Coherent Scientific

SPECTROSCOPY SOLUTIONS
from the Vacuum UV to the Far Infrared

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

Pulsed Laser Spectrum Analyser from Burleigh Instruments

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

CCD Array Detector from Princeton Instruments

WE HAVE MOVED!
SEE OUR NEW PHONE / FAX NUMBERS BELOW

GALILEO ELECTRO-OPTICS
- Micro-Channel Plates (MCP's)
- Channel Electron Multipliers (Channeltrons)

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

Single Grating Spectrometer from Spex Industries

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

Triple Grating Spectrograph from Spex Industries

116 Burbridge Road, Hilton, South Australia 5033
Telephone (08) 352 1111  Facsimile (08) 352 2020
January 1992
Volume 29, Number 8

CONTENTS

PRESIDENT'S COLUMN 174
Title. A. Thomas

GUEST EDITORIAL 175
The Funding of Scientific Research in New Zealand. G. Austin

ARTICLE 177
The Anglo-Australian Near-Earth Asteroid Survey. D. Steel

AIP / NZIP NEWS 183

FIX ON PHYSICS Education Supplement
Sound Production and Hearing in Diverse Animals. N. Fletcher
A Partnership Model For The Twenty First Century - A Pilot Programme. B. Lynch

ARTICLE 185
Physics Enrolments in Australian Secondary Schools - Trends & Implications. J. de Laeter and J. Dekkers

PRODUCT NEWS 189

BOOK REVIEWS 191

CONFERENCES & MEETINGS 196

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

Enquiries & Advertising
Judith Nikoleiski
Production Manager
Impress Studios
41 Kemp Street
The Junction NSW 2291
Phone (049) 61 3319
Fax (049) 61 1844

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

Design and Artwork
Impress Studios, Newcastle

Printer
Newcastle Camera Print

ISSN 1026-3831
Copyright 1992
Pub. No. PP 224960 / 0008

This month's cover picture shows the Tsunami Mode-Locked Titanium-Sapphire laser from Spectra-Physics Lasers. Capable of generating tunable near-infrared pulses as short as 75 femtoseconds, Tsunami is opening up new opportunities for the study of ultrafast phenomena in a diverse range of applications. In the photo, the Tsunami is being pumped by a Beamtek 2080 Argon Ion Laser, and frequency doubled to produce blue output with the model 3980 Frequency Doubler. See page 184 for more details.

Australian & New Zealand Physicist Volume 29, Number 8, August 1992

173
PRODUCT NEWS

Low-Cost High Technology Products from Russia now available in Australia

General Optics Pty. Ltd. is a new Australian company dealing with the distribution and sales of Russian High technology equipment in Australia.

The company puts a standard 1 year guarantee on its products which are sourced from carefully chosen soviet factories.

Rental is possible on most of the catalogue items if the customer prefers not to purchase straight away.

Almost anything is available and at significantly less than equivalent western prices.

Examples would include:

- Ion laser systems (e.g. 4W Argon $7000 & extra tubes $1000 each)
- 55mW HeNe Lasers $3000
- 40-60mW HeCd Lasers $6500
- 25mW CyF HeNe Lasers $600
- Specialised Pulsed Laser systems
- Full range of optical micro-positioning devices/tables (e.g. 3 axis tilt stages for under $75)
- Optics: e.g. Dielectric mirrors $40 each. Large Spherical mirrors up to 1m diameter
- Russian Holographic Plates
- Microwave devices up to 200GHz
- Fibre Optic products

For more information and/or catalogue please contact:

David Ratcliffe
General Optics Pty Ltd
P.O. Box 160
Kangarilla SA 5157
Phone: (08) 3837255
Fax: (08) 3837244

PRESIDENT’S COLUMN

Yet Another Clawback!

A prime purpose of the Physicist is to stimulate debate over issues that are of importance to the health of our discipline. The article by John Jenkin and the related letter from Lawrence Cram have raised just such an issue. Although apparently at loggerheads, each has something serious to say. Cram reminds us that no matter how bad things may seem we must not become maudlin. It is our responsibility to take heart from whatever positives there may be and to concentrate our energy on how best to get on with the job. On the other hand it must be difficult for anyone cushioned by the resources of Messell’s Foundation to appreciate the difficulties faced by Jenkin’s department. Moreover, my contacts around the country indicate that those problems are not by any means unique to La Trobe. It is therefore worthwhile to examine those problems from a national perspective.

