selection of the papers, especially the invited speakers. He pointed out that for the National Physics Congress he selected mainly those invited speakers who would be of interest to the general physics community too. He selected as many as 5 invited speakers for the session so that only wide spectrum of this important field could be covered.

Prof. Plibrow of Monash University opened the scientific programme with an interesting talk on magnetic resonance imaging (MRI) in medicine. He outlined the principle behind the MRI, and the contribution of 3D imaging. He also described NMR Spectroscopy (MRS) and pointed out how various metabolic functions could be studied in-vivo with this technique. He highlighted the importance of physicists in MRI/MRS programmes. Unfortunately, there were no medical administrators present in the audience to grasp the full import of this message.

Associate Professor Brian Thomas of the QUT described the technique of in-vivo analysis of body composition studies (IVABC), a field in which he has been active for over 20 years. According to him the genesis of current IVABC was the measurement of mineral of the major body elements, for example the measurement of total body Ca, Na and Cl by in-vivo neutron activation analysis (IVNAA) and body K by measurement of this naturally occurring 1.46 MeV gamma emission from K-40. He mentioned other techniques, such as XRF, conductance and impedance as well as CT and MRI, which are also being used for IVABC studies.

Dr. Barry Allen of ANSTO gave an interesting talk on Boron Capture Neutron Therapy (BCNT) and its potential and future use in Australia. He outlined the small animal BCNT facility the 100kw reactor at Lucas Heights where Malignant Xenografts have been successfully treated with BCNT. He presented plans for the treatment of human tumours on the 1.6 MeV HIFAR reactor with epithelial neutron beams. Filtering the beam through heavy water, he said, would improve the penetration of the neutron beam, then high-grade brain tumours, breast cancer, pancreatic cancer and chronic metastases could be also treated. The epithelial neutron beams of the HIFAR could be obtained by filtering out thermal and fast neutrons and gamma rays with Al, S, Ti C and Pb filters. Towards the end of his talk he briefly discussed the possibilities of using small, low energy (2 MeV) high current (10mA) proton accelerators which, through Li(n,p) reactions, could produce intensive neutron beams for therapy, such small machines costing approximately a couple of million dollars, could easily be located in hospital therapy departments.

Dr. Chaudhri of the Austin Hospital in Melbourne described various therapeutic applications of cyclotrons. He pointed out that although producing small isotopes for diagnostic studies were the most common use of medical cyclotrons, there were other important applications which were being carried out successfully by many cyclotron establishments around the world. These applications were therapy with fast neutrons and protons.

The “new generation” neutron therapy, according to him, were being pursued in about 15 centres around the world, although in many cases with less than ideal neutron beams. He explained that from the results of a few thousand patients who had undergone fast neutron treatment, it appeared that up to 20% of the tumour types could be treated more effectively with fast neutrons than with conventional gamma rays or x-rays. He further pointed out that with more appropriate neutron beams this ratio could be greater. He highlighted some of the outstanding problems for the production of the ideal neutron beam for therapy.

Dr. Chaudhri described the basis for proton therapy as being the existence of the Bragg Peak whose depth could be varied as required by simply adjusting the proton energy. In this way, he said, cancerous volumes could be suitably irradiated with a minimum damage to surrounding tissues. Discussing the historical development of proton therapy, he described how the Harvard Cyclotron was reduced by this type of treatment alone, after the physics programme ceased on that machine. Now the whole operation of the Cyclotron was funded by proton therapy income. The greatest success of proton therapy has been in the treatment of ocular tumours. There are a few other countries around the world who are using 70-72 MeV protons for proton therapy.

Towards the end of his talk Dr. Chaudhri expressed his disappointment that none of the two Medical Cyclotrons installed in Australia (Sydney and Melbourne) were capable of any neutron or proton therapy treatments. He promoted the idea of establishing a National Radiation Research Centre around a 70 MeV proton Cyclotron where besides medical applications, a great deal of unique...
applied work could be carried out for the local manufacturing industry. 

The last of the invited talks in this session was given by Dr. Richard Garrett of ANSTO who, at the very last moment kindly agreed to accept the invitation when Dr. Zeilinger of the IAEA could not attend. He discussed the latest developments in the use of synchrotron radiation for medical imaging. He described the key advantage of these sources for medical imaging as being the monochromatic nature of the radiation, which allowed the quantitative attenuation measurement of coefficients in the subject. This made it possible to employ a range of digital imaging techniques, e.g., K-edge subtraction combined with a contrast agent. He illustrated the potential of synchrotron radiation in medical imaging by describing two research projects underway at the National Synchrotron Light Source at the Brookhaven National Laboratory in the U.S.A.: Intravenous Coronary Angiography; and Multiple Energy Computed Tomography of the head and neck. He pointed out further that the Coronary Angiography project was a mature programme, with several human subjects having been imaged successfully.

Dr. Phakethy and Co-workers (Dr. Palamara, Orana, and Prof. Rachinger) described how high technology in physics can help solve problems in dentistry. By using different types of laser beams, scanning and transmission electron microscopy and the Argon Ion thinning techniques, they managed to study the effect of laser irradiation on the surface of the dental enamel.

Amongst the other contributed papers, Dr. Strood of the Monash Medical Centre gave a brief description of their Body Composition Laboratory, and Dr. Egan of the Austin Hospital gave a status report of the Positron Emission Tomography Centre.

The medical physics and radiation protection session was most informative and enjoyable. Most participants stayed until the close of the meeting which was well after 6 p.m.

Dr. M.A. Chaudhri
Austin Hospital, Melbourne

EDUCATION SESSION
Physics Teaching

The 1992 Victorian Physics Teachers Conference was held as part of this years Physics Congress. The conference was on the Thursday and the Friday with over 360 teachers attending. Nearly all the teachers were from Victoria with a few from interstate and one from New Zealand. The numbers were particularly good and were comparable with recent years, even though the conference was held in the second week of the school year.

With the introduction of the Victorian Certificate of Education (VCE) at the half way stage (Units 1 & 2 introduced at Year 11 in 1991, and Units 3 & 4 at Year 12 in 1992), the program was similar to recent conferences.

The program featured:
- Workshops on new areas of the course such as Digital Electronics and Structures & Materials.
- Presentations on the classroom management of the major student tasks (the extended practical investigation and research project), which will form part of the assessment of students.
- "This is How I Did It" and "This is How I Plan to Do It" sessions by over 50 teachers. The teachers each gave a 15 minute presentation on either some aspect of their teaching program from Unit 2 in 1991, or from what they propose to do for Unit 3 in 1992.
- Many of these teachers submitted written material prior to the conference, and the 173 page conference proceedings was able to be published and given to participants at Registration.

