The WA-2200 model High Sensitivity Wavemeter Jr is the newest addition to the Burleigh Instruments wavemeter product line. This device is designed for wavelength verification of laser sources with relatively low output powers such as diode lasers. The WA-2200 offers increased detection sensitivity which reduces the minimum input laser power requirement. Only 10 microwatts of input laser power are needed in the wavelength region from 1000-1800 nm. From 600-1000 nm, 50 microwatts are required. Based on a modified scanning Michelson interferometer, the Wavemeter Jr provides a measurement accuracy of +/- 1 part in 10,000 over the entire wavelength range. A visible detector board is available to complete wavelength coverage to 400 nm.

For further information on this or other Burleigh products, contact NORMAN JONES OR PAUL WARDILL at our Adelaide Office. Phone (08) 271 7966 Fax (08) 272 8581
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Front cover: Night-time view of the 22-m antennas of the Culgoora Compact Array of the
Australia Telescope. The five antennas can be moved along a 3 km east-west railtrack and
set down at stable stations for operation; a sixth antenna is located a further 3 km to the west.
Am I becoming overly sensitive to such matters? Is it an activity that peaks during the Parliamentary recess period when Cabinet and front-benchers are preparing for the Federal Budget and the back-benchers must be kept occupied?

We are faced by a continuing barrage of invitations to submit our point of view to Parliamentary/Governmental Inquiries. First, it was the public debate on the Green Paper on higher education, soon to be followed by the White Paper outlining the Government’s intended actions and allowing, no doubt, further opportunity to comment. Then followed the Inquiry into Superconductivity and Related New Materials, with submissions by invitation from bodies thought relevant and knowledgeable on the topic. The Institute has made a short submission that will be published in these pages.

The latest topic is Priorities for Reform in Higher Education, an inquiry by the Senate Standing Committee on Employment, Education and Training (closing date for submissions is 30 September 1988). This clearly overlaps the Government’s Green and White Papers on higher education but is unrestricted on issues that may be raised.

And, last week a call for submissions on teacher-education in mathematics and science was foreshadowed by a panel (chairman: Dr Graeme Speedy) constituted recently by Mr Dawkins to review that topic. This exercise is scheduled to take 15 months and the panel will report to the Government in September 1989.

The Institute appreciates the opportunities afforded to put its point of view on these important topics, all of which have bearing on our discipline and on the work of physicists in the Australian community. Primary responsibility for drafting an appropriate AIP submission falls on that hard-working body, the Science Policy Committee. The Committee meets in Sydney and is based loosely around the Executive, augmented by interested members who have in the main volunteered their services because of an interest in the broad topic of Science Policy.

Interstate representation and a consequent broadening of views is obviously very desirable. This year we have welcomed to the Committee Prof. Bruce MacKellar (University of Melbourne, and Victorian Branch Chairman), who brings in very positive views on a variety of topics plus wide-ranging contacts in Australia’s scientific, educational and government systems.

Bruce’s valuable input has raised the idea of corresponding members contributing to the work of the Committee as a compromise means of broadening further the representation while keeping the Committee’s travel expenses at a reasonable level. The role of corresponding members would be to comment upon and add to drafts prepared by Committee members as part of the critical reviewing procedure for SPC papers. Where appropriate, a corresponding member might initiate a paper at either the Committee’s or his/her suggestion.

Do we have any volunteers, particularly from beyond the Sydney-Melbourne axis? Please contact me if you are interested in contributing to this aspect of the Institute’s work.

John G. Collins
President

Chimera System
from Atlanta
Signal Processors Inc.
Details on page 192
In this issue the Ian William Wark lecture delivered to the Australian Academy of Science by Dr A.G.L. Rees is reprinted. We acknowledge the Academy for permission to reprint the lecture, we applaud Dr Rees for a magnificent lecture and we recommend that our Government mentors read the article and learn something about the reality of scientific research. This article will reach members of the Institute as we try to grapple with the Government's change in its higher educational policy statement from green to white. While all the issues are not clear as yet, there is one thing which is abundantly clear. The Government perception of the research component of the higher education sector is one which does not recognise creativity or imagination as a worthy part of the process of research. The higher education research sector is not to be reduced to a problem solving and service laboratory for a business and industry sector which refuses to recognise the need for its own research, and to accept the obligations that are necessary to develop that research. The present business and industry spokespeople support the Government's aim of directing and controlling research in both the higher education sector and the Government laboratories such as CSIRO to the benefit of business and industry.

The need for the Government supported laboratories to charge reasonable overheads is challenged by industry. Yet industry appears to have redefined many of its testing functions to be research, in order to gain tax benefits.

Not content with debasing the whole concept of research in the higher education sector, the Government proceeds to further reduce that sector's opportunities to do any scientific or other research by erosion of the already limited infrastructure available in universities and other institutions. The method is subtle. Over the next few years $65M will be removed from the higher education budget and given to the Australian Research Council to distribute as research grants. The argument of the Government is that it will remove money from all universities so that it may be returned in line with national priorities. As far as the universities are concerned, this money is removed from long term budgets, to come back in undetermined amounts as part of short term grants to individuals and groups. The long term support of the research infrastructure, i.e. technical and support staff, will be sacrificed and replaced by short term support, dependent on ARC handouts, at best on a three year basis. These changes will significantly effect the teaching as well since much of the infrastructural support has a dual role in teaching and research.

The research capacity of the higher education sector will be significantly reduced, particularly in developing areas of creative inquiry which do not have identifiable financially exploitable end points. As Dr Rees points out, much of the work of the very successful group of researchers at the CSIRO Division of Chemical Physics led to considerable financial return to Australia, but by today's criteria would probably not have been funded at the start because future success was not obvious.

Two things are essential. Our Government must re-educate to understand what is the meaning and contribution of scientific research to our society and our business and industry community must accept its obligations in the development aspects of science and technology. Neither is likely to happen in the current plan spelt out by such reports as the Government's discussion papers on higher education and the role of the CSIRO.

R.J. MacDonald
Hon. Editor

The University of Auckland
New Zealand

Two Lectureships in Physics
Department of Physics

The Department of Physics seeks to appoint two Lecturers. As part of an expanding research program in modern optics, one appointment will be in the area of Theoretical Quantum Optics, the other in Experimental Laser Physics. Other research interests in the Department include Nuclear Physics, Biophysics, Astrophysics, Electronics and Geophysics.

The present staff of the Department consists of a Professor of Geophysics, a Professor of Theoretical Physics, a Professor of Nuclear Physics (who is currently Head of Department), 8 Associate-Professors and 13 Lecturers/Senior Lecturers. The technical and secretarial staff number 32.

Applicants must have an advanced qualification in Physics and preferably have had some teaching experience. Preference will be given to those with a record of successful involvement in any branch of theoretical quantum optics or experimental laser physics.

The Lecturers will be expected to contribute to both the undergraduate and graduate teaching programs, supervise laboratories at all levels, join a research group active in modern optics, and to interact with and strengthen the existing research interests of the Department. The current interests of the theoretical group on quantum optics include squeezed and non classical light, quantum noise reduction in optical systems, quantum amplifier theory and quantum measurement theory. The current interests of the experimental laser group include the design and construction of new laser systems, the application of ultra-fast laser pulses and light propagation in optical fibres.

Commencing salary will be established within the range NZS35,000 - $42,100.

Conditions of Appointment and Method of Application are available from the Assistant Registrar (Academic Appointments), University of Auckland. Applications in accordance with the Method of Application, should be forwarded as soon as possible, but not later than the closing date of 1 September 1988.

The University of Auckland is an Equal Opportunity Employer and applications from females and males will be equally welcome.

W.B. Nicoll
Registrar
University of Auckland
Private Bag, Auckland, New Zealand
Gravitation Symposium

The Gravitation Symposium at the AIP Bicentenary Congress of Physicists on 27 January 1988, at the University of New South Wales, was only the second meeting by this group. Thus, although it was probably the youngest of the 16 odd groups at the Congress, because of world-wide interest in recent developments in this field, it received considerable attention both at the plenary lecture and the symposium talks.

Although fundamental gravity research is not a major field in Australia, there was judged to be sufficient interest in this area, (by three loosely connected groups), for Professor Geoff Opat to suggest that they come together under the umbrella of a gravitation workshop. The first meeting, chaired by Geoff Opat, was held at the 7th National Congress of the AIP in Adelaide in 1986.

The three groups (with respective group leaders) were: gravitational radiation experiments (Dr David Blair, UWA), the fifth force, or colloquially big G, (Professor Frank Stacey, UQ) and gravitational experiments on particles and antiparticles (Professor Geoff Opat, UM). On Wednesday afternoon, David Blair began the presentations from the WA group, on the latest developments on the niobium resonant bar gravitational radiation antenna, by discussing correlations and noise reduction for arrays of resonant bar antennas. A review of the current status of the antenna was then presented by Dr Peter Veitch, Nick Linthorne discussed parametric effects in the capacitance modulated re-entrant cavity tranducer, Darryl Ramm highlighted the development of an ultra-low noise tunable microwave source, using a tunable sapphire loaded superconductivity cavity, and David Blair concluded the session with discussions on a frequency controlled system for ultrastable oscillators and a phase stabilised loop oscillator, based on a sapphire loaded superconducting cavity resonator.

The Holy Grail of 20th Century physics, according to Dr Michael Nieto from Los Alamos National Laboratory USA, is the unification of quantum mechanics and gravity. This was the theme of his plenary address The Principle of Equivalence, Quantum Gravity and New Gravitational Forces (to be reprinted in a future issue of the Physicist) on Thursday morning, in which he reviewed various theories of unification and discussed a general theory of quantum gravity that he has proposed with Goldman and Hughes from Los Alamos Laboratory.

The momentum of interest generated from Nieto’s plenary talk contributed to the morning workshop being filled to overflowing. Frank Stacey began with geophysical indications and implications of a fifth force, in which he applied Nieto’s quantum gravity theory to geophysical data, including recent results from the US Air Force Geophysics Laboratory to determine ranges and amplitudes of the non-Newtonian force. I followed with a review of some novel fifth force experiments, which sought evidence of composition dependence effects and Michael Nieto concluded the session with a report on the status of the Greenland Big-G experiment.

Nieto kicked off the final afternoon session - this was his third talk that day - with an interesting outline on the status of the Los Alamos antiproton gravity experiment, scheduled to begin at CERN in 1991. This talk set the stage for the Melbourne group, who are examining various aspects of the superconducting drift tube problem that was discussed first by Witteborn and Fairbank in their experiment to measure the force of gravity on free falling electrons inside a copper shield. Frank Rossi highlighted gravity induced contact potentials in conductors, Tim Darling reported the effects of surface electric fields in gravity experiments with antimatter, and Gareth Moorhead presented the final talk on inertia induced electric signals in various metals.

The interest generated by this workshop was indeed exciting and stimulating, so the next meeting will be in Perth in 1990, where I hope to see participation by more Australian theoreticians in this field.

I would like to thank all participants for their interesting contributions, and other congress members for a successful and enjoyable symposium.

Gary J. Tuck
University of Queensland

Australian Acoustical Society Conference
Seismo-Acoustics and the Sea Floor Interaction
28th January, 1988

This one day conference was organised by the Australian Acoustical Society and was attended by about 30 acousticians of whom 10 were from overseas (NZ, USA and Canada). The invited speaker was Professor Alec Kibblewhite from the University of Auckland, New Zealand, who presented a review of low frequency acoustic propagation in marine sediments. This was followed in the morning and afternoon sessions by papers on different aspects of sea floor acoustic and seismic characteristics. The conference was supported by an associated symposium and workshop (classified on Sea Noise held at DSTO (Sydney) on the 27th and 29th January.

Invited Speaker
A.C. Kibblewhite
Geoaoustics and the Interaction of Waterborne Sound with the Sea Floor.

Contributed Papers
S.P. Kravis (B.M.R. Canberra)
Modelling of P-S Converted Waves in Marine Seismic Data
M. Hall (D.S.T.O. Sydney)
Acoustic Properties of the Continental Shelf Sea Floor
J.I. Dunlop (U.N.S.W.)
Measurement of Sediment Properties Critical to Acoustic Propagation Characteristics
N.R. Chapman, K. Stinson, S. Levy and D. Oldenburg (D.R.E. Canada)
Measurement of Elastic Properties of Marine Sediments by Inversion of Sea Floor Reflection Data
M.H. Lawrence (D.S.T.O. Sydney)
Determination of Geoaoustic Properties by Two-Frequency Synthetic-Aperture Method
J.F. Geitrus and M. Rowe (N.O.R.D.A. USA)
Deep Ocean Sediment Structure and Acoustic Bottom Loss Estimates from a Deep Towed Seismic System
N.R. Chapman and R.W. Bannister (D.S.E. NZ)
A Ray Model for Ocean Bottom Reflection Loss in Thin Sediments
J.I. Dunlop
School of Physics, UNSW

172 Australian Physicist Volume 25, Number 7, August 1988
Research plans lacking Adventure

The Australian Research Council, announced in the federal budget speech last September, seemed like a good idea at the time. The ARC was conceived to be the major mechanism for funding scientific research in Australia. It would subsume existing grant schemes and in the words of John Dawkins, Minister for Employment, Education and Training, enable Australia to "fully utilise its high-quality research for skill and innovation-based industries".

During gestation things appear to be going awry, to the dismay of its constituency, the research community, and the ultimate detriment of the Government's bold reforms.