At the present time University finances are dominated by a few key concepts, notably formula funding, area management and, of course, the clawback. In principle the first two have a lot to recommend them. A transparent funding system together with the freedom to manage resources without undue interference are very attractive. On the other hand, if a small department has a number of people at a senior level, promoted on merit by a university-wide committee, it can come as quite a shock to learn that those salaries exceed the budget to which the latest formula gives entitlement. Clearly good university management should anticipate such problems and provide assistance in making the transition.

Of course a transparent funding system linked primarily to student load has some potential to drive academically undesirable changes. This is presently hitting a number of departments very hard. Traditionally in first-rate universities we have wanted our students to learn from professionals - mathematicians from practicing mathematicians, science from practicing scientists. However, principles can be quickly forgotten in the battle for diminishing dollars. Of course an engineer can teach elementary physics, an economist elementary mathematics, a physicist some applied mathematics. But would ▲

Continued on page 176
The economic structure of New Zealand has been in rapid change in the last few years as the form of public institutions is modified to reflect the privatization visions of first the governing Labour and then the governing National Party. During these drastic changes the mechanisms used by the Government of the day to fund Government research laboratories have been continually modified to the effect that the laboratories have been considerably reduced in establishment and "restructured" sometimes more frequently than annually in an attempt to make them commercially competitive (quite with whom is not clear is most cases).

It is apparent from the recently published Ministry of Research Science and Technology (MORST) document entitled "Long Term Priorities for the Public Good Science Fund" that the Government sees the support of New Zealand industry as the only sensible reason for funding research at all. MORST has formulated a "Strategic Framework" to form a philosophical basis for their plan. Five of the six items in this framework describe the various ways in which research can provide short term help to primary and secondary industries. The sixth is an extraordinary item which clearly illustrates the thinking of the purposes of the plan,

"to accept higher levels of risk (for example, from hazards arising from natural phenomena) as a price for better economic performance".

It is difficult to see how to apply this priority directly but presumably we are to build hydrotens with much reduced safety margins from flood failure provided there is even some small profit to be made. Alternatively, perhaps, the Government intends to follow the UK lead and set up a new facility for the reprocessing of used nuclear reactor fuel rods and other radioactive waste from around the world so that we can "accept higher levels of risk ...for better economic performance". It is hard to see where the Government advisers have been during the last decade while public concern about all environmental problems has grown everywhere.

The procedure adopted has been to establish, in the jargon of the new age accountants of the New Zealand Government, 40 different "Output Classes" representing 40 different areas of economic or social activity to which the Government scientific research funds will be directed. The plan calls for 68% of the funds to be in direct support of "Output Classes" in primary and secondary industry, 20% for the "Exploration of the Earth" group of classes, 4% for environmental protection, and 1.3% for the "Pursuit of Fundamental Knowledge". Thus, the total Government expenditure on research directly in pursuit of fundamental knowledge, is approximately NZ$1 per head of population per year! The 40 "Output Classes" are supplemented or perhaps further confused by a description of 24 desired "Government Outcomes".

Apart from the torture inflicted on the English language in all this new "MORST speak" and the devastating effect it has had on Government scientist morale it now seems probable that the universities may not be able to avoid being included in the same structure.

It is clear that the Government has every right to decide the areas in which it will fund fundamental and applied science in New Zealand. Detailed specification in this area is not an original idea. Although motivated from an entirely different political viewpoint, this exercise is very reminiscent of the infamous Soviet 5-year plans. More recently the Canadian Government introduced a programme of "Strategic Grants" for the funding of university scientific research. After several years of these grants to universities, it is quite apparent that they have resulted in much less published research, fewer patents and reduced number of commercially significant "outcomes" for the money spent than the parallel system of funding university research by peer-reviewed proposals.

I believe, therefore, that although the Government has the clear right to impose a strategic plan on the areas in which research should be done, the Government would be well advised not to do so. The history of science leads me to believe that the establishment of the optimum strategic plan is an impossible task. For example who would have imagined in 1947 that transistor would make the vacuum tube obsolete within a few years. A more recent example, the discovery of ceramic high-temperature super-conductors, was totally unpredictable even by the most expert physicists in the field. In fact, ceramic research was regarded as a complete dead end, and graduate students were strenuously advised not to go into it since nothing useful would come out of it.