Some of the articles were:
- Using Industrial Visits for Year 11 Physics students
- Modelling Car Electrics
- Assessing Written and Oral Communications
- Designing and Construction of Model Solar Cars for the basis of the teaching electricity and mechanics
- Teaching Strategies for ESL students

A question and answer session on:
- the process of verifying the teachers assessments of the major student tasks mentioned above, and
- the format of the externally set exams.

In addition to the Physics Teachers Conference Program, there were several sessions with a more tertiary focus such as physics teacher education, computers in physics teaching and experiments in chaos. These sessions attracted some interest from secondary teachers.

While the full program did not give any time for formal liaison between teachers and physicists, there was many opportunities for informal discussions. This was a worthwhile beginning and can be built on in two years time.

Special thanks should go to the Physics Department at Melbourne University for their preparedness to take applications up to the day before the Conference began.

Dan O'Keefe
Camberwell Grammar School

A Report on the Australian Physics Teachers' Conference

Our part of the Australian Physics conference started with a welcome from the (younger looking) president of the Australian Institute of Physics. Normally this is not the part of the conferece that anyone remembers, but it made a distinct impression on me for two reasons.

1. He thanked us, the Physics teachers for the magnificent contribution we make to Physics education in the country, noting that every Physics researcher, lecturer, industrialist, whatever, can think back to the Physics teacher who inspired him/her at High School. I cannot recall the last time I was publicly thanked for my enthusiastic contribution by one of the 'big-wigs': I felt special.

2. He announced that the Australian Institute of Physics was actually reducing its sub so that more Physics teachers could join. This was certainly a new era in Physics teaching about to begin.

The conference did not disappoint me. Despite the fact that most of the 350 Physics teachers had registered the previous week (or the previous night) and thrown the organisation out a bit, AND it poured rain on the opening day, this did not allay the Victorian spirits.

The year 12 teachers (form 7) were about to teach their new, and wonderfully radical syllabus for the first time - and hence the panic for last-minute enrolment.

Victoria had pioneered a radical form 6 course in the previous year and now found themselves facing a 41% increase in their form 7 Physics numbers! What were they up to?

Well, my presence at the conference was not entirely coincidental as I had heard about their innovations at another conference in 1991, and been immediately intrigued.

In 1991, this creative group of teachers wrote and introduced VCE Physics Study Design, which restructuring and renovates the traditional Physics into four units; two at form six and two at form seven.

Unit 1: Heat, Light, Radioactivity and Nuclear Energy
Unit 2: Movement and Electricity
Unit 3: Investigation, Sound, Electronics and Electric Power
Unit 4: Motion, Gravity, Structures, Light and Matter
As well as practical work and problem-solving, new emphases include oral and written communication and the relationship between Physics, technology and society.

An overall emphasis is on students exploring the physics found in their everyday worlds.

In the small, easy-to-read guide booklet for teachers, each main topic has a 'context', some of which are optional. For example, the three optional contexts for SOUND are:

1. Speaking and hearing, including the causes of deafness, speech therapy and the bionic ear
2. Musicking, including acoustics, instrument-building and hearing protection.
3. Recording and production, including soundcheck, microphones hi-fi etc.

Each topic has a series of 'work requirements', which for SOUND includes a SOUND ENQUIRY, involving experimental design and forays into the community by students with sound meters. All such practicals are written up in a logbook.

Other fascinating innovations included:

1. The dismantling of an electrical device, with screwdrivers 'n all. The speaker had done a Goldair heater!

2. A structures unit that finally introduces engineering directly to the class. Materials such as concrete, steel or human/animal bones are tested for stresses and strains.

3. The Extended Practical Investigation at form 7 level. Time allowed is three weeks. Students choose their own topics and devise their own experiments, with teacher help if necessary.

4. Poster assessment of the Light and Shadow topic.

5. Digital electronics, either with expensive kitsets or with homemade models.

6. Research project on physics in a social context. The research is presented in a poster format, with oral accompaniment.

The guide booklet is full of succinct practical suggestions and guides to ensuring authenticity.

Local physics teachers (two males and two females) have just completed the writing of their textbooks to go with the new course:

- Physics One for units 1 & 2
- Physics Two for units 3 & 4
- Both have teachers' guides

These books are full of colour photos, many of people (young and old) who are doing things in real life situations. There are also plenty of diagrams and worked examples.


Along with the interesting bevy of grassroots speakers, telling us 'how I did this' or 'how I will do this', we also received a magnificent publication of all the talks which included all the circuit diagrams, worksheets, experiments, video sources etc. Ideal for the Kiwi do-it-yourselfer!

In amongst the trams (with no apparent schedules) and the pouring rain the conference was certainly inspiring stuff, and very encouraging to someone like me who has been experimenting with practical project work to make physics more relevant and creative for a number of years. I'm now intent on trying out a research project, using a poster as the means of assessment.

A useful contact for anyone wishing to find out more from the Australian end is Dan O'Keefe, Cambewell Grammar School, Melbourne.

Janis Cusack
Dannevirke High School
New Zealand

---

**LETTER**

Dear Editor,

The Cranky Comment by John Jenkin (ANZP March 1992) is a sad reminder that Australian Physics is stuck in the past. Why is so much energy spent on gloom and doom, questioning for a time machine to take us back to the 1960s? The 1980s? Bologna in 1088? Presumably Jenkins has some invisible axe to grind, but the inaccurate and unbalanced statements in his comment should nevertheless be countered lest our Journal be held to ridicule.

Research.

- CSIRO is hardly emasculated - indeed, it seems to have excellent leadership, a clear sense of its mission, adequate resources, and top-rate staff.
- The mining and agricultural industries have a sound record of research. Don't blame them for manufacturers' woes.
- It is desirable to have a greater intensity of R & D in manufacturing industry in Australia, and much of the expertise currently lies in Universities. Why not tap it?
- Jenkin might well benefit physically and mentally from a daily stroll to the mail room. Gardening might be even better!
- It is ludicrous to think that the government should pay for University teaching and research but not seek to monitor how the money is spent.
- There is a world of difference between the generous Australian funding for postgraduate students and their miserly treatment in the UK.

Teaching.

- Today's students exude even more vitality than those of past years. They are healthy, articulate, concerned for their future and that of others, and thirsty for knowledge and wisdom.
- Improvements in efficiency of teaching (e.g., the use of laboratory equipment for more hours per week) have been possible as enrolments have increased.
- There is something wrong when tutorial staff cannot speak English adequately - perhaps revised selection procedures, or training, might help.
- Where I work standards are improving steadily as we use new teaching techniques and tools, and help a larger number of students glimpse the wonders of science and learn of the powers of rational thought.