Mr Dawkins need not feel compelled to invoke the streaker's defence - the ARC remains a good idea, and has been widely endorsed by researchers. But the track record since September has not been one to sustain their confidence, and reservations are now being voiced.

Concerns being expressed by groups such as the Federation of Australian Scientific and Technological Societies (FASTS) are not those of vested academic interests protecting cosy arrangements. Rather they reflect disappointment in the unadventurous blueprint now emerging for the ARC.

These concerns will be shared by the Australian public, which apparently accepts the Government's view that a radical restructure of the nation's commercial and industrial base is necessary to improve Australia's bleak economic prospects. The rebuilding process will require research and development to be responsive to government priorities, in order to rectify the inadequacies in Australian technology and innovation.

But this responsiveness will not be forthcoming if the ARC is lumbered with an unimaginative and inflexible organisation, or if insufficient prior thought is given to how the ARC can function most effectively.

The problems with the ARC are in two related areas. The first is structural. The ARC will have four advisory committees to evaluate research and recommend the allocation of funds. These committees have been established along traditional disciplinary lines (physical science, earth sciences and engineering, biological sciences and social sciences) and look uncomfortably like the structure of the now defunct Australian Research Grants Scheme. "ARGS revisited" is being muttered widely around political and scientific traps.

This conventional structure is tailored to deal best with science and technology within the traditional disciplinary areas, and lacks a clear mechanism to deal with multi-disciplinary studies or new ideas at the interface of disciplines.

This is an unfortunate omission because there is good evidence in Australia of the remarkable success of multi-disciplinary science funding (e.g., the marine sciences) and the growing awareness that many of the innovations so needed by Australia are likely to occur at the interface of disciplines.

It was not for want of alternative suggestions that this structure emerged. FASTS has proposed a structure that would allow advisory committees for multi-disciplinary areas to exist alongside the traditional disciplinary committees. Similar views were advanced by the Federation of Australian Universities Staff Associations and by professional groups such as the Australian Marine Sciences Association.

Of course, had this advice been accepted, the next question might have been "which multi-disciplinary areas?". This highlights the second area of inadequacy of the Australian Research Council: its lack of explicit avenues for obtaining policy guidance, and for ensuring that policy and priorities will be put into practice.

One of the largely unsung successes of Barry Jones's Department of Science was the development of a new competence in generating science policy. Since July 1987, this capability has resided in John Button's Department of Industry, Technology and Commerce.

Another body, the Australian Science and Technology Council, which reports to the Prime Minister, also has a role in macro-level science policy. But nothing in the ARC's blueprint suggest how it will draw upon this policy expertise.

Before the ARC finds itself operating in a policy vacuum, or equally inappropriately, decides to use scarce resources to reinvent the science policy wheel, it should determine how to best obtain policy guidance from existing bodies.

It should ask them to identify which bands of the spectrum of science and technology Australia might choose to occupy. Thus, broad national priorities for research and development can be defined. Some of these will then become targets for special support from the ARC and, if necessary, special advisory committees should be established to deal with them.

The best example to date of this process is marine science and technology, in which careful policy and priority determination led to the growth of a strong national capability in marine research which did not exist in this country only ten years ago. But marine science obviously is not the only area that should receive priority status. There are others such as space science, climate research and new materials, that arguably might be designated as national priority areas with targeted multi-disciplinary support.

Had there been sufficient thought given to policy when drawing the blueprint for the ARC, it would have been evident that the structure now being put into place was inadequate for dealing with multi-disciplinary sciences and national priorities.

The same policy development and priority setting also will be necessary to support Mr Dawkins's reform of the higher education sector, outlines in the widely debated green paper.

Frustrations now exist because researchers and Government alike saw an opportunity to establish a rational and lasting basis for scientific research in Australia, to ensure that it contributed to the solution of the manifest difficulties this country is facing.

However, researchers have watched the proposal develop in a most unsatisfactory way, and the overwhelming concern now is that such a promising idea should yield a result which will be inadequate to the challenges which energetic ministers such as John Dawkins and John Button will place before it.

L.S. Hammond
Vice President, FASTS
Reprinted from The Age
by John B. Whiteoak
Australia Telescope Project Secretary

In a few weeks the Australia Telescope will be formally launched as an Australian bicentennial activity. Under construction since 1983, this 30 million dollar facility is a radio telescope designed to satisfy the needs of Australian scientists into the next century. Designed and built locally, it will be a lasting monument to Australian expertise.

Why we need a new Radiotelescope

The reference to astronomical and meteorological observations in Section 51 of the constitution of the Commonwealth of Australia implies a responsibility to carry out such observations. Over the years Australian astronomers have successfully met this challenge. Starting with the Great Melbourne Telescope in 1858, large optical telescopes have been built here, and today we have world-class instruments such as the 4-m Anglo-Australian Telescope.

Australians also featured prominently in the development of the younger science of radio astronomy. At the end of World War II, pioneering work was carried out by scientists formerly engaged in wartime radar development at CSIR (now CSIRO). Their achievements, initially obtained using surplus radar equipment, brought great prestige to this country. Australian research remained at the forefront during the following thirty years as CSIRO and university scientists constructed a succession of fine radio telescopes. The more recent additions included the Parkes 64-m antenna (completed in 1961), the 1.6 km Molonglo cross array (completed in 1965), and the Culgoora Radioheliograph (completed in 1967).

The instruments of the 1960s have been upgraded periodically, and still continue to support good research, even producing scientific breakthroughs from time to time. However, during the 1970s it became apparent that other countries were constructing a new generation of telescopes which would enable their astronomers to gain the research initiative. A new radio telescope was essential to preserve the research vitality of Australian radio astronomers.

In 1975 a group of representative Australian scientists met to plan a new instrument. The design goals included high sensitivity, high angular resolution (i.e. ability to map fine detail), wide frequency coverage, ability to map wide fields with high polarisation purity, and flexibility in operation. It would compete on equal or better terms with overseas radio telescopes such as the US Very Large Array (twenty-seven 25-m diameter antennas distributed along three 20 km arms set in a Y configuration), MERLIN (a UK array now of antennas at six locations up to 300 km apart), mm-wavelength arrays in California and Japan, and the future US Very Large Baseline Array (ten 25-m antennas distributed across the continent). It would also complement the new generation of telescopes (both orbiting and ground-based) operating at other wavelengths.
More important, it would be the only instrument of its type in the southern hemisphere. Northern telescopes, no matter how elaborate, cannot reach a significant portion of the southern sky, and therefore cannot observe unique objects such as the Magellanic Clouds (the two galaxies closest to our galaxy, yet still at a distance of 170,000 light years) and much of the important inner part of our galaxy's plane. Probably the most enigmatic part of our galaxy is the galactic nucleus, believed by some to contain one of the mysterious black holes. At northern observatories it can only be viewed near the southern horizon, whereas in Australia it passes almost directly overhead.

To cut a long story short, a final design, the Australia Telescope, was produced in 1982. The Federal Government gave its final approval in November 1983 and CSIRO were given the responsibility for construction of the instrument. Construction began with site works eighteen months later.

The Australia Telescope will be formally launched this September with an 'Opening' as part of this country's bicentennial celebrations. With CSIRO as a host institute it will operate as a national facility, available on merit to scientists from all over Australia.

What is the Australia Telescope?

The Australia Telescope is not a single instrument, but rather a collection of individual radio antennas located at three sites within NSW. These will be used together in two main configurations, the Compact Array and the Long Baseline Array.

The Compact Array is located at the Paul Wild Observatory at Culgoora near Narrabri, the former site of the well-known circular radiotelescope. It consists of six 22-m diameter antennas. Five can be moved along a common 3-km east-west railtrack; for operation each is set with an accuracy of a few millimetres on to one of 35 concrete observing stations. The sixth is on a 75-m long rail track a further 3 km to the west, and has two stations. By changing the combinations of stations between observing periods the spacings between the antennas can be varied. The signals received by the antennas will be transmitted to a central control building for correlation in computers. After editing etc., the correlated signals will be sent on magnetic tape to the Epping NSW Headquarters of the Division of Radiophysics for further analysis using a CONVEX C-210 mini-supercomputer.

Earth-rotation synthesis will be used with the array to create an image of a radio source. This technique was developed in Australia during the 1950s for observations of the Sun, and exploited for radio sources using the Cambridge One-Mile Telescope ten years later. It requires observations with a large number of different spacings between pairs of antennas. Tracking the source across the sky provides another requirement - a rotation of the source relative to the array. Subsequent application of Fourier techniques to all the correlated signals from pairs of antennas will yield an accurate image of the source. The finest image detail will be similar to that provided by a single antenna as large as the longest spacing between antennas. In the design of the array the positions of the stations were set only after detailed studies aimed at obtaining

A schematic representation of the Australia Telescope, showing the Compact Array at Culgoora, and the Long Baseline Array formed from the Compact Array, the 22-m antenna near Siding Spring, the 22-m antenna near Coonabarabran, and the Parkes 64-m radio telescope.
the required number of different spacings with the minimum number of antenna moves. Nevertheless, six antennas provide only 15 simultaneous spacings, and even the best solution required many days to completely simulate a 6 km antenna. Fortunately, sophisticated computer programs are now available to correct for missing spacings, and many observing programs will require only four days or less to complete.

The other configuration, the Long Baseline Array, is formed by using one or more antennas of the Compact Array with two other antennas - a seventh 22-m antenna at a site (Mopra) in the Warrumbungle National Park a few kilometres west of Coonabarabran, and the famous 64-m antenna near Parkes. To enable simultaneous observations at the three sites, it is intended that reference signals originating at the Culpooa control centre will be beamed to the sites using the Australian communications satellite AUSSAT. The antenna outputs will be collected on special wideband tape recorders and processed later at Culpooa.

Several large correlators are used to process the signals received from the antennas. Each correlator is based on a specially-designed VLSI (Very Large-Scale Integration) chip operating at 16 MHz. Each chip, 5 mm square, contains 50,000 transistors. Correlator boards containing 18 chips provide up to 1024 channels at input rates of up to 256 megabits per second; more than 300 boards were required for five correlators (three at Culpooa and one each at Mopra and Parkes to support single-dish operation).

The Performance of the Australia Telescope Wavelength Coverage

How does the Australia Telescope rate in terms of the initial wishlist? The planned wavelength coverage of the Australia Telescope exceeds that of any existing or planned array. Within the construction budget, operation will be available in four bands between 20 cm and 3 cm. However, the Telescope was designed to operate at much shorter wavelengths - the new 22-m antennas have four rings of solid reflecting panels (out to a diameter of 15.3 m) which are accurate to 0.15 mm. Equipment will be added later to extend the wavelength limits to 90 cm and 2.6 mm. The selected bands not only enable the continuum emission spectrum of radio sources to be sampled at approximately octave intervals, but also contain the wavelengths of the most important spectral lines of atoms and molecules in the interstellar medium. The extension to 2.6 mm will enable the observation of an important spectral line of carbon monoxide, an abundant molecule in galaxies where it is concentrated in clouds in which star formation is occurring.

### Observing Bands for the Australia Telescope

<table>
<thead>
<tr>
<th>Wavelength Designation</th>
<th>Frequency Coverage (GHz)</th>
<th>Important Molecular Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>99 cm</td>
<td>0.322 - 0.329</td>
<td>H$_2$, OH</td>
</tr>
<tr>
<td>50 cm</td>
<td>0.382 - 0.603</td>
<td>H$_2$O, OH</td>
</tr>
<tr>
<td>20 cm ($^{13}$C)*</td>
<td>1.25 - 1.78</td>
<td>SiO, CS</td>
</tr>
<tr>
<td>13 cm ($^{13}$C)*</td>
<td>2.2 - 2.5</td>
<td>H$_2$O, NH, HCN, HNC, CH$_3$</td>
</tr>
<tr>
<td>6 cm ($^{13}$C)*</td>
<td>4.4 - 6.1</td>
<td>SiO, CS</td>
</tr>
<tr>
<td>3 cm ($^{13}$C)*</td>
<td>8.0 - 9.2*</td>
<td>HCN, HNC, NH, HNC, CH$_3$</td>
</tr>
<tr>
<td>12 mm (C)</td>
<td>20.0 - 25.5</td>
<td>SiO, CS</td>
</tr>
<tr>
<td>7 mm (C)</td>
<td>42.0 - 50.0</td>
<td>SiO, HCN, CH$_3$</td>
</tr>
<tr>
<td>3.5 mm (W)</td>
<td>84.0 - 98.5</td>
<td>CO</td>
</tr>
</tbody>
</table>

* bands available initially
# later extension to 10.7 GHz

Angular Resolution

The most important feature of the Australia Telescope is its angular resolution - for radio galaxies in particular high-detail images are required to study the nuclear mechanisms responsible for the radio emission. The Compact Array, with a maximum separation of 6 km between antennas of a pair, will provide a synthesised beam diameter of 0.8 arcsec at 3 cm wavelength; this is much the same as the resolution of Australia's major optical telescopes during good observing conditions. Beamwidth scales with wavelength, and higher resolution will be available when operation is extended to shorter wavelengths.