In a recent article entitled "A Lesson in Humility" in Physics Today (December 1991), Daniel Kleppner, Professor of Physics and director of the Research Laboratory for Electronics at MIT reviewed the performance of the Brinkman Committee in the US, which is designed to set priorities in physics for the next decade. As a member of the committee, which reported 5 years ago, he was able to point to major developments in the following fields of physics which were not predicted by the Committee:

- High Temperature Superconductivity
- Supernova 1987A
- Atom cooling and atomic optics
- Buckyballs
- Chaos and non-linear dynamics
- Superdeformed nuclei
- Large scale structure of the Universe
- Mesoscopic physics

This list arguably represents most if not all of the major discoveries of the last 5 years in physics. So much for central planning.

Nortcote Parkinson, the man who invented Parkinson's Laws, has a description of how not to fund scientific research. This was written in 1960, so this too is not a recent thought. It starts:

"But this popular conception of how scientific work is supported by the government is completely false. Waste is then a result of control being excessive, not of its being absent. The modern fallacy is to imagine that an elected Conservative or Socialist can decide on a line of research and then leave the scientist to work out the details.

No king or minister could have instructed Newton to discover the law of gravity, for they did not know that there was any such law to discover. No treasury official told Fleming to discover penicillin. Nor was Rutherford instructed to split the atom by a certain date, for no politician of his day and scarcely any other scientist would have known what such an achievement meant.

Australian & New Zealand Physicist Volume 29, Number 8, August 1992
GUEST EDITORIAL

would imply or what purpose it would serve. Discoveries are not made like that. They are the result, as often as not, of someone wandering off on his own line of research attracted by some phenomenon hitherto unnoticed or suddenly seen in a new light.

Nowadays, when one country lags scientifically behind another equally prosperous country, the most probable reason is that the government has been telling its scientists what they are to discover. This means, in other words, that too much money has been allocated to specific projects and too little to abstract science. The more resources have been devoted to projects the politician can understand that, to the development of discoveries already made and publicised the fewer resources are available for discoveries which are now so inconceivable in so much as they have not yet been made."

It seems to me that this says rather well what we are talking about. It is very unlikely any committee of politicians, or any committee of distinguished scientists politicians might choose to appoint, is going to be able to predict with any degree of skill where scientific discoveries are going to be made. If you follow that argument through, it seems to me it suggests that "Output Classes" and "Government Outcomes" do not make much sense, because no one will be able to guess where these important areas are going to be. It is possible that in the case of technology it may be a little easier to anticipate which technologies are worth pursuing. But even there, frankly, I have my doubts, because technology itself changes extremely rapidly.

The Government should therefore be urged to drop its "Strategic Framework" and "Output Class" structure, particularly as it applies to universities and at least some parts of Government research laboratories. Instead, it should do everything it can to encourage original creative scientific research. There is no doubt that the historical data completely supports the idea that this strategy yields the best value for money for Government funded science. In spite of the contrary belief apparently held by the Government, the scientific research community is held truly accountable by the scientific review process for their scientific publications, the merit of their scientific proposals, and the commercial success of their discoveries and not by conforming to a Government imposed strategic plan. What is needed is a Government with the vision to set up the conditions necessary to encourage outstanding research and not to impose the dead hand of a Government 5-year plan.

Geoff Austin
Professor of Geophysics
University of Auckland

WAGGA 93

CONDENSED MATTER PHYSICS CONFERENCE

Charles Sturt University
Wagga Wagga, NSW
9 - 12 FEBRUARY 1993

Abstracts in all areas of Condensed Matter Physics are invited. Please submit abstracts on A4 page (or by e-mail in Document Interchange Format (RTF) or binhex) to:

David McKenzie, School of Physics
University of Sydney, NSW
tel: (02) 660 2903
fax: (02) 339 2219
e-mail: waggaphy.uts.edu.au

Registration and accommodation enquires to:
John Bell, Physics Department
University of Technology, Sydney
tel: (02) 339 2219
fax: (02) 339 2206
e-mail: waggaphy.uts.edu.au

Registration $45
Closing Date: 11 December 1992
Accommodation (full board) $34 per night

1993

MATHEMATICS-INDUSTRY STUDY GROUP

Melbourne, Australia
15 - 19 FEBRUARY 1993

The meeting will be organised by CSIRO Division of Mathematics and Statistics in collaboration with a Melbourne based Steering Committee with members from Monash University, Swinburne Institute of Technology and BHP Research.