Jenkin and I would find a lot of common ground in our hatred of the insidious evils of centralization, and our dislike of DEET policies. I suspect that my fear of the consequences of the betrayal of trust by politicians and government employees would be much deeper than his. But why pull back to the past? Why not jump out in front of the social engineers, and go where we want to go dragging them with us? One must surely feel sorrow rather than anger over Vice-Chancellors who (like too many of our "Captains") disguise their inadequacies and insecurities in unseemly and pathetic bids for more money and other trappings of office.

There are problems in Australian universities: uninspired staff, insularity, limited opportunities for young researchers, inequity, poor distribution of funds, and an absence of visionary leadership would be high on my list. But the problems will not be solved by retreat to the past. We need people with optimism and commitment to move into the next millennium: coming with us, John?

Prof L E Cram
School of Physics, The University of Sydney
Burleigh Introduces Scanning Tunneling Microscope for Education

Burleigh Instruments, working with staff and students at a major university, has developed the Instructional STM, a unique tool for introducing students to the realm of nanometer scale science through Scanning Tunneling Microscopy.

The Instructional STM is designed with the student in mind. Its hardware and software are easy to use and will withstand the day-to-day abuse of the laboratory teaching environment. The device does not, however, sacrifice performance to achieve durability. The Instructional STM provides true atomic resolution STM images. Furthermore, it delivers this performance at a fraction of the cost of other commercial systems.

Two of the most important features are the workbook and sample set included with every unit. This package allows the instrument to be easily added to a laboratory curriculum. The manual includes sections covering the history and theory of STM, an explanation of the operation of the Burleigh device, a set of proven experiments and directions for student data taking.

The Instructional STM is not limited to the accompanying sample set. Although designed as an educational tool, the instrument could also be used in the research laboratory.

For more information, please contact:
Paul Wardill
Coherent Scientific
138 Greenhill Rd
Unley SA 5061
Phone (08) 271 4755
Fax (08) 271 1202.

8W TEMoo Ar+ Laser

Lexel Laser of Fremont, CA announce the new 3500-8. The 3500-8 offers 8 watts of multiline TEMoo argon power and exhibits friendly features such as an improved ultra-low noise power supply design, a fully interactive analog/remote control, RS-232/IEEE computer interface capability and Frequency-Lock™, a single frequency stability accessory.

Lexel’s unique solid ceramic tube design with patented gas return path, is the most efficient design available today, offering 8 watts multiline power from a small frame argon ion laser.

Lower operating currents result in lower operating temperatures, better stability and longer tube life.

A solid invar resonator design allows for the optimal stability in an ion laser in both standard operation and single frequency mode operation.

For more information please contact:
Lexel Pty Ltd
400 King William Street
Adelaide SA 5000
Phone (08) 231 2155 or Fax (08) 233 2169.

DC Motor Actuators

Oriel Corporation of Stratford, CT announces new compact high performance DC motor actuators. These drives, sold under the trade names of Motor and Encoder Mikes™, come in 0.5, 1.0 and 2.0 inch travel lengths with flat and spherical lips. They are excellent for high resolution, sub-micron positioning applications.

The Motor Mikes™ use a fine pitch lead screw running in a high precision nut. The screw is driven by a small DC motor. End stops prevent jamming or damage to the mechanism. The Encoder Mikes™ have the same design with the addition of an optical encoder shaft that allows position readout to 0.1um.

You can easily retrofit your manual stages with Oriel's motorized drives. They are available with standard hub dimensions to replace most common micrometers.

A complete family of controllers, ranging from simple hand held toggle switch controllers, to computer compatible multi-channel models are offered to operate these actuators.

For information on Oriel Motor and Encoder Mikes™ contact:
Lastek Pty Ltd
400 King William Street
Adelaide SA 500
Phone (08) 231 2155 or Fax (08) 231 2169.

Frequency Stabilized Lasers Provide 1 MHz Stability, 0.1% Amplitude Stability

Aerotech Inc of Pittsburgh, PA announce their new single and two frequency stabilized lasers. These lasers utilize an innovative and patented stabilization technique to provide superior 1 MHz stability and 0.1% amplitude stability.

The Aerotech stabilization method is unique in that it utilizes R1 induction to thermally control the length of a specially designed mirror mount structure. This patented technique provides two advantages over the more common conduction method: more rapid servo response and therefore better frequency stability and a more compact package, since only the mirror mount is controlled.

With the stabilization technique, Aerotech's single frequency lasers achieve better than 1 MHz stability. An accessible potentiometer on the stabilization adapter permits the frequency to be adjusted between 100 and 600 MHz from the 'blue side' of the Doppler gain profile.

Amplitude stability for both their 1.0mW and 0.5mW single-frequency models is 0.1%, while amplitude noise is less than 0.1% rms. Output power or amplitude is typically adjustable between 0.5 and 1.2mW for the 1.0mW models. The 0.5mW models have a typical output power adjustment range of 0.35 to 0.70mW.

Both the 100SF series of single-frequency lasers and 170DS two-frequency lasers are ideal for application such as interferometry, holography, velocimetry and spectroscopy.

For further information, contact:
Lastek Pty Ltd
400 King William Street
Adelaide SA 500
Phone (08) 231 2155 or Fax (08) 231 2169.

SCANNER SOFTWARE

Copy for the Australian & New Zealand Physicist which has been faxed twice after the original, can barely be read by us, let alone be deciphered by our scanning software.

Copy faxed only once is read with difficulty by the scanner.

ORIGINAL COPY supplied as much as possible is a breeze for all (including the scanner) at Impress Studios.

Australian & New Zealand Physicist Volume 29, Number 5, May 1992
Prompt Critical

There's Life in the Old Girl Yet
Just as my son's PC-XT home computer was showing an occasional sign of age, accompanied by considerable operator frustration, along came a book describing how to upgrade it to a 386SX model. Most physicists are not exactly clueless about the innards of a modern personal computer, and usually there are one or two willing advisors hovering around the lab. But a PC is quite a complex little box of tricks and it is highly reassuring to have a source of good advice right at one's elbow when the lid is up and the transplant operation is under way.

The fount of knowledge which saw us safely through the upgrade was the newly released second edition of a paperback titled "Build Your Own 386/386SX Compatible and Save a Bundle". Written by Aubrey Pilgrim, a former quality control engineer with Lockheed, it is so up-to-date that some of the products described (like very high density disk drives and the new Kodak bubble-jet printer) are only just making their appearance on the Australian market as these words are being written.