The Long Baseline Array, with a maximum spacing of 320 km, will increase the angular resolution by a factor of fifty. Even higher resolution will be needed for some studies, and it is proposed to use the Australia Telescope with other antennas around Australia. Antennas of the NASA Space Tracking Station at Tidbinbilla and the University of Tasmania have already been identified as probable additions, and other possibilities also exist. A most challenging prospect is the future use of the Array in conjunction with antennas either overseas or in orbit. A few years ago the USSR initiated a project (RADIOASTRON) to launch a 10-m antenna into space by 1992. Other countries have now teamed up with USSR and these include Australia. A Memorandum of Understanding has been signed and Australia will now provide

---

**The School of Physics**

**Lecturer (Continuing)**

**The University of Melbourne**

Applications are invited for the above position from experimental physicists with a proven research record and interests which overlap with or complement one of the following fields:

- Information about the School is available from the Chairman, Professor A.G. Klein on (03) 344 6420; fax (03) 347 4783.
- Applicants should be willing to participate in the supervision of both honours and postgraduate students. A genuine interest in the undergraduate teaching program is essential.
- This position will be available from 1 January 1989.
- Salary in the range: $26,884 to $37,435 per annum.
- Further information regarding application procedure and conditions of appointment is available from Ms. J. Poulson on (03) 344 7546.
- Closing date: 30 September 1988.
- Position Number: 640090
- Applications in duplicate including names and addresses of at least three referees and quoting the position number should be addressed to:
  - The Director
  - Personnel Services
  - The University of Melbourne
  - Parkville Vic 3052
- An equal opportunity employer.
some of the equipment for the antenna. Another project, QUASAT, involving the launch of a 15-m antenna by 1996 is being planned by the European Space Agency, and Australia will play a key role by providing southern hemisphere antennas. Networks involving orbiting antennas should provide a beam size comparable with the angular size of the accretion disks surrounding the elusive black holes believed to dominate the dynamics of the nuclear regions of galaxies and triggering the giant nuclear explosions that create the extended distributions of radio emission.

Sensitivity and Versatility

The number and size of the antennas of the Compact Array were both limited by the available budget, and at centimetre wavelengths the sensitivity is less than say, the Very Large Array. However, there are other features which compensate for any disparity in antenna collecting area. Special wideband feedhorns enable simultaneous dual-polarization operation in two wavelength bands about an octave apart. Thus, for the initial observations combinations of 20 and 11 cm, or 6 and 3 cm will be available. Moreover, quick change of combination is possible - the horns and associated receiving systems are installed in a rotating turret set off-axis near the centre of each antenna, and an appropriate rotation places the required feedhorn on-axis.

Each dual-frequency, dual-polarisation receiving system is enclosed in a dewar and refrigerated using helium gas down to 10 K. Each of the four outputs has a bandwidth of 256 MHz. These signals are transmitted to the control building for correlation with the outputs from other antennas. Transmission through conventional coaxial cable would have degraded the bandwidth; therefore each output is digitised at 512 MHz and sent through optical fibres.

For an observing period of 4×12 hours, maps of the sky will be produced with an rms noise level per beamwidth of 15 mJy (i.e. 1.5×10^{-23} W m^{-2} Hz^{-1}).

At the shortest wavelengths, the performance of the Australia Telescope will be on its own. Of the other antennas mentioned earlier the mm-wavelength arrays in USA and Japan operate at short wavelengths but have a more limited capability in terms of collecting area or baseline.

The correlators provide a range of bandwidths to provide for both wideband continuum observations and observations of narrowband maser spectral lines. The spectral options vary from 16 channels covering 256 MHz to 8192 channels covering a bandwidth of 0.5 MHz. The highest frequency resolution of 60 Hz (which at 3 cm wavelength is equivalent to 0.002 km s^{-1} in radial velocity) is more than sufficient to cope with the fine structure in narrowband maser spectral lines.

Special efforts were made to have all antennas and their receiving equipment identical as possible, to lower limiting instrumental effects encountered with existing arrays. This should enable excellent wide-field coverage and polarisation performance. The latter is important because much of the non-thermal continuum radio emission from radio sources is linear-polarised, and the alignments of the plane of polarisation provide a means of mapping the magnetic fields present in the objects.

The operation of the Australia Telescope is extremely flexible. As mentioned the two basic arrays operate with two completely different ranges of resolution. If only a 3 km array is required, the two arrays can operate simultaneously, with the Long Baseline Array using only the 6 km Culgoora antenna, and the Compact Array using the other five antennas. Possible extensions of the Long Baseline Array have already been mentioned. In addition to all this, both the Parkes and Mopra antennas will operate as single independent systems; the latter, outfitted for wavelengths near 2.6 mm, would be the best antenna in the southern hemisphere at this wavelength.

It's Ours, and we Built it Ourselves!

The Australia Telescope is a fine example of 'made in Australia'. It contains over 80% local content. It was conceived and designed here, and constructed by local companies. The project produced innovative design and construction techniques which have provided valuable spinoffs for Australia's growing space communications industries.

For the 22-m antennas, the Division of Radiophysics in collaboration with Sydney consulting engineers Macdonald Wagner produced cost-effective designs. The Culgoora antennas have a large azimuth slewing ring to provide widely separated elevation bearings, an intermediate mounting of open trusswork, a stiff backup structure, and a heavy base equipped with bogeys. For the Mopra antenna, with a fixed base, a simpler yet stiffer wheel-on-track design was adopted. The Division developed a simple low-cost method for the construction of accurate reflecting panels. A former Brisbane ship-building company, Evans-Deakin Industries, fabricated and erected the antennas complete with reflecting surface in a 15 million dollar contract awarded in July 1985. Equivalent antennas purchased from overseas would have been considerably more expensive. For the construction of the largest Australia Telescope feedhorn, of length 2 m and maximum width 1 m, Radiophysics developed a new technique for lightweight construction.

Other areas of development which could provide spinoffs to industry have been mentioned already. These include sensitive cryogenically-cooled FET receivers, a network of interchangeable optical fibre links, and large correlating systems. In addition, extensive computer systems have been developed, with associated control and image processing software, to operate the antennas, collect and edit the signals, and produce the final maps.

Conclusion

By the end of 1989 the Australia Telescope will be probing the southern skies in earnest. Many of the outstanding problems in radio astronomy will be tackled: the detailed structure and dynamics of objects in the southern Milky Way (giant molecular clouds and star-forming regions, supernova remnants, stellar radio emission, the enigmatic galactic nucleus); the two Magellanic Clouds (what better galaxies exist for studies of the birth and death of stars); studies of the spectral-line emission from the neutral hydrogen atoms concentrated in the spiral arms of other galaxies; the energy sources of the nuclei of active galaxies and the stellar-like quasars.

It will take many years for the Australia Telescope to reach its full potential. There is no doubt, however, that well before this occurs it will be amongst the most powerful and versatile instruments in the world. Equally certain is that the start of operation will mark the dawn of a new era for Australian radio astronomy.
An International Satellite for Checking Disarmament Agreements: A Role for Australia?

by Jeff Kingwell
CSIRO Office of Space Science and Applications

A conference on Australia's role in international treaty verification, Checking the Arms Race, was held in Sydney on 13-15 May 1988. At this conference, the possibility of an Australian contribution to an international or multinational satellite monitoring agency for the checking of compliance with international agreements was mooted. This article explores this concept further and gives a summary of the historic background to the proposal.

Introduction

In 1978, the French President, M. Giscard d'Estaing, proposed at the United Nations Assembly that an International Satellite Monitoring Agency (ISMA) be established, with access to existing military reconnaissance satellites and ultimately its own dedicated surveillance systems. ISMA would assist UN member states in verifying arms control agreements, ceasefire monitoring, and in relief operations following natural hazards such as earthquake, tsunami and cyclones (d'Abovic and Guionnet, 1986).

At that time, the only relevant satellite systems were in the hands of the USSR and the USA, and they, with rare amity, vetoed the French initiative on the basis that ISMA wouldn't tell them anything new, but would reveal to other parties much about the USA's and the USSR's own technical capabilities (or, in the jargon of strategic arms negotiation, their NTMs or National Technical Means). ISMA would of course also reveal to third parties the extent of compliance of both superpowers with treaties, as well as reducing the degree of freedom on any nation to conduct large-scale military preparations in secrecy.

Proposals, that were similar to, but not identical with, the 1978 initiative have been recently voiced by inter alia the Summit meeting of the European Economic Communities (Vouin, 1985), the Council of Europe 1983 (Space Policy, 1985), Senator George Brown of California (Brown, 1987), the Pugwash Conference (Space Policy, 1987) and Congressman Robert Mrazek (Washington Remote Sensing Letter, 1988).

Varying Perspectives

Support for the ISMA concept exhibits a spectrum of emphases. For small nations such as Sweden, the stress is on conflict avoidance and enhanced international stability: for medium countries such as France, the prospects of increasing regional security and prestige are at the forefront, with the suggestion of a European military/surveillance consortium receiving a deal of attention (d'Abovic and Guionnet, 1986). The idea here is for France, Italy, Spain and perhaps West Germany to share upkeep and information from an intelligence-gathering satellite system Helios, alias SAMRO, alias SPOT militaire (Jasani and Larsson, 1988).

US sources supporting the concept of an international satellite agency often emphasise what may happen if the US is left out, especially in regard to loss of control of influence, loss of prestige and perceived technological leadership, and concomitant loss of commercial benefits. For example, McLucas and Maughan, an international commercially-oriented satellite consortium which would have within its ambit meteorological observations, earth-resources data and, ultimately, strategic/tactical intelligence observations for a peace-keeping role.

How would it work?

The superpowers have long used low-earth-orbit satellites to provide strategic and tactical intelligence. Civilian satellites used for assessment of earth resources have an analogous role, and to some extent have developed or spun-off from the military surveillance systems. With the rapid growth of earth-observation satellite capability over the last 16 years, a number of nations apart from the superpowers now have a means of obtaining frequent (daily) information about the presence and change of features on the earth's surface. Human artifacts such as large radar installations, docks and barracks, warships, military airbases, marshalling areas and the like could be surveyed.

A multilateral or international satellite monitoring agency may begin operations by using information readily available from the family of remote sensing satellites already operating (Figure 1), and by using impending systems which have additional capabilities, such as the ability to operate in darkness or see through cloud by using active radar methods.

Later, the agency could take responsibility for its own dedicated and specialised satellites with enhanced resolution or other customised attributes.

Potential Australian Role

Australia, a small but relatively technologically advanced country, can and already does play a significant role in international arms control. Examples of this commitment were the selection of an Ambassador for Disarmament, and Australia's key involvement in the seismic network for detecting underground nuclear tests. The latter is centred around the Nuclear Monitoring Group of the Bureau of Mineral Resources.

Australian competency and even technical leadership in key sectorial technologies (such as the Fast Fourier Transform chip which can be used to rapidly process complex remotely sensed data such as that obtained from spaceborne Synthetic Aperture Radar: multi-spectral spectrometry and image processing: thin-plane interferometers; and the photon-counting array developed for use on future earth-orbiting astronomical telescopes) are pertinent to the proposal. Moreover, the inevitable involvement of the politics and policy areas of government may give the Australian space industry the kind of focused official attention that has not always been obvious.

As claiming to 42% of the land area of the Antarctic continent, it would seem appropriate for Australia to assume special responsibility for checking of compliance with the Antarctic Treaty. Such an ambition is difficult with present on the ground resources, since, for example, there are more Soviet manned bases in the Australian Antarctic Territory than there are Australian ones. Satellite surveillance from a base in the AAT would seem to be a valid and achievable approach.
Jeremy (1987) provides a detailed technical feasibility study of the establishment of a facility which would provide a suitable starting point for real-time and constant surveillance of Antarctica from space.

A plausible scenario for Australian government participation in an international conflict-reducing venture of this kind (with the policy objectives of increased international stability, regional security, and enhanced Australian industrial capability) would be for the country, possibly through the Department of Foreign Affairs and Trade, to fund our industry and R&D agencies to develop spaceborne sensors and receiving/processing software and equipment. Data receiving installations could conveniently be operated by an existing agency, the Australian Centre for Remote Sensing (ACRES), with some incremental and continuing financial support for the additional functions.

These data should be examined by a specialist group of perhaps 4 people, possibly based at the Department of Foreign Affairs and Trade. At least some of these staff should be familiar with photogrammetric methods and all should have access to corroborative evidence and information needed to supplement the satellite-based information. Satellite data in isolation may be misleading or inconclusive (Jasani and Larsson, 1988) whether for arms verification or for mineral exploration, and must be supplemented by ground truth. Satellite data, by its ability to view large areas frequently, is however virtually unsurpassed in ability to point out which areas would bear closer examination.

As a result of such an approach, Australia would have guaranteed access to current satellite intelligence, as a full partner, with substantial elements of real technological control and a suitable level of technological equity.

**Distinction for SDI**

Technophobes may equate ISMA with the Strategic Space Defence Initiative (SDI), possibly seeing both as blue sky projects with little prospect of implementation. Some points of differentiation are given below.

<table>
<thead>
<tr>
<th>ISMA</th>
<th>SDI</th>
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<tr>
<td>Stabilising influence by providing information about potential hostile acts.</td>
<td>Destabilising influence through introducing new arms race cycle, enhanced first strike capability, and offensive capability (Kingwell, 1986).</td>
</tr>
<tr>
<td>Essentially passive.</td>
<td>Essentially a weapons system.</td>
</tr>
<tr>
<td>International or multi-national.</td>
<td>Under development only by one (or possibly two) superpowers.</td>
</tr>
<tr>
<td>Established technology, so costs can be contained and anticipated.</td>
<td>Involves novel, controversial technologies; architecture is open ended, so final cost indeterminate.</td>
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<tr>
<td>Objectives clear and simple.</td>
<td>Objectives ambiguous.</td>
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**Conclusion**

Proposals have been made over the last decade for the establishment of an International Satellite Monitoring Agency to operate high-resolution, earth-observing satellite systems to check compliance with international arms control treaties, cease fires and similar accords, and to give current information for the amelioration of natural disasters.