For further information, please contact
Dr. N. G. Barton, CSIRO Division of Mathematics and Statistics,
PO Box 218, Lindfield NSW 2070
Telephone: (02) 413 7702
Facsimile: (02) 416 9317
noel@syd.dm.csiro.au

PRESIDENT'S COLUMN

Continued from page 174

this really lead to the open-minded, adaptable graduates that Australia must produce to remain competitive? I do not believe so. Again, wise management will bear this in mind when assessing the quality of education provided by an institution.

Now let me turn to the clawback, an area where we have led the world! It is now under consideration in Britain. However the IOP is opposing it strongly. The reason is that some 40% of the funds to be clawed back presently provide research infrastructure for science departments and particularly physics departments. It is highly unlikely that 40% of the funds coming back will be earmarked that way. The Australian experience would certainly suggest not.

Until now I have tried to keep the tone of this column diplomatic. However, this month it has to change. The success rate for initial ARC applications seems likely to drop below 20% this year. Since the internal funds to support research have been eliminated by the clawback there is no margin for error. Modern physics research is difficult or impossible without significant research funds and without a doubt, excellent work will miss funding this year. The cost of that unrealized potential does not enter many bureaucratic formulas. It is a national disaster.

Frankly, I believe that the unchallenged supremacy of Treasury hardliners has become intolerable! Rumours abound that they are demanding yet another clawback. The underlying philosophy is as simple as it is stupid, namely that every cut to funding makes the universities more efficient. (More leeches to the neck!) Thomas Carlyle dubbed economics the "dismal science". Writing in Indiana University's Business Horizons recently, L. McTern Anderson (a professor of marketing and business administration) asserts that "ironically, the dismal science's label is more applicable today because of the discipline's performance record and its pervasive influence" (my emphasis). He further states that "economists' forecasting records are dismal, and their simplistic assumptions are as ill-suited for the dynamic 1990s as a model T Ford is for an autobahn".

It says a great deal about human gullibility that our political leaders are constrained by advice from a group with those credentials. It becomes laughable when the losing side has in just the last forty years given the world new ideas like lasers, pulsars, high-temperature superconductivity, quarks, liquid crystals, nuclear magnetic resonance, tomography and many others which have changed the world, including the transistor without which these narrow-minded zealots would have no computers to use against us.

Let us, at this stage in our history, stop the rot! Admit with Martin Feldstein that "one of the great mistakes of the past thirty years of economic policy has been an excessive belief in the ability to forecast". Let us have a science policy that fosters basic sciences like physics which have given and continue to give so much to society.

A. W. Thomas

Australian & New Zealand Physicist Volume 29, Number 8, August 1992
More and more we have become aware over the past decade or so that extraterrestrial effects can severely influence the habitability of our planet. Whilst there is much emphasis now in the media and in government policy, upon mankind's own effect upon the environment (for instance, the Greenhouse Effect, the Ozone Hole, space junk and other macroscopic pollution), there is one prediction for the future in which I feel assured: that extraterrestrial factors over which we presently have no control will attain a higher and higher significance in our perception of the future of the Earth. This article discusses the extraterrestrial factor with which scientists - not only astronomers and physicists but also geologists and, increasingly, evolutionary biologists - are most familiar. It is also the most effective in causing rapid and catastrophic alterations to the terrestrial environment: impacts by asteroids and comets. A description is also given of what we in Australia are doing in order to eventually safeguard mankind against this hazard, to which may be ascribed the dinosaurs demise and man's ascendency.