Flicking through the pages of this upgrade manual is deceptively. Some chapters are lavishly illustrated with pictures that most scientists would regard as trivial, such as three pictures showing each of the three cables in turn being connected to a hard drive. The comprehensive description of keyboard layout seems hardly necessary, as is the listing of computer magazines. But tucked away in the text one can find the answer to just about every query that might arise when contemplating, then purchasing, and finally reassembling the reborn computer.

As well as quite a lot of useful data, Aubrey Pilgrim has managed to weave into his presentation a few snippets of the history of IBM PC computers, explaining how they have evolved. Some readers will be bored by the treatment, but many others will find it quite enlightening.

Is it worthwhile to upgrade a PC? Perhaps not, if it is running well. If the motherboard is developing the silicon equivalent of Alzheimer's disease a 386 brain transplant could be the answer. We scored well with a versatile 386SX motherboard, including one megabyte of memory, for $340. We also had to buy a new floppy disk controller and an AT-type keyboard (XT keyboards won't work with a 386 model).

The new board allowed us to utilise the memory chips from the old board, which work happily with one wait state in interleaved mode to give a total of 1.64 megabytes of memory. So for about $500 my son now has a rejuvenated PC with incredible scope for expansion just as soon as his pocket permits.

The nice thing about Aubrey Pilgrim's book is the confidence it bestows in embarking on a major PC upgrade on the kitchen table. I suspect that the next PC in the family to go troppo will likewise be turned into a 386. I'll just say to the owner "Here's the guide book. Go to it!"

Aubrey Pilgrim's 227-page paperback "Build Your Own 386/386SX Computer and Save a Bundle" is published by Winthrop/McGraw-Hill with a price tag of A$31.95.

Colin Keay
Book Reviews Editor

Plasma Waves

D. G. Swanson
Academic Press, San Diego, 1989
x + 422 pp., A$120.35 (hardcover)

This is a concise and clearly written advanced text, pitched at an audience that already has introductory knowledge of plasma physics. It comprises eight chapters under two parts, linear and nonlinear plasma waves, which are preceded by a short introductory chapter. Chapter 2 discusses very clearly the properties of waves in cold plasmas and includes a brief but excellent excursion through the topological genera of plasma waves described by the CMA diagram and wave normal surfaces, and includes examples of various electromagnetic and electrostatic wave modes. Chapter 3 on waves in fluid plasmas looks at dispersion relations and introduces the concepts of wave amplification through convective and absolute instability. In Chapter 4 a description of the kinetic theory of plasma waves is included and this concentrates on the physics. As a consequence detailed theory is avoided, and, as the author points out, there are more appropriate books where the theory can be readily found.

Topics covered here include waves in thermal and hot plasmas, electrostatic waves, power flow and relativistic effects. Bounded homogeneous plasmas are considered in Chapter 5 with specific examples including the comprehensive 1

110 Australian & New Zealand Physicist Volume 29, Number 5, May 1992
treatment of cold plasma-filled waveguides under various conditions. In Chapter 6 on inhomogeneous plasma waves the WKB method is introduced along with mode conversion theory, ray tracing, and the drift wave instability.

The second part of the book, devoted to non-linear waveforms comprises two chapters. In Chapter 7 weak turbulence theory is introduced under quasilinear conditions while Chapter 8 on finite amplitude waves includes interesting sections on solitary waves, trapped particle effects and parametric instabilities. Three useful appendices are included which cover applications of the complex variable to problem solving, a description of various special dispersion functions frequently used in plasma physics, and an alternative approach to the development of the amplitude equations of geometrical optics.

This book would make an ideal text book for the plasma wave components of an honours course and worthwhile reading for others new to the field. Its appeal is enhanced by the inclusion of relevant problems scattered throughout the text and, what is rare in a book at this level, answers to a selection of these problems.

B.J. Fraser
Physics Department
University of Newcastle

Finite Size Scaling and Numerical Simulation of Statistical Systems

V. Privman (Ed)
World Scientific, Singapore, 1990
ix + 518pp., US$67 (hardcover)

In M. Dresden’s excellent biography of the great Dutch physicist H.A. Kramers we learn that at the 1937 van der Waals Congress in Amsterdam, Kramers made the suggestion that statistical mechanics can only yield discontinuous phase transitions in the thermodynamic, or infinite size, limit. This was a confusing issue at the time, so being the chairman of that session, Kramers put the question to the vote. Of course it has since become well established that Kramers was right. Many years later the finite size scaling theory of M.E. Fisher and M.N. Barber described the way in which the transition is subsequently rounded and shifted in a finite system.

One particular consequence of the theory is that the finite size behaviour of quantities such as the magnetization and susceptibility is governed by the critical exponents of the infinite system. Turning that idea around on its head, it is possible to obtain the critical exponents from finite systems. Together with Nightingale’s phenomenological renormalisation, finite size scaling has proven to be a powerful and effective tool in describing phase transitions in infinite systems.

Limitations of finite size are particularly relevant to experimental systems such as absorbed monolayers at surfaces, where the surface of the substrate is typically (100 Å)². Such effects are also rather pronounced in Monte Carlo simulations, which are restricted to a sequence of finite sizes by necessity.

This book is a collection of review articles by many of the key workers in the field of finite size scaling in phase transitions and related disciplines. The articles are mostly centered around work of the particular authors, although an emphasis is placed on addressing readers with no prior knowledge of finite size scaling theory. However, it is expected that the reader has a background in phase transitions.

Such a book is clearly warranted as there have been significant developments in the field since Barber’s definitive review of the subject in 1980. Chief among these are the advent of (i) conformal invariance, which predicts the precise finite-size nature of two dimensional systems at the bulk critical point, and (ii) faster computers enabling more extensive numerical simulations. In addition there has been further effort in extending the theory to first order transitions.

The book begins with theoretical reviews, with V. Privman giving an overall introduction to the theory, D. Jasnow on field-theoretic techniques and J. Rudnick on results for the spherical model, which enjoys the property that it can be solved in all dimensions. The next three chapters by K. Binder, D.P. Landau and K. K. Mon review applications of the theory in Monte Carlo simulations. The recent developments related to conformal invariance are covered by M.P. Nightingale and M. Henkel, with the emphasis on transfer matrix techniques and the quantum Hamiltonian limit, respectively. Further on the application side, C.V. Bhatnagar discusses finite size scaling in lattice gauge theory, A. P. Young discusses simulations in spin glasses, and L.S. Schulman considers finite size effects associated with metastable phases.

One of the editor’s hopes for the book is that in addition to being a comprehensive summary and introduction, it conveys the excitement and dynamics of a rapidly growing and developing field of science. I think it manages to achieve this.