Australia, as a respected middle-power country with an expressed interest in international rapprochement, an established capability in remote-sensing applications and a growing capability in the design and manufacture of space-based instruments and of terrestrial data-processing stations, is well placed to play a significant role in such an agency.

A starting point of a multinational or international monitoring agency could be the utilisation of existing earth-resources satellites; a second stage may be the construction and deployment of dedicated and specialised peace keeping satellites.

**References**


Physics Awards for Excellence

At an informal ceremony on 21 April in the School of Physics at the University of Sydney the Chancellor, Sir Hermann Black, presented the Science Foundation for Physics awards and the inaugural Cadbury-Julius Sumner Miller awards for 1988.

The awards are in recognition of academic excellence in the courses Physics I (each to the value of $600), Physics II (value $700), and Physics III (value $800) and are made to students going on to next year's courses in Physics.

The Science Foundation awards, up to five in each category, have been made since 1982. The Cadbury-Julius Sumner Miller awards, two in each category, were made for the first time this year in memory of the late Professor Julius Sumner-Miller, formerly Professor of Physics at El Camino College, California, who died on 14 April 1987. Cadbury-Schweppes, for whom Professor Sumner Miller recorded many TV ads in Australia, has undertaken to honour his memory by instituting six scholarships under conditions similar to those of the Science Foundation awards.

The winners of the Cadbury-Julius Sumner Miller awards (No. I) are Leung Hok Chin and Andrew Tridgell.

The winners of the Science Foundation for Physics awards (No. II) are Haide Lia, John Brekenridge, David Mar, Julian Madgery and Kenneth Wessen.

HSC Physics Teachers' Workshop

The School of Physics at the University of Sydney recently conducted a very successful workshop on the physics syllabus. Over 100 teachers came to the School for a Friday evening and Saturday session which concentrated on the waves and optics components of the syllabus. Physics teachers and university lecturers combined to present the talks, some of which concentrated on the syllabus itself, while others covered a broader material. A laboratory session in which teachers could use equipment and question 'experts' was very well received. The workshop was the third in a series on the HSC syllabus, and the positive responses of the participants showed that the format successfully met a need recognised by teachers and university staff alike.

Watch out for FORTH!

FORTH is perhaps one of the longest and best kept secrets in the computer world. So says Dr Paul Walker, one of the organisers of the first ever Australian conference on applications of this computer programming language. More than half of the delegates to the FORTH Symposium which was held recently at the University of Technology, Sydney came from overseas and interstate. According to President of the Silicon Valley FORTH Interest Group, Rob Reiling, the Australian symposium was the largest inaugural FORTH conference anywhere in the world in the 20 year history of FORTH.

Dr Walker, who is with the Department of Physics at the University of Sydney, believes that FORTH offers the programmer unparalleled flexibility and direct control of the computer.

With the recent introduction of the Novix and Harris RTX-2000 high performance microprocessors, whose assembly language is FORTH, real-time applications are where FORTH will have a decisive advantage. One of the features at the symposium was a low cost supercomputer board based on the Novix 4016, designed and manufactured on Australia's Central Coast by Maestro Pty. Ltd.

The Symposium was addressed by US visitors Charles Moore, the inventor of FORTH, Elizabeth Rather, President of FORTH Incorporated, and several other overseas speakers. The quality of presentations, most of which were from Australian designers using FORTH, was exceptionally high and the proceedings will be published internationally. The seven special interest workshops scheduled were in such heavy demand that some had to have repeat sessions offered to accommodate the overflow.

"The Symposium brought together professionals from all around Australia and the world, who previously had been working in near-isolation," Dr Walker says.

"Apart from being an invaluable exchange of ideas, the Symposium provided a potential resource of FORTH designers available for contract programming work, and plans for professional level courses in FORTH. New commercial relationships were established and planning was commenced for the next Symposium to be held in Melbourne next year. So watch out for FORTH!!" Dr Walker said.

For further details contact:
Dr Paul Walker, Department of Physics, University of Sydney Tel: (02) 692 3622

Australian Science and Technology Information Service

The establishment of an Australian Science and Technology Information Service has been planned for promoting public understanding of science and technology among three strategic groups.

The general public (via the media) Secondary schools (students with their teachers) Politicians (with their administrators).

The impetus is an appreciation of the need for practical projects to enhance the public understanding of science and technology and political accountability. The goals are to assist in improving the economic, educational and cultural bases of the nation.

The plan follows extensive consultation in science and technology, the media and science education in Australia, the UK and USA. It is in line with initiatives of The Royal Society, UK, the American and British Associations for the Advancement of Science and the Scientists' Institute for Public Information, USA.

Media Referral Service

A free and independent service of referral and information will put people in the media, throughout Australia, in direct contact with reliable and articulate experts for information and comment on scientific and technological matters.

• With the co-operation of scientific and technological organisations, local expert commentators in all areas of specialisation will be made available to people in the media and politics for information, quotation and consultation.

• Information and names of experts throughout Australia will be stored on a system for rapid retrieval to match the short time-frame of media reporting. This information will be secure and accessible only through the staff of the Service.
Liaison with the media will serve the needs of general reporters, extending coverage of science and technology in outlets which reach the greatest audiences, e.g. commercial television, radio and mass circulation newspapers.

International information exchange with other English-language services will be offered as a service unique to the Australian media (agreements have been reached with the UK and USA).

Educational Services
A Schools' Speakers, Consultants and Visits Bureau will co-ordinate personal contact between schools and active scientists and technologies.

- Schools will be able to consult the Bureau to arrange visits by scientists pertinent to their current needs.
- Specialists will be asked to speak and demonstrate in schools as part of a process of enrichment for students and reinforcement for teachers.
- Visits by school classes to laboratories in universities, colleges and industry will be arranged.
- Committed communicators would be available for consultation informally by teachers for assistance with problems of content and presentation of their subject which go beyond the limits of textbook teaching.

Political Services
- Circulation to Federal and State politicians and public servants annually of a brief up-to-date directory of the principal sources of information about science and technology which may be approached directly for information and advice.
- Demonstration to politicians and administrators that the scientific and technological community is able and willing to assist them in the making of policy and its implementation. The Service will not engage in lobbying politicians - a role for the academies, societies (especially the Federation of Australian Scientific and Technological Societies) and institutions.

Services for Supporting Organisations
- Facilitating direct access to the organisations' own experts to the national media - with proper institutional credits.
- Access to a service monitoring the national press, radio and television, including national and international newswires.
- Summaries of media reports on science and technology, collated nationally, and periodic analyses of media reportage.
- Up-to-date lists of politicians and relevant public servants.
- A service of address labels.

Later Developments
- Updated summaries, in lay language, of research and development in Australia will be prepared on a specialisation-by-specialisation basis and in co-operation with participating scientific and technological societies and institutions.
- Information about research and development in Australia in terms which are meaningful to reporters, students, teachers, politicians and the public.
- Training for scientists in communications skills.
- Briefings for the media on major areas of topical interest.
- Guides on how best to develop good media relations - for use by individuals registered with the Service and conference organisers.

Principles
Independence: The Service is to be independent of any institution, society, commercial enterprise, government agency, sectional interest or financial contributor.

Impartiality: The Service is to be impartial in matters of debate, including controversies among scientists and technologists (where viewpoints are known to differ more than one expert will be offered for comment).

Advice: The Service will provide practical advice to the heads of contributing organisations and participating experts on effective communications, but it will not act on behalf of any group or individual in a public relations capacity or advocacy role.

Representation: The Service will be a co-operative venture of the bodies representing the scientific and technological community - the academies, societies and institutions.

Finance: The budget for the first year, including start-up costs for projects of the first priority is of the order of $300,000. This would amount to less than 0.5 per cent of the total budgets for the Australian Research Council and the National Health and Medical Research Council. Funding of this budget is being sought. The initial period of operation would be three years with a review towards the end of the period and an aim to become partially self-sufficient.

Further information:
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Steering Committee:
Dr Robert Crompton (Chairman),
Dr Ken McCracken,
Dr Peter Fockley,
Professor Robert Porter.

Australian Scientific Association Industry

It is no secret that the future of advanced countries lies with their ability to capitalise on advanced technology. One only has to look at world leaders in the economic sphere, like Japan, for confirmation of this trend. Scientific instruments are the building blocks for many advanced technologies. Likewise, medical instrumentation forms the basis for many of the advances in health care.

The NSW medical and scientific instruments industry is twice the size of the computing software industry in this state, on the basis of annual turnover and the number of people employed in the industry. The industry's annual growth rate was 50% higher than the software sector's in 1986/1987 and export sales account for nearly one quarter of the industry's turnover.

These are some of the findings of a survey that was commissioned last year by the NSW branch of the Australian Scientific Industry Association (ASIA) at the request of the NSW Department of Business and Consumer Affairs. The purpose of the survey was to determine the dimensions of the scientific instruments industry in NSW in terms of the number of companies operating and the products they produce, and the exports and employment generated.

There are almost 200 companies involved in the scientific instruments industry in NSW. Broadly the industry falls into seven categories:
- optical (scientific)
- medical
• weighing, testing and measurement
• meteorological, navigational and survey
• dental
• photographic (scientific)
• other areas.

Ninety of the companies surveyed are involved with medical instruments, and many of these companies started up during the 1980s.

A high level of Australian raw materials, labour and componentry are used throughout the industry. Imported materials account for less than 15% of total manufacturing costs, although the medical sector tends to be more dependent on imported componentry than others.

The degree of product and production process complexity varies widely. A few older companies are still using processes which have been around since World War II. However an increasing number of scientific and medical companies are leaders in technology, with significant ongoing R&D programs and advances, which are generating interest worldwide. For example, Teletronics, a subsidiary of Nucleus, is the world's third largest pacemaker manufacturer, and the sister company Cochlear Pty, Ltd. was involved in the development of the bionic ear. Australia's only respirator manufacturer produces in NSW a full range of anaesthesia and intensive care products which are exported to the Middle East and Asia. Another NSW company has recently set up a sales and distribution system for medical infusion pumps in the USA, and the Office for Trade Development has recently identified good to excellent prospects for exports from the scientific and medical instruments industry to New Zealand.

The majority of the companies surveyed are privately owned and small with a $1-2 million turnover per annum size range. Many of these small companies are highly entrepreneurial in their business approach, demonstrating well above average turnover growth. These companies are rarely reliant on government support, and having no time to waste on bureaucracy, they are often unaware of, or ignore the government incentives which are designed to benefit them most.

Around 10,000 people are directly employed in NSW in the medical and scientific instruments industry, nearly half of whom are in manufacturing. Even though there is a high concentration of technically skilled, tertiary educated people in the industry, it is evident from the reported staff recruitment difficulties that education institutions have failed to recognise the professional skills needs of the industry.

Because of its significant contribution to the economy of NSW, the medical and scientific instruments industry clearly warrants continued support and encouragement by the government to enable it to expand further and flourish.

- Labex '88, an international laboratory and products exhibition is being held at the RAS showground in Sydney from August 1-4. Two government ministers are scheduled to address the visitors, and

ASIA is planning working lunch seminars for each of the four days of the exhibitions when science and business professionals will have the opportunity to hear and question the policy makers.

- The Australian Scientific Industry Association (ASIA) is an association for all persons, bodies, organisations, and companies with an interest in science-based materials, instruments or equipment, their development, production and marketing. ASIA is currently seeking a part time paid worker to help co-ordinate its activities in NSW.

Enquiries: Richard Thompson, ASIA, telephone (02) 800 211.

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**A Timely Pitch for Patience in Science**

Watching pitch fall by drop from a funnel is like watching grass grow, according to University of Queensland associate professor of physics Dr John Mainstone.

But pitch-drop watchers have more purpose, observing a 60-year-old experiment set up to show the liquid properties of an apparently solid material.

*Dr Mainstone with the pitch-drop experiment - proof that some things that seem solid are in fact liquid.*

The experiment, begun in 1927 by the University's first professor of physics, Professor Thomas Parnell, has netted six drops in six decades.

And the seventh drop is expected to fall this year after a nine-year journey down the neck of the glass funnel.

Just when that will happen is anybody's guess, though Dr Mainstone says the perfectly-formed, shiny black drop will probably elongate then hang by several threads before finally plopping into the glass beaker below.
Dedicated pitch-drop watchers who miss the event will have several more chances, according to Dr Mainstone.

He estimates there is enough pitch left in the funnel for the experiment to continue for another few hundred years.

"The viscosity of pitch is enormous, probably about 10,000 million times that of water at room temperature in the case of this sample," Dr Mainstone said.

"And the experiment is not kept under any special conditions, so that the rate of flow varies with seasonal changes.

"That's why the drops form so exceedingly slowly, with varying gestation periods before they fall."

Dr Mainstone said the University of Queensland's pitch-drop experiment was one of only two known in the world.

The other was set up, apparently coincidentally, in the same year by physicist Professor H.S. Allen at the University of St Andrews in Scotland.

"There's no indication, such as correspondence, that Professor Parnell and Professor Allen ever knew each other," Dr Mainstone said.