The History of the Impact Idea

Most readers will be familiar with the hypothesis, first promoted in a paper by Nobel prize-winning physicist Louis Alvarez and co-workers, that the age of the dinosaurs came to a full stop 65 million years ago due to the impact by a large asteroid upon the planet (Alvarez et al., 1980). Since then much work has been done in this area, and hundreds of articles (learned and popular) have been written, with the Alvarez name becoming famous in this regard probably above his many other major contributions to physics. However, it is often overlooked that previous to this British astronomers Victor Clube and Bill Napier published a paper pointing out, on a rather broader canvas, that such episodes of impacts must occur on the Earth with worrying frequency, and thus the progress of life here has been subject to many introductions from the skies above (Napier and Clube, 1979; see also Bailey et al., 1990, and Clube and Napier, 1990). It is now generally believed that more than one impact occurred at the time in question - at the boundary of the Cretaceous and Tertiary geological ages - with several candidate craters of the correct antiquity having recently been identified in Iowa, Montana, and the Caribbean region. Presumably there were many other impacts elsewhere since there is no reason to suppose that area of the world to have been a particular target, so that what may have happened was the break-up in space of a giant comet, with each of the planets then receiving strikes from large and small fragments. Eugene Shoemaker (U.S. Geological Survey) has found evidence for plant growth between impacts, putting a lower limit on the spacing (at least one growing season), whilst there has also been identified at the rock boundary a layer of amino acids (in which comets are believed to be rich) which spread over about 100,000 years, giving an upper time limit (Shoemaker, 1990; Zhao and Bada, 1989; Zahnle and Grinspoon, 1990). That time is long on a human scale, but short astronomically or geologically, and is in fact appropriate for the break-up and eventual decay of the fragments, meteoroids and dust resulting from a comet undergoing a hierarchical disintegration. With that mention of amino acids I should here point out that it seems likely that the Earth's inventory of water(ies, all of the oceans, lakes, rivers and ice) and organic chemicals are apparently derived from cometary impacts earlier in our 4.6 billion year history (Anders, 1989; Chyba, 1990; Chyba et al., 1990), Steel, 1992): so comet impacts are not all bad. But terrestrial catastrophes caused by impacts are not a new idea. The first Earth-crossing (Apollo-type) asteroid was discovered in 1932 (Watson, 1941); prior to that date, several comets (such as Halley's) were known to cross our orbit, so that the chance of a mega-impact was not at all unknown. Over the next four decades a few more near Earth asteroids (NEA's) were found as chance occurrences on photographic plates, but it was not until the 1970's that focussed programs searching for such objects began, in the United States. The majority of our presently-known population of about 150 NEA's which threaten the Earth have been found as a result of those programs, with which the names Shoemaker (Gene and Carolyn) and Helin (Eleanor) are associated (Shoemaker and Shoemaker, 1988; Helin and Roman, 1990). Calculations of collision rates based upon our current knowledge of the NEA population, and the estimated total number yet to be found, showed that the impact rate upon the Earth for large objects is dominated by the asteroidal, rather than the cometary, population. At most about 8-10% of large impacts appear to be cometary in origin (although the difference between a comet and an asteroid is a moot point). As a guide, the present belief is that an impact by a 1 km or larger asteroid onto the Earth occurs about once per 100,000 years; an impact by a 100 metre body occurs on the order of once per few centuries or so (Olsson-Steel, 1987; Chapman and Morrison, 1989; Morrison, 1992). However, especially for the smaller bodies, these impact rates are highly uncertain since most known NEA's are larger.
The domain of asteroids in the inner solar system. Most asteroids inhabit the main-belt, between the planets Mars and Jupiter; Mars is the outermost of the four terrestrial planets, shown as the central four near-circular orbits. The main-belt asteroids, many millions of them, also have near-circular orbits, in general, else they would come too close to Jupiter, whose strong gravity would eventually eject them from the solar system on an hyperbolic orbit. Two of the larger asteroids are shown here: Vesta, with an orbital eccentricity of 0.09, and Juno, eccentricity 0.26. Also shown is a generic Apollo-type asteroid orbit, of eccentricity 0.8: this orbit intersects the heliocentric distances of Mars, the Earth and Venus, and would be expected to strike one of these within a few million years. There are believed to be about 10,000 such objects larger than 300 metres across, and 320,000 bigger than 100 metres. The three asteroids are denoted with dotted lines about their orbits, the dots being spaced by one week. This shows one of the reasons that Apollo asteroids are difficult to spot: they spend relatively little time near perihelion or close to the Earth, and most of it far from the Sun around aphelion.

An Australian Program

Since a large fraction of the sky is inaccessible from the observation sites of the above searches (Mount Palomar in California, and Kitt Peak in Arizona), it was clear that a southern hemisphere program was warranted. In 1990 funding for a three-year program became available from the Australian Research Council, and the Anglo-Australian Near-Earth Asteroid Survey (AANES) came into being in May 1990 (Steel and McNaught, 1991). This program was initially run from the University of Adelaide, with Robert H. McNaught carrying out the duties on-site at the Siding Spring Observatory (SSO), but recently the host institution became the Anglo-Australian Observatory (AAO) with the author of this article also becoming resident at SSO. Ken Russell (AAO) is now contributing directly to our efforts. This article describes the successes we have enjoyed so far: note that the AANES acronym is a mis-spelling of AeNEAS, the main character in Virgil’s epic poem The Aeneid, who was a Trojan hero in Greek and Roman mythology. In view of the long-time association between classical gods, in particular the Greek deities, and asteroids names the acronym for our program seems appropriate.