Murray T. Batchelor
Department of Applied Mathematics
Australian National University

Transport for the Nuclear Industry

D. J. Blackman and M. H. Burgess (Eds)
Nuclear Technology Publishing,
Kent, UK, 1991
210pp., £45.00 (hardcover)

These are the proceedings of a specialist conference held at Bournemouth in May, 1991. The volume is concerned primarily with the procedures and hardware for the transport of high and medium level nuclear wastes, and with the demonstration and validation of the safety features engineered into the various packages. Other issues relating to the economics, legal status and politics of nuclear waste transport and disposal are outside the ambit of this volume, even though these might be of more interest to a technically literate general reader. The largely unedited transcripts of post-session discussions, at the end of the volume, are interesting and topical being concerned, in part, with the realities and the nuclear mind-sets of the high priests of the nuclear industry vis a vis those that are ascribed to members of the public. For instance, CHAIRMAN: “On the general question of interaction with the public, I feel we could spend half a day just talking about how to deal with the unreasonable and unjustified critical attitudes”. A non-specialist reader, who is ambivalent about the merits of nuclear power, might find it instructive, although peculiar, that the specialists are clearly on top of the realities of making containers which can withstand any plausible or hypothetical accident, but display a near-total lack of appreciation for, and ability to deal with, the realities of public opinion.

S. Myhra
Division of Science and Technology
Griffith University

Dynamical Collision Theory and its Applications

S.K. Adhikari and K.L. Kowalski
xv + 494pp., US$79.95 (hardcover)

This is a book for students of few body problems in Physics and/or of microscopic model approaches to many body collision theory. It is not a text for a novice however, as the authors presuppose a reader to have considerable knowledge of nonrelativistic scattering theory. Nevertheless, the content of this book is an excellent review of the techniques and approximations in current use and so is to be highly recommended to all who are or will be involved with analyses of scattering in few and many body systems.
BOOK REVIEWS

Elementary Particle Physics (3rd Edition)
J. S. Hughes
Cambridge University Press, 1991
xxii + 431 pp, UKS16.95 (paperback)
Anyone who has taught an introductory undergraduate course in Particle Physics will be familiar with the first two editions of this text.
Briefly: it adopts an historical approach, it avoids too much mathematics, and it gives a lot of weight to the data. All good attributes. Although it was a good text it was not, in my opinion, the best. However it provided valuable supportive material to my preferred book (Perkins).

So, what changes has the author made for this third edition? Very few to the existing chapters. A small amount of important new data is included, mostly on physics at the Z-pole from the LEP electron-positron collider at CERN. And Chapter 12 (Higher Symmetries) is enlarged.

The main change is a new, long (over 50 pages) concluding chapter on "Particle physics and cosmology". It gives a simple clear account of the Big Bang, Dark Matter and Neutrinos. The last section is especially good and covers Solar Neutrinos, Oscillations, Magnetic Moments, Detectors and SN1987A, but surprisingly not the Majarana Neutrino option. These are not easy subjects to simplify but this book does a good job. It is written at a level which most Honours students should be able to handle.

This last chapter greatly improves this text, but for me it will remain a good book but not the best. Other lecturers may well disagree. I would certainly advise them to consider this book and make their own decision.

Stuart Tovey
Research Centre for High Energy Physics
University of Melbourne

Condensed Matter Conference Proceedings
J.L. Beeby, P. A. Maksym and J. M. McCoy (eds)
Physica Scripta, Vol T39
Stockholm 1991
400 pp., US$38 (softcover)

The 11th General Conference of the Condensed Matter Division of the European Physical Society was held in Exeter, UK in April 1991; a sort of EEC "Waggia", but featuring more countries (>20) and participants (>1100). The 400+ contributed posters are not even listed in this volume, but the cream of the 64 invited papers is given in full. Parallel sessions of the conference covered high Tc superconductors (of course), magnetism, "soft" matter (organics, liquids) and semiconductors, the last area being the largest and concerned mainly with low-dimensional structures.

Intentionally or not, these areas are evenly covered in the crème de la crème, the plenary talks (layered intercalation compounds, M. Balkanski; magnetic materials, J. M. D. Coey; superlattices, R. J. Nicholas), the Hewlett-Packard Prize (organic conductors and superconductivity, K. Bechgaard and D. Jérome) and the Mott Lecture (electron interactions in the extreme quantum limit, R. G. Clark). Readers in any of these areas will find the book very useful. It is topical, informative, detailed, comprehensive and well-presented. Even so, and given that this volume is not overpriced and appeared promptly after the conference, this review is able to end with a couple of popular refrains: "not a textbook, as such, for any course" and "more suited to the institutional than personal library".

R. A. Lewis
Department of Physics
University of Wollongong

The Electron
D. Hestenes and A. Weingartshofer (Eds.)
Kluwer Academic Publishers
Dordrecht, 1991
xxi+399pp., DFL 160.00 (hardcover)
In August 1990 a workshop was held at St Francis Xavier University in Nova Scotia to discuss and review the state of knowledge about the electron and its interaction with the electromagnetic field.
This book is the result of that meeting. It contains contributions from eighteen contributors on both theoretical and experimental aspects of the subject.
One major topic with which the book launches off is the phenomenon (7) of an

Elements of Physics
Marcel Wellner
Plenum Press
New York & London 1991
xiii + 693 pages $49.50 (hardcover)
This text would be useful as a supplementary text for students studying physics in their final year of high school (NSW year 12), and a reference about the basics for students in their first year of university physics. As for mathematical level, to quote from the preface "while the language of calculus is indispensable here, its manipulative power will, with some regret, be left pretty much unexploited". "A calculus course concurrent with the present material is assumed".
In style the book is reminiscent of text books of the fifties and sixties, in plain black and white two-columns-per-page format with many small line drawings, plenty of simple worked examples and not a photograph to be seen.

K. Amos
School of Physics
University of Melbourne

Condensed Matter

Australian & New Zealand Physicist Volume 29, Number 5, May 1992
BOOK REVIEWS

Zitterbewegung, an extremely high frequency (~10^{18} \text{Hz}) motion of the electron predicted early in the days of quantum mechanics. Much of the discussion centres around the question of whether the effect is real and if so whether it might explain the phenomenon of intrinsic spin. Also figuring prominently is the use of “space-time algebra” a type of Clifford algebra which harks back to the days of quaternions in the last century when scalars and vectors were treated in a somewhat more unified way than is currently taught in physics. The last theoretical topic which I wish to highlight and which is also given prominence is Self-field quantum electrodynamics. This is an attempt to recapture some of the spirit of classical electrodynamics by reducing the quantum properties of the field to those of the source and thus avoiding some of the infinities that arise in standard quantum electrodynamics.