"There was a lot of interest at the time in the fluid properties of apparently solid materials, and I think they acted independently in setting up the experiments to demonstrate that was so.

"But our experiment seems to be the only one behaving as we would expect.

"At St Andrews, the pitch is pouring from the funnel, but in a steady stream rather than drop by drop."

Professor Parnell set up the experiment by warming a sample of pitch and pouring it into a glass funnel with a scaled stem.

Three years later, in 1930, when the pitch had consolidated, he cut the stem and the pitch began to flow.

The first drop fell in 1938, and successive drops about every eight years after that. The interval between the sixth drop in 1979, and the imminent seventh drop, is the longest so far.

The experiment, begun at the University's first home in George Street in Brisbane's inner city, is now housed on the St Lucia campus in a glass case in the foyer of the Parnell Building.

The building was named for Professor Parnell, and is home to the Physics Department.
Science in Bondage
The Inaugural Ian William Wark Lecture

by A.L.G. Rees

The Award

With the Ian William Wark Medal and Lecture the Academy hopes to encourage those who work, like Sir Ian Wark, at the boundary of science and industry. The aim of the award is to focus attention on the application of scientific discoveries for the benefit of the community.

Sir Ian Wark admired scientists who creatively applied their knowledge and methods to design and improve technological processes. His own research began in 1921 without practical objectives but was soon applied in the mining industry for the concentration and separation of minerals.

He was born in Melbourne and educated in chemistry at the University of Melbourne and University College London. After postdoctoral studies in California he lectured at the University of Sydney. From 1926 to 1939 he worked as a research chemist for a number of mining companies, particularly Electrolytic Zinc. In 1939 he became Chief of the CSIRO Division of Industrial Chemistry from which position, in 1944, he appointed Dr Rees to set up the first chemical physics group in any government-financed laboratory in the world.

In 1958 Ian Wark was appointed Director of the CSIRO's Chemical Research Laboratories. In 1960 he became a member of the organisation's executive and from 1965 to 1971 he was chairman of the Commonwealth Advisory Committee on Advanced Education. He won many awards and fellowships and was knighted in 1967. He was elected to the Fellowship of the Australian Academy of Science in 1954 and has had the Academy's theatre named after him. He left his papers, an account of his efforts to promote the value of applied science, to the Academy's Adolph Basser Library.

The Awardee

A.L.G. Rees,
CBE, FAA

Lloyd Rees was born in Melbourne in 1916 and studied at the University of Melbourne and the Imperial College of London University. In 1939 he lectured in chemistry at the University of Western Australia.

In 1944 Ian Wark appointed Dr Rees to establish a new Chemical Physics Section. In the 1950's the Section grew rapidly and in 1958 became a division of the CSIRO with Dr Rees as Chief. After importing technology in the 1940's, the CSIRO scientists started showing new techniques to the rest of the world in the 1950's.

While Dr Rees was leader, his team invented a number of scientific instruments, some of which were manufactured in Australia and some overseas. These included the atomic absorption spectrometer, an infrared monochromator and an ultra microtome (which cut extremely thin biological sections for use under an electron microscope). Two scientists in the Division of Chemical Physics made an oil-free-vacuum pump that produced the vacua free from oil vapour as required in research and manufacturing. These very sophisticated pumps are now made under licence in the USA.

An important part of Dr Rees' contribution has been as an advocate of Australian science overseas. He was elected to the Australian Academy of Science in 1954 and was on its Council for 10 years. From 1969 to 1973 he was Foreign Secretary of the Academy. He organised international conferences, edited journals and was elected president of the International Union of Pure and Applied Chemistry. He served on the executive of the International Council of Scientific Unions and was President of the Royal Australian Chemical Institute.
This is not an occasion on which to deliver an address on the life and work of Sir Ian Wark; these have been the subject of other exercises and will undoubtedly encourage a biographer of adequate stature to record them in detail for posterity. However, I would not wish to begin this inaugural memorial lecture without specific reference to the man and his very considerable achievements.

Current attitudes to Scientific Research

Ian Wark's career falls naturally into three major parts, and, like Gaul, it forms a formidable whole. These parts are: personal scientific research, research direction and administration, and promotion of non-university tertiary educational institutions. These activities were pursued largely in circumscribed and consecutive periods of his life and in each he made an outstanding impact.

Wark's scientific work began with academic research in coordination chemistry, but after five years he made the transition to research into the scientific basis of two industrial processes, namely, the electrodissolution of zinc and the separation of minerals by flotation. His personal work in flotation earned him a high international reputation.

Personal scientific work virtually ended in 1939 with appointment to the Council for Scientific and Industrial Research (CSIR). His creation of the CSIR Division of Industrial Chemistry was a major contribution to Australia's development and influenced scientific work throughout the country.

At 65 years of age Wark was appointed Chairman of the Commonwealth Advisory Council on Advanced Education, in which role he was to be the agent of transformation of the technical colleges into tertiary institutions of dramatically improved facilities, resources and standard.

The sum of these achievements is immense; each one of them is sufficient in itself to ensure that Ian Wark is remembered with gratitude and admiration by present and future generations.

In each of these activities Wark's approach was dedicated, exhaustive and impeccable; everything he did commanded complete concentration to achieve what he envisaged to be the best possible result. The incentive for all this purposeful activity is a little more difficult to identify, but there can be no doubt that he was driven, in each facet of his career, by service to the community. It is natural that Council of the Australian Academy of Science should direct this lecture to focus attention on applications of scientific discoveries that have benefited the community. My lecture will embrace this instruction, but, as the title Science in Bondage suggests, it will identify factors that diminish research achievement and its effectiveness in providing benefit to the community and it will contain my personal views on corrective measures.

Wark and his Achievements

Even the most disinterested member of the community could not have failed to register that science and scientists are not enjoying universal acclaim in this country at present. Over the past 100 or so years science has passed from being a gentleman's hobby to being everybody's slave. In fact, science is very much under threat; it is in bondage.

Business and industry leaders are blaming scientists for failing to communicate their research results to industry as a reason for absence of commercial use of research advances; anti-science lobbyists and extreme conservation groups have blamed scientists for the perceived harmful consequences of the application of scientific results and the media have made the most of all these issues by the exercise of selective emphasis. In fact, science has been made the whipping boy on which these groups have vented their frustrations.

There is obviously a problem of significant dimensions to be resolved; it needs to be identified in some detail and steps taken to correct it at its point of origin, of which there are several of major importance.

Of the many individuals who have some involvement with science and scientific research in the political arena, bureaucracy, policy determination and administration, research direction, development management, commercial exploitation and so on, none, I am sure, would admit that he did not understand what is meant by science or research. Unfortunately this is probably the central problem; there are gross differences in comprehension across the community about the nature, scope and significance of science and the meaning of the word research, specifically about the precise distinction between scientific research and non-research science.

Definitions

It appears that we should establish some acceptable definitions. Scientific research, including research in engineering, endeavours to make real advances in knowledge and understanding of natural systems and phenomena; it penetrates the frontier of scientific knowledge. This activity is characterised by some content of creativity, for without it new concepts, new techniques, new experimental devices and new results would just not appear. Research is characterised by unpredictability; it is the exploration of the unknown. Qualifications, such as pure, applied, basic, committed, do not alter these statements.

Non-research science and engineering are professional practice of the respective disciplines; they represent the application of established knowledge and understanding to the realisation of a defined objective. It does not involve creativity, because it is not going beyond the boundaries of existing knowledge and understanding. It includes development work among other things. Rather than creativity, the successful prosecution of some classes of non-research science may require the exercise of considerable ingenuity, which is the clever manipulation of existing knowledge to achieve a recognisable technical goal.

The universal practice of lumping research and development together as R and D, particularly for funding purposes, is unfortunate, but it probably highlights the difficulty that many people have in distinguishing the R from the D. It has led to confusion and a devaluation of the word research; some of the lowest routine testing becomes classified as research for statistical and funding purposes. Certainly, most politicians and social scientists and, for that matter, some natural scientists and technologists use the word research to describe straightforward professional work.

The recognition of the difference is fundamental to the successful use of science for the benefit of industry and the
community. The creative researcher is increasing the understanding of a particular area of science, which may have been chosen for study because of its relevance to some industry or broad national problem. This is really adequate justification for his existence; he becomes a specialist reference point. But he may also produce a new result of significance and the trick is to judge whether it has commercial potential. To convert a new exploitable result into a commercially or otherwise viable product needs other skill, but not creative research.

All this was realised and practised by the early science-based industries, exemplified by the extremely successful electrical firms, Philips in Holland, and General Electric and Bell Telephone Laboratories in USA. Each of these companies supported large, autonomous creative research laboratories independent of their development and manufacturing operations from the early years of this century. Each has contributed enormously to advances in chemistry and physics and to many dramatic technological advances.

**Research Funding**

In Australia we are steadily progressing in the opposite direction. In government-financed areas the funding in real terms has been reduced progressively for many years. At the same time constraints have been imposed on the nature of the scientific work for which the funds are granted; the core research component is encouraged at the expense of research. This is brought about by the growing requirement to specify a potential economic benefit in the application for funds. In relation to the current restructuring of CSIRO, for instance, phases such as research with high potential to create new products, greatest potential to contribute to Australian economy, customers involved in priority setting and so on underline the complete lack of comprehension about the nature of and the environment necessary for successful creative research. This philosophy leads to an assembly of insulated projects and tasks with defined - and even promised - objectives and which ultimately degenerate into low-grade problem-solving science.

In the tertiary educational institutions we have the unhappy spectacle of senior academic scientists justifying their research in terms of possible future commercial or industrial applications. To the demands for commercially exploitable results we can attribute the disturbing tendency on the part of some academics to announce now research results in the daily press before submitting them to the scrutiny of their peers in the scientific literature, to make unappealing claims about benefit to the community and to make exaggerated estimates of the economic value of the research results. This sort of reaction is produced by the demands of the bureaucrats and the politicians, who, it is clear, have failed to understand the purpose of research in tertiary institutions. Apart from the obvious purpose of keeping the staff member at the front of understanding in his field, it fulfils one of the primary objectives of a university or tertiary college, namely to provide instruction, in this case the training of graduates in research and in understanding the nature of creative inquiry. Withdrawing research funds or diverting them to other purposes such as commercial targets is a denial of the capability of these institutions to fulfil their statutory objectives.

**Control of Scientific Research - The Planners**

Nowadays the official attitude in Australia appears to be that science should be planned, administered and directed, not by scientists, but by management experts, lawyers, accountants and politicians and that research scientists should be managed. This would have been unthinkable in the days of Julius, Rivett and Clunies Ross. Recently CSIRO has been subjected to investigation by management consultants with no special expertise in or understanding of creative science; it has been restructured to fit an arbitrary preconceived management framework; names of Divisions have been changed to remove offending disciplinary titles; constraints have been imposed on the type and scope of scientific work that may be done; financial support must be begged from reluctant industry. It is a national disaster that recent governments have been seduced into believing that science needs bureaucratic control; on the contrary, creative science can flourish only in an environment affording freedom.

One of the most successful scientific research operations in any country is that operating in West Germany under the umbrella of the Max Planck Gesellschaft zur Förderung der Wissenschaften (Max Planck Society for the Advancement of Science) which consists of 52 research institutes covering a range of disciplines roughly equivalent to CSIRO Divisions. These institutes are self-administered; the governing body does not find it necessary to group institutes together under a controlling body at another level; the directors are expected to run their institutes without centralised control. Why should we need it in CSIRO?

What other professional group is under the direction and control of individuals or groups composed of people of no competence in, of no professional qualifications in or real understanding of the profession? Can you imagine the reaction of the judiciary or a symphony orchestra to a proposal to place them under the control of anyone other than one of their own kind?

Moreover, the constraints, control and directions imposed by politicians on scientific research recently are equivalent to telling authors what and how to write, artists what and how to paint, judges what judgements to hand down. It is science in bondage.

**Creative Science as a Natural Resource**

Pure or basic scientific research is a long-range prospect for direct economic return, but in any case it is providing the basis for solving tomorrow’s problems. It also provides the science base, that aggregate of established scientific fact and understanding on which current non-research scientific activity must depend.

Without ever being able to prove it, I would be prepared to assert that no creative scientific research result, however pure or basic, will remain permanently without some utility in technology. I am constantly being amazed at the frequency with which abstruse, way-out research suddenly becomes relevant, often right in the market place. It would be a bold man, in my view, who would identify a piece of scientific research as totally and absolutely useless.

Some science policy publicists have attempted to establish that science and technology advance independently of each other and that industrial progress is unrelated to basic research activity. This cannot be sustained in the face of case studies of the origins of technological innovations. To quote a US study, “every technological innovation depends at various points in its antecedents on basic science, either in the form of a body of fundamental knowledge and understanding or in a single key
research discovery." Three well-known examples of pure curiosity-prompted researches that have led to beneficial applications may be adequate to establish the point. They are:

1. Faraday's discovery and demonstration of electromagnetic induction in 1831 was the starting point of all electromechanical engineering applications since.

2. Einstein's mathematical theories of the interaction of radiation and matter published in 1916 and 1917 established the complete theoretical basis of the modern devices known as lasers and masers.

3. Cade's discovery in 1949 in Melbourne of the therapeutic action of lithium salts in manic depression is estimated by the US Mental Health authorities to have saved $17.5 billion world-wide in the past 15 years.

Obviously pure creative science is an economically sound natural resource.