Search Technique

In the sixteen years through to 1990 during which the 1.2 metre U.K. Schmidt Telescope (UKST) was operated at Siding Spring Observatory in New South Wales, five NEA’s were found amongst the 14,000 photographic plates routinely taken as part of a southern hemisphere sky survey, or taken of other fields of interest to astrophysicists. The UKST was formerly run by the U.K. Science and Engineering Research Council as an outstation of the Royal Observatory, Edinburgh, but a few years ago began to be operated as part of the Anglo-Australian Observatory. This telescope is world-renowned as the best of the large Schmidt instruments, with excellent optics giving fine images over its entire 43 square degree field.

On a plate taken of a field near the ecliptic a large number of main-belt asteroids are found, often of order 200 (or 5 per square degree). These are recognizable by their roughly parallel trails (since main-belt asteroids are mostly low-inclination), with tail lengths proportional to their apparent angular motion across the sky (10 to 15 arcminutes per day) relative to the fixed stars. However, it became clear that many NEA’s were being detected on the plates but not picked up by the observers and plate processors due to the faintness of their trails and the time required to scan each plate (up to one hour per plate under a binocular microscope, with perhaps ten plates being taken per night). NEA’s are recognizable due to (i) The length of their trails, often being a factor of three or more longer than the main-belt trails (a long trail indicates a fast-moving object, or FM0); (ii) The semi-random angles of the trails; and (iii) Their occurrence in essentially any area of the sky, and thus plates taken well away from the ecliptic. From May 1990, with the inception of AANES, the recognition rate of NEA’s increased markedly, with eleven Earth-approaching asteroids (eight of them potential impactors) being found so far. As with any scientific research program it would be fair to state that we are still on a steep learning curve, with some NEA’s presumably still being missed: we have already attained a discovery rate on a par with the two photographic searches in the U.S., or higher, but believe that we can do rather better still.

178 Australian & New Zealand Physicist Volume 29, Number 8, August 1992
When a suspected NEA is picked up on a NEA plate, a rapid follow-up is necessary if its orbit and ephemeris is to be determined. A main-belt asteroid will have moved only by about 4% of the width of a plate in 24 hours, at a more-or-less constant angular velocity, whereas a NEA may have moved more than a plate width, and be accelerating, so that further observations within 24-48 hours are generally essential. For this reason the plates are searched for suspect trails immediately they are available the day after exposure. Should such a trail be found, the Minor Planet Center and the Central Bureau for Astronomical Telegrams at the Harvard-Smithsonian Center for Astrophysics is immediately informed, so that other potential observers may obtain astrometric observations in case the vagaries of the weather prevent data collection at SSO. We also make direct contact with Mount John University Observatory in New Zealand and the Perth Observatory if the object is sufficiently bright. For a bright trail (better than mag 17) we obtain follow-up exposures on film using the 0.5 metre Uppsala Southern Schmidt Telescope at SSO, or the 40-inch ANU telescope which is equipped with CCD chips. For a faint trail, or if the position is highly uncertain, it is necessary at times to obtain a plate or film using the UKST.

Apart from the search program described above we also conduct follow-up observations for the discoveries made elsewhere. These are most often made with the Uppsala instrument although UKST plates are necessary at times. Apart from recent discoveries (within the previous few days) so as to secure a new NEA, at times observations are necessary in order to improve an ephemeris. An example of this is 1991 EE, which was found in March 1991. Since it was known that this asteroid would pass close by the Earth in September, a radar campaign using the Arecibo radio telescope in Puerto Rico was planned by Steve Ostro (California Institute of Technology). However, the narrow Arecibo beam meant that the ephemeris for 1991 EE had to be improved, requiring astrometric data as soon as possible as it came out of the glare of the Sun: such a position was measured by Ken Russell in early September, after U.S. observers had been unable to pick up the asteroid, and Ostro was then able to conduct a successful radar run. Previously Ostro has obtained echoes from a number of NEA's, such as 1986 DA (which was found to be largely metallic in nature) and 1989 PB (which was found to be bifurcated; a binary asteroid?) (see Ostro et al., 1991, and Yeomans et al., 1992, and papers referenced therein). Since AANEAS began we have also obtained positions for 1990 MF and 1991 JX which have allowed radar detection for each. Apart from providing information on the size, composition and spin rate of a NEA, the radar data are also of import in terms of its orbital dynamics: a single radar detection (and hence a precise geocentric range) can provide a refinement of its ephemeris equivalent to increasing the duration of its optical observation arc to many years.