The experimental contributions dwell largely on ionisation by microwave or intense optical fields, where the interaction of free electrons with radiation is important, although there is one quite large review of the properties of gaseous ions (free electron/atom contained in an ion trap). Compared to the theoretical articles however, there is relatively little original discussion here and most of these articles do just review the important recent results. It is thus the theoretical part of the book which contains the less formal discussions which will not be found in journals and I feel it is those with an interest in the foundations of quantum electrodynamics who have gained most by the publication of this tome.

Murray Hamilton
Physics Department
University of Adelaide

Techniques and Mechanisms in Gas Sensing
P.T. Moseley, J. Norris &
D.E. Williams (Eds)
Adam Hilger, Bristol, 1991,
xv + 390pp, UK£39.00 (hardcover)

This book was written to be complementary to the 1987 title in the same series, ‘Solid State Gas Sensors’, editors P.T. Moseley & B.C. Tofield. Between them they cover all major gas sensor types, both current and emerging. As the preface suggests this later book does two things, firstly it concentrates on methods that are commercially well established and secondly it presents updated materials on the mechanism of operation of some solid state sensors.

The early chapters concentrate on the latter aspect and give an excellent in depth report on the operation of oxide semiconductor gas sensors, particularly tin oxide. With reference to experimental results reported in literature, a detailed discussion on the theory of operation is presented. The chapter on more recent phthalocyanine materials is also informative, but because of the current worldwide interest in these materials should have been expanded.

Several of the remaining chapters examine standard methods used in industry, including general approaches such as calorimetric, and infrared methods as well as gas specific methods such as solid/liquid electrolyte cells and measurement of oxygen by its paramagnetic property. By comparison some of these chapters are disappointing. For example, the chapter that examines humidity sensing is descriptive with no analysis, ignores some of the measurement problems and omits a reference section, while the chapter on oxygen determination, by using its paramagnetic property, somehow appears out of context.

Of the remaining chapters, two provide useful overviews of emerging technologies namely, metal oxide semiconductor (MOS) and optical fibre gas detection. The final chapter summarises present work on gas sensor arrays using pattern recognition methods. Both conventional pattern recognition and artificial neural network methods are discussed. The chapter makes an excellent conclusion to the book.

At the end of each chapter there is a useful summary as well as a list of important references. Thus, for researchers and industrial personnel involved in the monitoring of gases, this is a very useful reference book.

M R Haskard
Sensor Science and Engineering Group
University of South Australia

Gaseous Electronics and its Applications
R.V. Crompton, et. al. (Eds)
Kluwer Academic Publishers
Dordrecht 1991,
xiv + 344 pp, US$124.00 (hardcover)

"Gaseous Electronics and its Applications" is a collection of presentations made at the second Australian-Japanese Gas Sensors Workshop held in Japan in November 1990. There are about 20 papers from a mix of both Australian and Japanese gas sensors, divided somewhat arbitrarily into several sections.

Unfortunately, the flow of some contributions is difficult to follow due to some problems with translation of the Japanese contributions into English. Other than this minor flaw, the reproduction of the material is quite satisfactory and most diagrams are large and easy to read.

This volume is definitely written for the specialist or more advanced graduate student simply because it is a collection of papers describing a selection of work at the leading edge of this field. There is no introductory or background material and unless one is familiar with the area the information presented would be very difficult to assimilate. Having said that, the collection does provide the expert with a relatively complete and succinct summary of the state-of-the-art in some aspects of the measurement of swarm parameters and interpretation of the results. The applications covered generally involve the plasma processing of semiconductors and the papers in this area provide an interesting expansion of the more fundamental work on basic collision parameter determination.

Perhaps one of the most interesting papers (by Robson) presents "a unified theory of swarm experiments in terms of which all experimental arrangements can be discussed". There is a general summary paper (by Hayashi) on collision cross sections of atoms and molecules and a chapter containing several papers on plasma etching and deposition. Most contributions include a fairly long list of references which may be quite useful to the specialist in a particular area. A more balanced assessment of the field can possibly be gained by consulting the publication giving the abstracts of all the papers presented at this meeting (about 34).

In conclusion, although this volume (at about $140.00) is not a cheap addition for a personal library, it provides a useful reference source for researchers at all levels involved in gaseous electronics. It is, by no means, a complete summary of work in this general field but is both interesting and sufficiently detailed in a selection of areas to make it a worthwhile acquisition.

C.N. Haddad
Division of Applied Physics
CSIRO Lindfield NSW

Geometry and Physics
S. Gindikin and I.N. Singer (Eds)
North Holland, Bologna, 1991,
xv + 750pp., US$128 (hardcover)

I.M. Gelfand is undoubtedly one of the giants of 20th century mathematics. From the humblist of origins, a Jewish boyhood in a village near Odessa, he rose to
Book Reviews

Eminence, becoming probably the most revered mathematician in Russia today. He was almost entirely self-taught. As a young man he attained the lowly position of library controller, and proceeded virtually single-handedly to rewrite modern mathematics, and in particular mathematical physics. It is a story which easily rivals Einstein’s early years as one of the great legends of modern science.

These remarkable facts are briefly told in the introduction to this volume of papers honouring Gelfand’s 75th birthday. I wish I could be as enthralled by the remaining 750 pages of this book. The articles all written by students and friends appeared in four volumes of the Journal of Geometry and Physics and therefore should already be available in any library which could possibly be interested in acquiring this book. The articles are extremely specialized and make no concessions to the reader. They cover an enormous wide range of topics, mirroring the breadth of Gelfand’s achievements. Possibly he is the only person in the world who might have a hope of understanding them all.

Many of the articles are of a purely mathematical nature. I will just single out a few which might have interest to physicists (be they of a very mathematical persuasion). Plato and Fransdol have an essay on the singleton theory of light (a kind of neutrino theory of light). Aswell and Itzykson discuss rational billiards, particles reflected elastically by walls making angles in rational multiples of π. There is a paper by Arnold on the interior scattering of waves, and one by Sinai on ergodic properties of chaos of hyperbolic systems. Other than these, there are a variety of articles on Kac-Moody algebras, Dirac operators, quantization of symplectic orbits and Clebsh-Gordon coefficients.