The Chemical Physics Experience
Since I have had a fairly close association with the many brilliant young scientists who put Chemical Physics as a scientific discipline on the Australian and world scientific map in the 40s, 50s and 60s and whose uncommitted researches spawned results of dramatic scientific significance, many of which led to successful commercial exploitation, I feel that it would not be inappropriate for me to fulfill the terms of this lecture by referring to the Chemical Physics experience.

This experience began in 1944 when the Chemical Physics Section (Division of Chemical Physics from 1958) was established with Sir David Rivett's approval and active encouragement in the CSIRO Division of Industrial Chemistry, whose Chief was Dr I.W. Wark.

The first task was that of establishing the experimental and theoretical techniques of chemical physics, which were very poorly represented, if at all, in Australia at the time; most were then very recent developments in science. In a few years a sound scientific base had been established. Almost from the beginning a continual flow of guest workers came from other CSIRO Divisions, universities, colleges, research institutions and industry to spend periods ranging from days to years in the laboratories and to discover the potential usefulness of the new fields of investigation and the associated techniques.

It was natural for the young, inquisitive, impatient and brilliant group of scientists that made up the staff of Chemical Physics to want better experimental tools, even though they had been provided with the best from overseas at the time, because their researches were demanding better performance from their instruments. It was astonishing the way people like Cowley, Farrant, Walsh, Morrison, Hodge, Mathieson, Davies, Moodie and others set about providing better tools by modification and redesign of existing instruments and by producing new instruments based on new principles or new designs. It was at a point close to the end of the 1940s that the conversations around the canteen tables turned to the possibility of indigenous scientific instrument manufacture. This was not within the terms of reference of Chemical Physics and had never been set as a goal; it was simply an exploitable result of the research work, a result that had been recognised by the creative scientists, and not, you will note, by technologists or industrialists. From this point on there was no intent to set out to create a new instrument for its own sake, but everyone in Chemical Physics was alert to the possibility of an exploitable improvement in any experimental apparatus.

Actually the first excursion into local manufacture of sophisticated indigenous equipment from Chemical Physics was that of a novel ultramicrotome for electron microscopy by the Fairey Aviation company in Salisbury, South Australia. Unfortunately, a change in management just when overseas sales had begun killed the enterprise.

Reference to the complete list of exploitable results or for that matter to a few of the major contributions to the advance of scientific understanding that came out of Chemical Physics is well beyond the limits of this lecture, but perhaps I would be permitted to interpolate a few words about the research in electron diffraction. Recently John Cowley and Alex Moodie, both Fellows of the Academy, were honoured by the award of the first Ewald Prize by the International Union of Crystallography for their work on electron scattering and in particular for their evolution in the 1950s of a theory of dynamical scattering of electrons by crystals. Their work is very relevant now to the development of the new superconducting materials. No amount of planning would have produced this sort of outcome; in fact, under present circumstances the Cowley-Moodie theoretical work would not have been permitted.

To put the Ewald Prize in perspective I mention that it is to be awarded once every three years for contributions of exceptional distinction to the science of crystallography without restrictions of nationality, age, experience or time; in fact, it is a completely international award to any living scientist. The media have chosen to ignore this award.

Let me return to the story of exploitable research results from the Chemical Physics experience. I have chosen from a long list of possibilities to discuss three related items that provide me with adequate illustration of the points I am trying to make and with an opportunity to put the record straight on matters that have attracted criticism.

1. Multiple-pass monochromators - The first patentable item to emerge was the multiple-pass monochromator, which was the expression of a new principle in spectroscopic optics formulated by Alan Walsh in an effort to improve the resolution of infra-red spectrometers. In 1951 an overseas spectroscopic instrument manufacturer was granted an exclusive licence, which generated royalties for a number of years. This was the first direct commercial benefit to the Australian community, or rather to its representative, Consolidated Revenue.

2. Optical diffraction gratings - At this time, in the early 1950s, spectroscopic instruments for most purposes used prisms of glass, quartz and so on for dispersion of the radiation. However, for some special-purpose spectrometers under development a different class of dispersive element was needed, namely, an optical diffraction grating. But diffraction gratings were virtually unavailable because they were not manufactured for sale, but produced in one or two laboratories around the world. These gratings consist of parallel, precisely-shaped grooves embossed in optically flat surfaces, say, a few inches square; the grooves are at spacing up to 30,000 grooves per inch. Tolerances in the mechanical engines to rule these grooves are demanding - one millionth of an inch or better in many parts; they demand the ultimate in mechanical precision. In hindsight I am amazed that we had the courage or temerity - perhaps both - to decide to enter this field. At all events the decision to allow D.A. Davies and G.M. Stiff to develop a
ruling engine was taken, but it needed to be reinforced by subsequent rather tougher decisions as the project grew. However, there was never any doubt that it was the right thing to do. Usable gratings were produced by 1960. Davies developed a satisfactory process for the replication of the master gratings so that multiple copies could be produced. Spectrometers designed in Australia and manufactured for export by several firms incorporate these gratings still, even though, in the meantime, new methods of producing gratings and many new commercial facilities have been established in other countries.

Had the present constraints on scientific activity in CSIRO been in force in the 1950s this work would never have got off the ground. We had no experience in ultra-precision engineering, no expertise in Australia in spectroscopic instrumentation, but we had people with the right qualities. We would have missed not only the opportunity for commercial exploitation, for the introduction of new skills into the workforce, for the creation of new export industry and for employment associated with grating production and spectrometer manufacture, but also the valuable spin-off skills of the production of diamond ultra-microme knives and diamond knives for eye surgery.

3. Atomic Absorption Spectroscopy - I am sure that everyone of you knows something of the story of atomic absorption spectroscopy, a field of scientific study that was initiated by Alan Walsh and which has its commercial expression in a whole range of scientific instruments known as atomic absorption spectrophotometers. Both the scientific initiative and its subsequent development as an identifiable field of science and the commercial exploitation are success stories of the greatest magnitude. Sir Alan Walsh is present tonight; he has been honoured by universities, learned societies and industry throughout the world for his tremendous contributions to science and industry. On the most conservative basis this development has been worth many hundreds of millions of dollars to this country. The annual world production of atomic absorption instruments alone has been in excess of US $100M for some years.

In 1952 Alan Walsh and his colleagues had been concerned with trying to understand better the chemical physics of arc and spark electric discharges, which were the basis of the predominant analytical method of emission spectroscopy at the time. It was a hopeful piece of scientific investigation and, to say the least, very thought-provoking. The inspiration of using the absorption of atomic spectral radiation by free atoms of the same element as a general analytical approach did not belong in the program. It would probably not have been supportable in today’s context without a proposal for funds verging on perjury. Certainly it was the product of an uncommitted research environment and would not have arisen otherwise.

Throughout the long period of development of the atomic absorption instrument and technique it was necessary for research scientists and technical and engineering support staff not hitherto involved to be added to Alan Walsh’s team. However, in the first two or three years the work progressed to a point where patent protection was feasible and commercial potential was recognised and established. And that was where the real problems began.

The first reaction from the overseas experts was open disbelief; those whose vested interest in the established methods and instrumentation seemed to be threatened attempted to expose deficiencies and disadvantages in the method; others simply lived the announcement with reserve and awaited judgement by others. So for several years the development of both the instrumentation and the analytical potential were promoted by the group in Chemical Physics and two or three people elsewhere in CSIRO and in New Zealand; very little interest was displayed overseas, although the main UK spectroscopic instrument manufacturer asked for and was granted an exclusive licence to manufacture an atomic absorption instrument. A few years later the exclusivity was withdrawn for lack of adequate exploitation. A few isolated overseas firms displayed interest and several acquired non-exclusive licences to manufacture, but even by the early 1960s most of the users were in institutional and a few industrial laboratories in Australia using a do-it-yourself kit of components. These were manufactured under guidance from Chemical Physics staff by three tiny firms that had some of the basic technical skills and understanding and the enthusiasm of unfulfilled creative talent. Australia should be very grateful to the three or four people who had the courage to accept the risk and work for many years like galley slaves. At the time there was nothing remotely like spectroscopic instrument manufacture in Australia; those skills were simply not in the work force. No established firm in Australia showed any interest in manufacture although the method and the instrument had been widely demonstrated and publicised.

The decision to produce an integrated atomic absorption instrument was taken in 1962 by the small firm Tectron, whose proprietors and managing director, Mr Geoffrey Frew, took tremendous personal financial risks to undertake production and marketing of the instrument. Chemical Physics instantly became involved in the developmental work and undertook the design of the monochromator, trained personnel in various specialisation techniques, including ruling and replicating diffraction gratings, but all with appropriate arrangements for reimbursement. The much publicised CSIRO-industry interface, which the government and others see as a barrier that CSIRO is obliged to penetrate, would have been hard to find in those hectic days; it was impossible to tell where industry started and CSIRO finished.

As Tectron expanded rapidly and commanded substantial export markets, the problem of providing a sales and technical service operation of adequate capability demanded urgent solution. The solution ultimately arrived at, namely, sale of a portion of the company to the scientific instrument manufacturer, Varian Associates of USA, was, in my opinion, the only possible one at the time, because it provided immediately an already established worldwide network with qualified personnel already in place. Varian now owns the operation completely, but the firm has honoured its gentleman’s agreement to retain manufacture in Australia. Since assuming full control the Australian company has expanded its range of instruments, has gained a progressively larger share of the market and is consistently one of the most profitable divisions of the Varian corporation. The company employs some 450 people and is the repository of a range of technical and manufacturing skills as good as, if not better than, any other of this class in any country in the world. Ninety people are employed on research and development at an annual cost of $3M. The managing director is an Australian who has spent most of his career with Tectron and Varian.

At intervals for a period of many years Chemical Physics has been taken to task by politicians for allowing the exploitation
of atomic absorption to fall into non-Australian hands. Some industrial leaders have complained that they did not have an opportunity to acquire an interest in Techtron, others that they did not have an opportunity to take up the manufacture because they did not know about it. And for some years now manufacturing industry and governments have been berating CSIRO for not communicating with industry.

In reply to these lashes - and on behalf of the whipping boy - I wish to make the following points:
1. Development work was never part of the CSIRO’s terms of reference or its financial appropriation, but was always necessary in some degree to generate any interest in exploitable results among Australian manufacturers.
2. The licensing arrangements for atomic absorption from 1958 on were non-exclusive and on the same terms for everyone.
3. There were ultimately 17 licensees of the basic atomic absorption patent who were licensed for manufacture in nine countries.
4. Any Australian firm or individual could have applied for a licence on the same terms.
5. Both technical information and advisory assistance were available on the same terms to all prospective licensees.
6. Techtron was established and developed on private funds exclusively; the financial risks were borne entirely by the firm’s owners. Techtron paid royalties on the same basis as any other manufacturer. The owners were entitled to do whatever they wished with their asset, and what they did was, in fact, in Australia’s best interests in the circumstances. Moreover, Mr Frew did not forget his obligation to science; he contributed 50,000 old-fashioned dollars to the Academy for specific purposes.
7. It seemed to be part of the Australian governmental and industrial attitude to science and scientists to blame the failure of Australian industry to take up exploitable research results on CSIRO and its scientists. In other countries representatives of manufacturers have to be restrained from pestering scientists who may have potential items for manufacture. Why should we be expected to do industry’s job for it in Australia? It is nonsense.
8. The whole expenditure by the Division of Chemical Physics throughout its 43 years of existence, let alone that part of it spent on research in spectroscopy, is chicken-feed compared with the benefits either to Australian industry through productivity increases attributable to the use of atomic absorption spectrochemical analysis or to the Australian economy through its generation of a skilled labour force and through its substantial export trading.
9. Techtron was the nucleating point for the further development of sophisticated scientific instrument manufacture in Australia, particularly around Melbourne. Its success in the international market gave confidence to others.

Nowadays, the value of Australian production in the spectroscopic scientific instrument field alone, most of which is exported, is in excess of $100M per annum.

Science for Human Benefit - The necessary conditions

Inquiry with the object of increasing understanding of natural phenomena and natural things has always been part of human activity. The more modern, formalized expression of this, pure scientific research, is valuable in its own right and warrants support on this basis alone.

However, the injunction attached to this lecture requires that discussion should centre around the successful application of scientific discoveries for human benefit - it requires recognition of the real world around us. In presenting some aspects of a few successful applications of discoveries I have explored a number of factors that influenced the course of the innovative process. It would be a fitting conclusion and would coincide with Sir Ian Wark’s own convictions to enumerate the necessary - and perhaps even the sufficient - conditions that have been identified in this lecture for successful creative research and for the transformation of a novel result into something of benefit to the community.

The general conditions for creative research include:
1. Provision of an educational system and career reward prospects that encourage creative talent in mathematics and science.
2. A community respect for science and the scientist.
3. An adequate national science base.
4. An environment for academic and institutional research that provides freedom of inquiry.
5. Research funding without economic return conditions
6. Abandonment of proposals to impose conventional management regimes on either pure or applied creative research.

The particular conditions for the successful use of the output of creative research for the national community benefit include:
1. The ability to recognise a potentially exploitable research result.
2. The existence of a separate development facility with an adequate in-house science base, preferably in industry.
3. The availability of the requisite supporting technology in Australia.
4. Adequate understanding of the science on which the new invention stands in the manufacturing agency.