This introduces a follow-up topic. If a NEA is discovered, either in the AANEAS program or elsewhere, the back-computation of its ephemeris can indicate previous (unrecognized) observations which may exist in the UKST plate library. In this way it has been possible for us to track down previously serendipitous astrometric positions, thus immediately extending the arc to a decade or more for some objects, so that our knowledge of their orbital parameters can be radically improved without waiting for subsequent apparitions.

Discoveries to Date and their Significance

The first AANEAS discovery, 1990 MU, is noteworthy in that it is one of the largest Apollos, being about 6 km across; detections in previous apparitions on UKST plates (precoveries) have been found for this asteroid which means that its orbit is now well-determined and secure. It has therefore been given a permanent number and the discoverer (Rob McNaught) has the privilege of naming it; he has chosen Emu, an Australian aboriginal name which fits in with its original denomination, and the constellation of the sky (in aboriginal ideas) in which it was found. Another noteworthy Apollo is 1991 RC, which has one of the smallest perihelion distances of all known asteroids, and may be genetically linked to 1956 Icarus (Steel et al., 1992a). Five comets have been found, one of which has the near-record perihelion distance amongst all known long-period comets, being always more than 7 AU from the Sun. Apart from the above twenty-three supernovae have been found, allowing early data collection from observatories worldwide, and several asteroids have either been picked up in previous apparitions (and thus recorded on old UKST plates) or recovered after having been 'lost': one since 1927!

The preliminary denotations given to asteroids often confuse people. The year of discovery is first given, then a letter which indicates the foreboding of the discovery, and then another letter indicating the ordering of the discoveries within that two-week period. Thus 1991 AA would be the first asteroid discovered this year (although many 'discoveries' turn out to be re-discoveries of previously observed objects), whilst 1991 ED would be the fourth asteroid found in March.

A most surprising and bizarre object found in 1991 February is 1991 DA. This appears asteroidal in nature but has an orbit like a Halley-type comet, stretching from near the planet Mars out to beyond Uranus. This object is such an oddity that, for instance, NATURE (Chapman, 1991) and NEW SCIENTIST ran short articles announcing its discovery. 1991 DA has the third highest eccentricity of all known asteroids, and the third largest inclination to the ecliptic (over 61 degrees). Observations at SSO and also at the European Southern Observatory in Chile have shown evidence of any coma. Our own observations with the Anglo-Australian Telescope have none of the spectral emission lines characteristic of a comet (Steel et al., 1992b).

Orbital integrations have shown that although this body crosses the orbits of several planets at least for the past 15,000 years it has been quite orderly and non-chaotic, so that complete de-volatilization (or the formation of an insulating crust) may have occurred over that time, the object originally having been an active comet. Around 15,000 years ago 1991 DA had a nodal crossing near Saturn, so that integrations extending back before that start to diverge, depending upon the exact start parameters (see figure); it is therefore possible that this object was captured into its present orbit at about that time (Steel et al., 1992b). Astrometric observations of 1991 DA continue from SSO (it is deep in the southern sky so inaccessible to most observers) so that an improved ephemeris can be derived, and thus physical observations using large telescopes such as the AAT can continue for as long as possible; there is great interest in outer solar system bodies at this time due to the outbursts of unknown origin seen for several comets, most notably Comet Halley earlier in 1991. Asteroid 1991 DA has a period of about 42 years so that it will not return to perihelion again until 2032.