Peter Szekeres
Dept. of Physics and Mathematical Physics
University of Adelaide

EMC - Electromagnetic Theory to Practical Design
P.A. Chatterton & M.A. Houlden
John Wiley & Sons, Chichester 1992
UK £39.95 (hardcover)

Why another textbook on electromagnetic compatibility (EMC)? The authors postulate the need to produce ‘an introductory level text’ to ‘form a bridge between conventional electromagnetics texts and EMC books for working engineers in the field of EMC’, not ‘another electromagnetic text in the standard mould’ nor ‘a detailed EMC handbook’. They state that their text suggests how to present ‘this important but very complex subject to final year undergraduates and first year postgraduates’.

Have they achieved their aim? Yes and no. They have provided a bridge from Maxwell’s equations to some of the simple but powerful practical concepts that can be applied to solving a wide range of EMC problems. In this, the book goes some way to removing the ‘black magic’ aura which sometimes surrounds descriptions of EMC problem solving. The appeal to the need for setting specific boundary conditions to allow solutions of Maxwell’s equations, even with the often unavoidable approximations and restricted applicability that this entails, is made consistently throughout the book, and the approximations and applicability are generally well described.

So, yes, they have produced a good introductory bridging text.

But, no, they have not entirely avoided aspects of the EMC handbook and of the standard electromagnetics text (anyhow, if you wish to discuss Maxwell’s equations and their implications, how do you avoid sounding just a bit like an electromagnetics text?).

It was only the deficiencies in the EMC handbook aspects that I found bothersome.

Of most concern was Chapter 6, Important Factors in Practical EMC Design. The problem here is that, while including much useful information, the authors are attempting to summarize in one chapter many topics that elsewhere have a whole chapter or, indeed, entire books devoted to them. This is made most apparent in their brief discussion of filtering, one of the most important topics in EMC. It receives only the sketchiest of treatments; the important topic of filtering mains disturbances is not treated at all, and the special requirements imposed on mains filter design by the statistical characteristics of mains wiring impedances are not mentioned. No reference is given to the important work of Schlick, and others on mismatched mains filter design to control interfacial resonances, which can arise if conventional filter design techniques are employed in the mains wiring environment. This is a strange oversight because the lists of references at the ends of each of the chapters are otherwise very comprehensive and up to date.

The brevity of the treatments in Chapter 6 also risks obscuring the subject matter. For example, on pages 250-252 the breaking of ground loops by use of transformers and common mode choke is discussed. Out work on common mode choke is summarised, but the wire impedance Z_{w} is introduced with no explanation or definition and its meaning can only be unambiguously determined by reference to the prime source. Elsewhere in the book the symbol Z_{w} also signifies the wave impedance of an electromagnetic wave.

Unfortunately, the book is also littered with orphan words typical of those left behind after cut and paste operations with a word processor, and there are more typographical errors than one would expect to see in a text book with the production values and the price of this one. For example, the caption to Figure 5.22 on pages 204-205 refers to radiated susceptibility measurements when, quite clearly, radiated emissions measurements are presented; on page 261 the text description of the disposition of layers of a multilayer board does not agree with the disposition of the layers shown in Figure 6.51 on page 263. The proof reading has missed other errors also.

The index is good, without being excellent.

In summary, the authors have partially achieved their stated objectives. Perhaps a revised and expanded second edition will achieve more, and if it is intended for use by students a lower-priced paperback edition would find favour.

Ian P. Macfarlane
Electromagnetic Compatibility Section
Telecom Research Laboratories

New Books

Differential Equations of Thermodynamics (2nd Ed.)
V. V. Synchev Hemisphere Publ.
(Taylor & Francis) New York 1991
viii + 252 pp., UK £61 (hardcover)

Elementary Particles (3rd Ed.)
I.S. Hughes
Cambridge University Press
Cambridge 1991
xxii + 431 pp., UK £16.95 (paperback)

Introduction to Renormalization Group Methods in Physics
R.J. Creswick, H.A. Farach and C.P. Poole, Jr.
John Wiley & Sons Inc.Chichester 1992
xiv + 409 pp., UK £52 (hardcover)

Meteorological Fluid Dynamics, R.K. Zeytounian
Springer-Verlag, Berlin 199,
xi + 346 pp., DM 66 (hardcover)

Gas Discharge Physics
Y.P. Raizer
Springer-Verlag, Berlin 1991
xi + 449 pp., DM 148 (hardcover)

Principles of Nuclear Magnetic Resonance Microscopy
P.T. Callaghan
xvii + 492 pp., AS153 (hardcover)
THE BRAGG GOLD MEDAL

The Council of the Australian Institute of Physics at its meeting in February 1992, unanimously supported the South Australian Branch proposal that the Australian Institute of Physics should award annually a Gold Medal commemorating the work of W L & W H Bragg to the author of the best Ph.D thesis in Australia completed in the previous 13 months.

The prize will be a solid 9ct gold medal, using the obverse die of the South Australian Branch medal which bears the profile of W L Bragg in front of that of his father W H Bragg, and the words W L & W H Bragg Medal for Excellence in Physics.

State Branches and Physics Departments are now invited to nominate candidates for the first award of the Bragg Gold Medal. Nominations should be made to the State Branch Secretaries whose addresses are given in this journal. The conditions of the award are available from AIP Branch Secretaries or Physics Departments. It should be noted that for the first award the thirteen month period has been extended to 18 months.

Conditions of the Award

The Australian Institute of Physics will award one gold medal annually to the student who is judged to have completed the most outstanding Ph.D. thesis in Physics under the auspices of an Australian University and whose degree has been approved, but not necessarily conferred, in the previous 13 months. No candidate may be nominated more than once.

The Medal, commemorating the work of WL & WH Bragg, will be made of solid 9ct gold and will be known as the Bragg Gold Medal for Excellence in Physics.

The medal will be awarded to the chosen candidate at a function to be arranged by the AIP branch of the state of the candidate’s university. The Medal will not be awarded in absentia; the candidate must be present for the presentation at a time which is mutually convenient to both the candidate and the State Branch. Reasonable expenses, including the cost of travel to Australia from overseas if necessary, will be met by the Council of the AIP.

Only one medal shall be awarded; there is no possibility of a dual award. If the committee considers that none of the theses submitted reach an appropriate standard, no award will be made.

Eligible Candidates

To be eligible for the award, the candidate should have had a degree of Ph.D, degree approved by the ruling body of an Australian University within 13 months prior to the 30th June in the year of nomination. No candidate may be nominated more than once.

For the inaugural award, nominations of candidates may be made from those whose degrees were approved between 1 January 1991 and 30 June 1992.

The Process of Selection

Each Australian university may nominate one candidate.

The State Branch sponsoring the winning candidate shall arrange a suitable function at which the candidate may describe the work for which the award was made, to the AIP and at which the Medal shall be presented.