Finally, it is in everyone’s interest for us to ensure that we lead science out of its own particular Egypt and free it from bondage.
Learning by Video

The Mechanical Universe
Introductory Physics
26 Programs - 1/2 hr format

Classical mechanics has long been recognised as an essential part of any education in science. This engaging television course presents the basic ideas of physics, its history and the spirit and methods by which science operates in an inviting and intellectually rigorous way.

An array of rich visual techniques including precision close-up photography of experiments, computer animation sequences and historical re-enactments, are employed throughout the 26 half-hour video programs. What makes the course unique is that calculus is treated as a part of classical mechanics and simply taught along with the topics covered in the course which covers mechanics and heat. The specially developed textbook has two versions, one for science and engineering majors, the other for non-science majors.

Semiconductor Devices
11 Programs - 1/2 hr format

Use these informative video programs to build a progressive electronics training department with a reputation for technical depth. Course content stresses the theoretical and applied aspects of various semiconductor (solid state) components. A non-mathematical approach is used to describe the various components, with formulas and solutions demonstrated to illustrate application-related aspects. The average student can complete the course in about thirty hours of study equally divided between the video components and the recommended reading and review assignments. These excellent video lessons with the student workbook and exercises are geared to give the technician, with no prior training, the skills required for top-grade performance.

Digital Electronics - 1/2 hr format

Course instructors will be able to present state-of-the-art information on digital electronics. Lessons cover the concepts and techniques necessary for a beginning electronics technician to understand. Instruction in each program is straightforward using a printed study guide and is keyed toward the prescribed texts. The average trainee can complete this course in about forty hours of study divided equally between the video components and the recommended reading and review assignments. With this instructional material, trainees acquire the on-the-job skills demanded by today's high-tech industries.

Basic Electricity and DC Circuits
29 Programs
15 Lab Lessons - variable times (average 16 mins)
14 Theory Lessons - 1/2 hr format

This course provides a basic understanding of electricity. Students need little or no prior knowledge of electricity or mathematics. Step-by-step explanations teach students to analyse and control electricity and accurately predict its behaviour with simple circuit laws. Instructors at the work site or in the classroom will be able to deliver fundamental and practical information vital to further study and advancement in the field of electronics.

Basic AC Circuits
29 Programs
14 Theory Lessons - 1/2 hr format
15 Lab Lessons - variable running times (average 16 mins)

An information packed video series that provides basic theory and problem solving techniques required for analysis and application of alternating current circuits. Fundamental concepts, laws, and terminology are explained clearly with examples at key points. Using the theory lessons separately or in conjunction with the lab sessions will give instructors added freedom in course constructions and delivery.

For further information contact:
Madeline Moore, Video Learning
Telephone (03) 690 9644

New Photomultipliers from THORN EMI

THORN EMI's new series of 30 mm diameter fast linear focused photomultipliers will improve instrument performance and open up new possibilities in low light level detection, particularly in high energy physics, scintillation counting, spectrometry and photometry. The 9124 and 9127 photomultipliers are the latest tubes using the new D400
dynode structure. This revolutionary design provides a unique combination of good pulse height resolution, extended linearity, high gain and fast rise time by associating the electron optical qualities of a large input dynode with the advantages of a linear focused multiplier section.

Performance figures include linearity within 2% up to 40 mA for the 9124 with CsSb dynodes and up to 150 mA for the 9127 with BeCu dynodes. Other features are high gain of $10^6$, fast rise time of 3.2 ns, low dark current of 0.2 nA at $10^6$ gain, and a single electron response of typically 2:1 peak-to-valley.

For further information, please contact ETP-Oxford:
Fred Blake on (02) 858 5122; or Phil Spinks on (03) 347 0733

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**Backscattered Electron Detector for S.E.M.s**

The Robinson Backscattered Electron Detector is an Australian made product that has become a world leader since its introduction 7 years ago. It is now available to suit most S.E.M.s.

The Robinson Detector produces an image of the specimen that most microscopists have never seen. It can show detail that the secondary electron (Se) detector cannot see. The Robinson Detector produces an image which does not suffer from charging artifacts or excessive edge brightness. The images have excellent atomic number contrast and lets you see more phases in your sample than other detectors.

By fitting a Robinson Detector to your electron microscope you add another dimension to specimen imaging. Spatial resolution is less than 80 A and it has a higher signal-to-noise ratio than the SE Detector. Yet it operates at beam currents similar to those used for SE Detector imaging.

The Robinson Detector is robust and can usually be fitted to a WDX or other port. It will give more topographical information about your specimen and can be fully retracted when not in use.

There are many Robinson Detectors in use in Australia, USA, Europe and Japan. A large percentage of production is exported.

For more information on Robinson Detectors, contact ETP-Oxford:
Fred Blake on (02) 858 5122; or Phil Spinks on (03) 347 0733

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**Burleigh Release New Controller for Inchworm Motors**

Burleigh Instruments have introduced the 6000 Series controller (illustrated) for use with their range of piezoelectric Inchworm motors. The 6000 series controller is a lower-cost alternative to the existing 7000 series and can operate from one to three motors simultaneously in either open or closed loop mode. The controller responds to input signals from a joystick or handset or may be interfaced to an IBM PC by means of the new computer interface card.

The 6000 series controller and Inchworm motor provide backlash free motion over ranges from 6 to 200 mm and speeds of up to 2 mm per second. The motor features a non-rotating shaft, forward and reverse limit switches and provides a push force of 15 N. A complimentary brochure is available on request.

For more information contact:
Paul Wardil
Laserex International
Tel: (08) 271 7966

**New Alpha Hand Monitor uses Novel Detector**

A new alpha monitor for checking the hands of glove-box operators is now available from NE Technology. Called the SHM1 Single Hand Monitor, it features an air proportional counter, invented at MOD, AWRE, Aldermaston and the subject of a patent application by the Ministry of Defence. It has been specially developed to give exceptional uniformity, ruggedness and serviceability and this has been noted and approved by the MOD.

The full face of the hand is measured in a single operation lasting only a few seconds and since the operator need not leave the glove-box area to monitor hands, the potential zone of contamination from a leak in one of the gloves is very much reduced.

All data is analysed by the built-in microprocessor and clear indications are given to show whether hands are free from contamination according to present alarm levels.

The mains powered instrument is built into a slim and easily decontaminated housing and includes an alpha-numeric display which provides information for guidance during operation.

For further information, please call ETP-Oxford:
Fred Blake on (02) 858 5122; or Phil Spinks on (03) 347 0733

**Using LeCroy’s 9400 Digital Oscilloscope**

A new series of application notes for the LeCroy Model 9400 Digital Oscilloscope is designed to assist users in a variety of applications. The 9400 is a dual-channel instrument with 8-bit ADCs capable of sampling transient waveforms at 100 megasamples/second and repetitive signals at 5 gigasamples/second. The illustrated, 4-colour
BASICA interactive program that enables remote control of the LeCroy 9400.
The 9400 Oscilloscope in Ultrasonics (AN ITI 003, 8 pages) deals with traditional non-destructive test (NDT) ultrasonic waveforms. Examples are included to show the advantages of using
the 9400 and how it can greatly simplify sequences of complex measurements.

For more information, call ETP-Oxford:
Fred Blake on (02) 858 5122; or
Phil Spinks on (03) 347 0733

Chimera System
Atlanta Signal Processors Inc. (ASPI) is introducing their new Chimera System, which allows a user to do applications, development and prototyping for the Texas Instruments TMS320C25 DSP microprocessor. The Chimera System consists of software and a board (illustrated on Page 170) that plugs into an IBM PC, AT or compatible.

For additional information write to ASPI, 770 Spring Street, Atlanta, GA 30308 USA.

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**Support physics publishing in Australia**
Supernova Revisited

Dear Editor,

In the May 1988 edition of the *Physicist* there appeared an article by an anonymous author entitled *Supernova Emitting Gamma Rays*. There is one paragraph in that article with which I wish to take issue. The paragraph reads:

"Most supernova models predict that all elements from iron onwards in the periodic table - in fact, about three quarters of the 100-odd elements that occur naturally on Earth - can only be formed in supernovas. The fusion processes that fuel stars, including our own Sun, are not sufficiently energetic to form any element heavier than iron."

This whole paragraph is completely wrong. All stellar models for the past more than thirty years have predicted the formation of the elements heavier than those of the iron group to have occurred as a result of long chains of neutron capture and beta decay reactions starting with iron as the seed nucleus. The abundance of iron in the interstellar gas clouds from which population I stars condense is \(0.1\%\) and this is all that is required to account for the existence of the observed abundances of the heavier-than-iron elements. The production of about half the isotopes up to bismuth occurs in the mantles of red giants during hydrostatic helium and carbon burning, well before the pre-supernova stage. The mechanism is known as the s-process (slow), with the time between successive neutron captures being many years. The rest are attributed to the r-process (rapid), which requires an enormously greater density of free neutrons, the existence of which has been postulated in supernovae but the models do not predict it. The r-process remains siteless.

Fusion reactions up to the iron group are endothermic and this is the only reason nucleosynthesis by fusion reactions ends at the iron group. The energy released by the fusion processes supports the star against gravity and provides its luminosity. The energy taken by the s- and r-processes is negligible in comparison. Thus the formation of elements heavier than iron has nothing to do with how energetic the fusion processes are.

D.G. Sargood
School of Physics
University of Melbourne

Women in Science

Dear Editor,

We would like to bring to the attention of your readers, information about WISENET (Women in Science Enquiry Network, Inc.), a non-hierarchical organisation formed after ANZAAS 1984. Our aims are basically to promote increased participation by women in science and to explore programs for change in science which will make it more appropriate for world needs.

Among our activities is the establishment of the WISENET Science Shop which will match community groups with research problems with researchers prepared to spend some of their time working in the public interest. WISENET is also currently completing a Directory of Women in Science and Technology in Australia.

Membership is open to both women and men who have a commitment to the WISENET objectives. For further information and an application form, please contact WISENET, GPO Box 452, Canberra ACT 2601, or the WISENET Science Shop, F Block, Kingsley St, Acton, ACT, 2601 or telephone (062) 496006.

WISENET Membership Committee

Australian Institute of Physics
Silver Jubilee
1963-1988

T.W. Jones' article on deep underground detectors contains a brief section on the detection of supernova events, lamenting their infrequency as far as detectability goes. Little did he know when writing his article that the first such detection was only months away. The
characteristics of the neutrino pulse proved to be exactly as he predicted.

The remaining 5 articles merit paragraphs of their own, especially P.O.P. Kalms' fact-filled review of large particle accelerators and detectors under construction, but space does not permit.

Quarks and Leptons: is such an illuminating little book that I would not hesitate to recommend it to all practising physicists and senior undergraduates if it were not for the ridiculous price tag of $54.00. It is totally inexcusable to charge such a price for what is merely a paperbound collection of eight reprints which, in days gone by, you could always get for nothing by mailing request cards to the authors. Regrettably I shall have to refer my students to the library copy of Proc.Roy.Soc. for these particular gems.

Colin Key
Book Review Editor

Manifolds and Mechanics
A. Jones and A. Gray
Cambridge University Press
Cambridge 1987

Increasingly in the literature of theoretical physics and applied mathematics one finds articles which adopt a geometric approach, but which use concepts and notation unfamiliar to most physicists. The stated aim of the authors of Manifolds and Mechanics is to bridge the gap between the traditional approach to classical mechanics (based on Newton's equations, Lagrangians and Hamiltonians) and the more modern differentiable manifolds approach.

In high school one first meets vectors as directed lines in three dimensional Euclidean space, and only at a later stage does one introduce the concept of the Cartesian components of vectors. At a more sophisticated level, with vectors and tensors in any number of dimensions, the components or coordinates become all-important and the geometric aspects become submerged. In the modern approach to differential geometry, vectors and tensors once again acquire geometrical significance and become entities independent of the choice of coordinate system. However one needs to go beyond directed lines in space, and this is where manifolds and their tangent spaces come into the picture.

Chapters 1-7 concentrate on setting up the mathematical framework. This part is clear and readable, though some older physicists may need to consult an advanced calculus text (such as M. Spivak, Calculus on Manifolds, 1965) to understand the notation. The remaining 7 chapters then apply the formalism to problems in classical mechanics. This section is less convincing, leaving one with the impression that, despite the unquestioned elegance of the new approach, one still has to resort to the use of coordinates in any actual computation, and one ends up solving exactly the same equations as before.

This book is a useful introduction to the field and with its aid a traditionally educated physicist should be able to decipher papers written in geometric code.

G. Derrick
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University of Sydney

Nonlinear Diffusive News
P.L. Sachdev
Cambridge University Press, 1987
vii + 246 pp., $108.00

This monograph is best viewed as a comprehensive account of Burgers equation $u_t + uu_x = uu$ and various near-neighbour generalisations such as the non-planar Burgers equation and Burgers equation with damping, together with brief digressions on Fishers equation, other nonlinear heat equations and so on. Burgers equation is central to an understanding of the development and structure of shock waves, and being exactly solvable by the Hopf-Cole transformation to the linear heat equation, readily lends itself to detailed analysis. The account given here cannot be compared for lucidity of exposition to the discussion in Whitham's text, Linear and Nonlinear Waves (Wiley, 1974), and I would not recommend it as an introduction to this topic, or for the casual reader. Much of the remainder of the book which deals with generalised Burgers equations, and other nonlinear of singular perturbation theory, matched asymptotic expansions, and similarity methods. Again the discussion given here could not be recommended for the novice to these techniques. The concluding chapter discusses some specialised numerical schemes for nonlinear diffusion equations. In summary this monograph is essentially for specialists in the topic area, and for this class of reader, is a useful compendium of results which would otherwise be scattered through the literature. It is perhaps also unfortunate that the subject matter of the book has been so narrowly selected that there is no discussion of reaction-diffusion equations, or of the class of nonlinear diffusion equations arising in the study of porous media.