The State Branch of the winner shall provide a personal profile of the winner and a report of the presentation function for inclusion in the Physicist. The winning candidate shall provide an article on the work.

The State Branch of the winner should determine the candidate’s reasonable travelling expenses to attend the function, and arrange with the Federal Executive of the AIP for reimbursement.

The South Australian Branch shall arrange for the gold medal to be struck and suitably engraved.

The Executive shall write to all finalists nominated by Branches notifying them of the result.
CONFERENCES & MEETINGS

May 25 - 29
ICPE Conference on Physics Education for Reforming the Fundamental Physics Teaching, Nanjing, China
Prof. Geoffrey I. Opat, School of Physics, The University of Melbourne, Parkville, Victoria, 3052, Australia. Phone (03) 344 5121, fax (03) 347 4783

May 26 - 29
National Institute of Standards and Technology, USA
Accuracy in Powder Diffraction II
For further information and for Young-Scientist-Grant application forms contact: E. Prince, Reactor Radiation Division, National Institute of Standards and Technology, Gaithersburg, MD 20899, U.S.A. (E-mail: prince@nbsenr or prince@enr.nist.gov)

May 28
The ACT Division of Australian & New Zealand Assoc. for Advancement of Science Symposium on Drought - Water - Flood, Canberra ACT Australia
ACT Division, ANZAAS, GPO Box 2816, Canberra ACT 2601, Australia

June 29 - July 3
ICSFS-6 6th International Conference on Solid Films and Surfaces
Ecole - Cité Descartes - BP 99, Noisy-Le-Grand, France
Dr. J. Lecante, CEA and LURE, Bâtiment 209D, Université Paris-Sud-91405 ORSAY Cedex. Phone (33) 164 46 80 03, fax (33) 164 46 41 02

July 6 - 10
Fifth International Conference on Thinking - Exploring Human Potential
James Cook University of North Queensland, Townsville, Australia
John Edwards, Conference Convenor, Department of Pedagogics
James Cook University, Townsville QLD 4811, Australia
Fax (077) 251 690 (within Australia) or 61 77 251 690 (overseas)

July 20 - 21
Recent Advances in Two-Dimensional and Nanostructure Electron Systems
School of Physics, University of New South Wales, Sydney, Australia
Contact: D. Neilson, University of New South Wales, Kensington, NSW 2033
Phone (02) 697 4564, Fax (02) 663 3420,
or Internet neilson@newt.phys.unsw.edu.au

August 17 - 20
The 14th Triennial URSI International Symposium on Electromagnetic Theory, Sydney, Australia
Dr. G. L. James, Chairman of the Organising Committee, CSIRO Division of Radiophysics, Phone (02) 868 0222 or (02) 868 0290, fax (02) 868 0400

August 26 - 28
Fifth New Zealand National Physics Conference, University of Auckland
Dr. G. D. Put, Department of Physics, University of Auckland, Private Bag 92019, Auckland, N.Z. Phone NZ (09) 373 7999/1117, Fax NZ (09) 373 7445

Sept 8 - 11
ASPEN Symposium - Introductory Physics Education in University, Japan
Contact: Prof. Yashiko Tsuruoka, Dept. of Physics, Tokai University, 1117 Kitakaname, Hiratsuka City, Kanagawa 259-12, Japan.
Phone 81-463-58-1211, fax 81-463-58-812

Sept 14 - 18
APSEM/BECON'92 Physical Sciences in Medicine and Biomedical Engineering Conference.
Contact: Prof. B.J. Thomas, School of Physics, Queensland University of Technology, GPO Box 2434, Brisbane QLD 4001, Australia
Phone (07) 864 2586 or Fax (07) 864 1521, OR Mr. M. McCarthy, Department of Physical Sciences, Royal Brisbane Hospital, Bowen Bridge Road, Herston Qld 4029, Australia.
Phone (07) 232 8520 or Fax (07) 232 1389

November 12 - 14
16th Scientific Meeting of the Australian Society for Biophysics, University of NSW, Sydney
Prof. Hans Coster, Department of Biophysics, University of NSW
PO Box 1, Kensington, NSW 2033, Phone (02) 697 4583, Fax (02) 663 340

November 25 - 27
Australian Acoustical Society Annual Conference 1992, Ballarat, Victoria
John Upson (Convenor), Phone (03) 370 7166 or (03) 370 7166,
Fax (03) 370 0332, Geoff Barnes, Phone (03) 720 1266, fax (03) 720 6952

December 1 - 5
ICPE Conference on Physics Education for Development, Philippines
Prof. Geoffrey I. Opat, School of Physics, The University of Melbourne, Parkville, Victoria, 3052, Australia. Phone (03) 344 5121, fax (03) 347 4783
OLD LASERS NEVER DIE
WITH LEXEL BETA-I TUBES.

They don't even fade away.
Lexel's Beta-I replacement plasma tube restores new laser performance at a fraction of the cost of a new laser. And that's just one advantage:
☐ Performance equal to or better than original system.
☐ Unmatched warranty, 2 years or 2000 hours.
☐ No modification to your existing laser.
☐ Immediate delivery.
☐ Service available for your whole system, not just the tube.
Beta-I's proven ceramic design has no glass to break or gas refill system to fail. It's one of the most reliable plasma tubes made. Beta-I tubes continue the quality and value that Lexel has provided for more than 18 years.

For details and location of the Lexel Service Center nearest you, call (800) LASER-XL, in California (415) 770-0800. Or write: Lexel Laser, Inc., 48503 Milmont Drive, Fremont, California 94538.
Coherent Scientific

FOR SPECTROSCOPY SOLUTIONS
from the Vacuum UV to the Far Infrared

BURLEIGH INSTRUMENTS
- Fabry-Perot Interferometers
- Laser Wavelength Meters
- Laser Spectrum Analysers

Pulsed Laser Spectrum Analyser from Burleigh Instruments

PRINCETON INSTRUMENTS
- CCD and Intensified CCD Detectors
- Photodiode and Intensified Photodiode Array Detectors

OPTRONIC LABORATORIES
- Radiometric and Photometric Calibration Standards
- Radiometers and Photometers
- UV, Visible and IR Spectroradiometers
- Detector Spectral Response Measurement Systems
- Spectral Reflectance/Transmittance Measurement Systems

SPEX INDUSTRIES
- Grating Spectrometers
- Raman Spectroscopy Systems
- CCD and Photodiode Array Detectors
- Spectrofluorometer Systems

Triple Grating Spectrograph from Spex Industries

Single Grating Spectrometer from Spex Industries

138 Greenhill Road, Unley, South Australia 5061
Telephone (08) 271 4755  Facsimile (08) 271 1202