R. Grimshaw
School of Mathematics
University of New South Wales

Hamiltonian Dynamical Systems
A Reprint Selection
R.S. MacKay, J.D. Meiss
Adam Hilger, Bristol, UK, 1987
vii + 767 pp., £20.00 (paper)

This volume of selected research articles covers the state of the art (<1986) in Hamiltonian dynamics within the limitations imposed by the editors. There is no discussion of the theory of integrable systems, Lie perturbation theory, infinite dimensional systems, non-canonical Hamiltonian formulations, symmetry, solitons and quantum mechanics. Further, apart from some remarks in the 4th introductory article by A.S. Wightman, "The Mechanisms of Stochasticity in Classical Dynamical Systems", no discussion is offered on how (a) typical a class the Hamiltonian systems are within the class of dynamical systems. Was it an editorial accident that any references to this topic are left out of the otherwise excellent bibliography?

Within these boundaries the collection is logically structured. Four excellent introductory articles survey the selected material. The research articles are then grouped on the basis of the complexity of the dynamical behaviour, that is discussed. Starting from the ordered behaviour of equilibria and periodic orbits, we are led via quasiperiodic behaviour and the breakdown of invariant tori to chaotic systems and finally are presented with full scope Hamiltonian systems where order and chaos coexist. The last section contains application oriented articles.

The book presents an excellent collection of research articles capable of introducing the non-specialist to the beauty of intricacies of Hamiltonian Dynamics above the usually boring textbook level. (It is a pity that many of the underlying ideas, going back to Poincaré and Birkhoff, are not yet available on the undergraduate textbook

Australian Physicist Volume 25, Number 7, August 1988
Above this it provides the researcher with a wealth of good research so broadly scattered over the literature, all in one volume. It is only a pity that the bibliography is limited to the works cited in the presented articles and does not look beyond the boundaries of the presented work.

I. Mareels
Department of Electrical Engineering
University of Newcastle

Nonlinear Optical Properties of Organic Molecules and Crystals, Volume 1
D.S. Chemla and J. Zyss (Eds.)
Twenty-seven years have elapsed since the first demonstration of optical second harmonic generation Franken and co-workers. Nonlinear optical technology now pervades laser-based instrumentation and is at the heart of many optical detection techniques and spectroscopies, as well as being intrinsic to optical communications and information science. What would now be regarded as conventional nonlinear optical devices tend to be based on a still-growing range of non-centrosymmetric, birefringent crystals or (in the case of four-wave mixing processes) on simple fluids. This book approaches the challenge of a new generation of nonlinear materials tailored for specific purposes with the synthetic versatility of organic chemistry. In broader terms, such an approach falls within the emerging field of molecular electronics.

The two editors are recognised experts in their subject and have contributed a substantial review chapter which comprises one third of the book. They are joined by a variety of well-regarded authors who contribute the remaining eight chapters. These include a terse but elegant introductory chapter by R. Sithey, and instructive reviews of areas such as growth and characterisation of molecular crystals, Langmuir-Blodgett films, and polymeric materials. Another chapter, by J.M. Halbout and C.L. Tang, makes a case study of nonlinear optical devices based on just one molecule, 4-phenylbenzonitrile.

We are promised a second volume in this set. After declaring the artificial distinction between linear and nonlinear optics in their preface, the editors have chosen to make an equally artificial subdivision between second-order processes in the first volume (but not excluding electric-field-induced nonlinear optics in fluids) and third-order processes in the yet-to-be-published second volume. Such is the dilemma which faces an editor! Moreover, the various chapters of this book do not seem to be particularly well coordinated and similar material tends to be treated in more than one place. Nevertheless, the book is authoritative, so that both volumes deserve a place in the library of any establishment active in optical technology.

Brian J. Orr
School of Chemistry
Macquarie University

Gauge Field Theories
Stefan Pokorski
Cambridge University Press,
Cambridge, 1987
xiii + 394 pp $180.00
Fifteen years ago there was a severe shortage of good books on gauge theories, but nowadays there is almost an oversupply. There must be a couple of dozen different books on the market, and it has become difficult to choose between them.

Pokorski’s book is a slightly unusual one. It is addressed to graduate students and young research workers in theoretical physics, but it already assumes some knowledge of canonical quantum field theory, at the level of Bjorken and Drell, for instance: this puts it immediately beyond consideration as a textbook for a graduate course in Australia. It is intended as a concise reference to some of the field theoretical tools used in current research. It is not concerned with phenomenology or the present status of the theory of fundamental interactions; and this attitude is carried so far that the Weinberg-Salam model is not even mentioned in the index!

The ground covered by the book includes the path integral approach, renormalisation group, chiral symmetry and chiral anomalies, and an introduction to supersymmetry. All this material is presented in a very crisp and succinct fashion. In summary, then, this is a useful compendium of technical material for the specialist in the field. It may well be of interest in certain quarters in Adelaide.

C.J. Hamer
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University of New South Wales

Symmetries and Semi-Classical Features of Nuclear Dynamics
A.A. Raduta (Ed)
Springer-Verlag, Berlin, 1987
vi + 465 pp DM 80.00
Over the past ten or so years, there has been increasing interest in the modelling of complex many-nucleon systems. Large scale numerical calculations based on the fermion shell model and its variants (Hartree-Fock, Random Phase Approximation etc) have been supplemented by algebraic methods which try to extract the large-scale or collective behaviour exhibited by the quantum
mechanical system in terms of a few favoured modes or trajectories. In these Summer School Proceedings are several lectures which show how equivalent classical mechanical systems can be obtained through the use of collective paths, coherent states and canonical reduction of the quantum mechanical system. Examples are given of the realisation of identical physical processes in terms of either a bosonisation or a semiclassical reduction via Hamiltonian dynamics.

Another main theme is the application of dynamical symmetries and symmetry groups in the investigation of nuclear structure and reactions. This can be carried out as a continuation of the above program or as a basis for phenomenological modelling. Various lectures cover both aspects, giving the flavour of these areas of topical research interest.

Apart from the two main themes in symmetries and semiclassical features, the proceedings contain several articles on giant resonance states (especially the magnetic or proton-neutron scissors mode) and extreme states (fission and relativistic heavy ion collisions).

In summary, given the utility of classical concepts in other areas, e.g., solitons and instantons in field theory, the book is useful reading not only for those working in the nuclear field but also for those interested in the modelling of semiclassical features and in the application of dynamical symmetries in quantum-mechanics.

Iain Morrison
School of Physics
University of Melbourne

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The Theory of Target Compression by Longwave Laser Emission
G.V. Sklizkov (Ed)
167 pp $87.00 (hard cover)

The concept of the laser driven inertial controlled thermonuclear fusion (ICF) relies on compression and simultaneous heating of a thermonuclear fuel within a pellet irradiated by an intense laser radiation. Overall efficiency of this process is a product of efficiency of absorption, hydrodynamic efficiency, efficiency of burning of the fuel and efficiency of the driver itself. The longwavelength gas lasers (infrared region) have typically higher efficiency than other types of lasers and, moreover, are able to operate at relatively high repetition rate which is crucial for a future commercially feasible reactor. However, a substantial portion of the long wavelength laser energy absorbed is converted to the energy of so-called fast electrons. These electrons penetrate the pellet and deposit a portion of their energy within the fuel increasing thus its entropy. Obviously, such a preheat of the fuel prevents efficient compression. This (experimentally verified) argument against exploitation of the long wavelength lasers as drivers for ICF finally led at the late 70s first to philosophical abolishment of the longwavelength ICF scheme and then, naturally, to closing down of most of then existing longwavelength ICF projects around the world, including the Los Alamos ANTARES CO, facility in 1984. Ironically, those who, in fact, ignited the condemnation of the longwavelength ICF (exploiting the same scenario as the short wavelength ICF) came up with a new view on the problem by demonstrating that the fast electrons can sometimes be even useful, if used properly. The idea is that the fast electrons with specific spectral properties can be used to deliver the laser energy deeper into the target closer to the ablation region, as in a short wavelength laser were used, without preheating the fuel. Therefore, this mechanism falls in the category of so called indirectly driven compression.

The book, a part of series of proceedings, represents a set of 7 collected papers by leading Russian Theoreticians in the field of laser driven ICF. After the new ideal of indirectly driven compression by fast electrons is introduced the papers follow in a logical sequence starting with discussion of simple models of generation of fast electrons in a laser produced plasma. Single and multiple interactions of electrons with localised fields at plasma resonance are considered to obtain the fast electron distribution function comparable with that deduced from the experimental data. The knowledge of the distribution function is a starting point for studies of the energy transport by the fast electrons in the plasma of spherical targets. To start with, an analytic approach is used based on the so called forward-backward approximation. The method is then successfully numerically verified by using the DIANA code in the multigroup approximation. Understanding of the energy transport then allows one to formulate the physics of indirectly driven acceleration and compression of spherical targets irradiated by longwavelength radiation. Unlike the standard situation, when the radiation is assumed to be absorbed within a narrow region of the critical density, a modified model of a steady corona has been developed where the laser energy is deposited (via the fast electrons and/or inverse bremsstrahlung) in a large volume of the plasma. The details of the energy deposition depend on the spectral properties of the fast electrons and requirements on these properties have been formulated that allow for 5-10% hydrodynamic efficiency to be achieved. These analytical results are again compared with the predictions of the DIANA code. It has been demonstrated that a low-entropy compression of targets irradiated by longwavelength lasers is possible provided that the fast electron energy spectrum has a cutoff at high energies.

The fact that the books present predominantly the results of analytic theory and the clarity of the physical arguments makes it easy to understand the physical background of the proposed new scheme of the longwavelength ICF exploiting fast electrons for indirect driving of the compression. From that point of view the book can be highly recommended to all specialists in the field. Unfortunately, translation does not match the quality of the book. It is more than obvious that the translator is not from the field, to say the least. Many sentences require knowledge of both (Russian and English) languages to understand what was originally meant to be their meaning. Already in the title of the book the words longwave laser emission are used where one would expect long wavelength laser irradiation. However, a more serious problem is presented by expressions like epithermal electrons (=superthermals), to suppress target (=to compress target), the profile bending (=profile modification), light suppression (=radiation pressure), similitude relation (=scaling law), energy release (=energy deposition), retardation velocity (=deceleration). Surprisingly, many units in the formulae as well as subscripts are frequently left in the original Russian alphabet form or are sometimes unusually translated as, for example, instead of using W for Watt one can often meet Wt as a literal translation of Russian BT.

R. Dragila
Laser Physics Centre
Australian National University
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<tr>
<th>Date</th>
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<tr>
<td>Aug 28-Sept 2</td>
<td>Engineering and the Physical Sciences in Medicine, Brisbane. Mr. J. Whiting, Uniquest, University of Qld. (07) 377 2733.</td>
</tr>
<tr>
<td>Aug 29-Sept 1</td>
<td>22nd AGM of the Astronomical Society of Australia, Narrabri. Dr J.R. Foster, PO Box 94, Narrabri 2390.</td>
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<tr>
<td>Aug 30-Sept 1</td>
<td>Temperature Measurement School, Perth. Dr T. Edwards, Murdoch University (03) 332 2228.</td>
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<tr>
<td>Sept 12-16</td>
<td>Temperature Measurement School, CSIRO National Measurement Laboratory. Rob Bentley, CSIRO Division of Applied Physics (02) 467 6764.</td>
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<tr>
<td>Oct 31-Nov 2</td>
<td>CSIRO Division of Applied Physics Golden Jubilee Symposium and Open Days. Dr John Cook, CSIRO, PO Box 218, Lindfield, 2070 Phone (02) 467 6211.</td>
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<tr>
<td>Nov 3-4</td>
<td>National Science and Technology Analysis Group Conference, Canberra. Dr. D. Widdup, FASTS (062) 47 3554.</td>
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<tr>
<td>Dec 4-7</td>
<td>13th Conference on Optical Fibre Technology, Hobart ACOFT Conf. Sec., 1 Ree, PO Box 79, Edgecliff NSW</td>
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<td>1989 Dec 31-Jan 28</td>
<td>AIDC National Science Summer School, Canberra R Jory, Director AIDC NSSS. (062) 52 2085.</td>
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<tr>
<td>Feb 13-17</td>
<td>5th New Zealand Symposium on Quantum Optics, Auckland. Prof. J. Harvey, Physics Dept., University of Auckland.</td>
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<tr>
<td>June 26-29</td>
<td>14th Australian Radiation Protection Society Annual Conference, Perth Mike Rafferty, Corp. Sec. (09) 389 2262.</td>
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<tr>
<td>July 3-7</td>
<td>International Conference on Martensitic Transformations, ICOMAT 89, Sydney. Prof. N. Kenna, University of Wollongong (042) 27 0457.</td>
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<tr>
<td>Sept 25-29</td>
<td>Conference &amp; Workshop on the Teaching of Optics at the Tertiary Level - Asia Pacific Education Network (ASPE). Prof. G.I. Opat, School of Physics, The University of Melbourne, Parkville, Victoria 3052, Australia (03) 344 5121.</td>
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</table>
Optical tables and benches
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