The Future

As can be imagined from the above, so far this program has been a resounding success. However, a much increased effort is highly desirable. Apart from obtaining funding to continue AANEAS after the end of 1992 we would also very much like to be able to expand the present program. Currently up to 30% of potential observing time with the UKST is not used due to the bright moon period, or the seeing being too poor (worse than 4.5 arcsec) for the normal survey exposures. Glass photographic plates are too expensive for use at such times in an...
The strange dance of 1991 DA. In these plots (courtesy David Asher, University of Oxford) the variation in the orbit of 1991 DA over the past 50,000 years and 25,000 years into the future is shown. It is found that the exact start parameters are of huge importance in the calculations: there are six lines in each plot corresponding to one of the orbital elements being slightly changed, for instance a thousandth of a degree in the inclination to the ecliptic. In the present epoch, and extending back almost 20,000 years and 25,000 years into the future, all of the plots are well-behaved since 1991 DA is in a 2:7 mean-motion commensurability, or resonance, with Jupiter (i.e. its orbital period of 42 years is 3.5 times the 12 years of Jupiter). However, as the orientation of its orbit precesses, going back in time, at about 15,000 years ago 1991 DA had a nodal crossing near Saturn, so that close approaches to that giant planet were possible; for all of the time since 1991 DA has kept well away from the jovian planets Jupiter, Saturn and Uranus. The six integrations rapidly diverge prior to that time so that there is no chance of our knowing the exact history of 1991 DA. Looking at the topmost plot, for the semi-major axis, other resonances are also seen to occur in the integrations, showing that temporary stability is possible: for instance 1:3, 3:10, 1:4 and 1:6 resonances are shown by the oscillatory parts at the left of the top plot. The second plot is for the eccentricity, the wide variations seen affecting the perihelion distance, which is shown in the third plot. Note that two of the integrations indicate 1991 DA to have been an Earth-crosser within the past 50,000 years, and it seems likely that it could achieve perihelion within 1 AU at some time in the future, should it survive its passage between the giant planets. Since this asteroid is about 5 km across, a terrestrial impact would undoubtedly lead to the extinction of many of the animal species on Earth, and most likely the end of human civilization in its present form.

International Interest

Things are also moving on the international front. Under direction from the U.S. Congress NASA has formed a committee to investigate ways of greatly improving the current discovery rate. The overall idea has international approval as witnessed by the fact that in August 1991 the International Astronomical Union passed at its General Assembly in Buenos Aires a resolution setting up a working group to consider the problem; the writer is a member of that group. Of 24 people on the NASA committee, six are foreign nationals (to the U.S.) and amongst those two are from AANEAS (Ken Russell and the author). At the time of writing we are preparing the final report for Congress which will make recommendations for a greatly expanded search program to find essentially all NEA’s larger than 1 km across within 25 years, and a large proportion of the 100-500 metre objects. Likely requirements would be a network of at least six 2.5 metre dedicated search telescopes equipped with CCD mosaics covering a large field, three in each hemisphere. Australia would be the obvious site for one of
Caught as a streak against a background of stars, the tell-tale path of an asteroid. This is the discovery photograph of 1991 DA, described in more detail in the text: the photograph width is about ten arc minutes long, or one-third the diameter of the Moon in the sky.

These each of these sites would be expected to find upwards of 200 NEA's per year, with dedicated astrometric telescopes (1.0-1.5 metre aperture; narrow field of view) being charged with follow-up so as to accurately determine their orbits. In this way almost all of the estimated 10,000 NEA's over 500 metres in size could be found, and their orbits numerically integrated to see whether an Earth-impact is likely in the foreseeable future. If it is, then one would imagine and hope that the human race would be galvanized into some sort of coordinated action; another NASA committee, including input from the U.S. military, is considering how such objects might be intercepted and diverted, or their potential effects otherwise ameliorated. This committee met at Los Alamos in January 1992, the author being the only non-US member; amongst the participants was Edward Teller.

There are a number of justifications for such a program, quite apart from the scientific interest in asteroids and comets per se, their role in supplying the building blocks of life to the Earth in the past, and their impacts causing the punctuated marks in the "punctuated equilibria" through which evolution has apparently progressed. This justification lies predominantly in two areas, one beneficial and the other detrimental to mankind. The first is linked to the concept that such bodies as those for which we are currently searching will likely be our major source of raw materials, from water to metals, as we exploit space in the next century and construct large habitations away from our planetary home. This idea stems from the fact that many Earth-crossing asteroids are more accessible, energetically, than the surface of the Moon even though a long trip may be necessary in order to reach them. Velocity changes of less than 5 km per second are required for rendezvous in many cases.

Their detrimental effect is due to the catastrophic consequences of a large impact. Purely on the grounds of economics, such a program may be justified in that the annual expectation of damage is of the order of US$100 million or more (Chapman and Morrison, 1989). However, more economics pale beside the ability of Earth-crossing asteroids and comets to wreak death and misery; conservative estimates put the chance of one's dying due to an asteroid impact rather higher than the likelihood of meeting your end in an aeroplane crash (Chapman and Morrison, 1989). Even this comparison does not give the full flavour of the problem: an impact by a 1-2 km body could kill half of the human...
race and end civilization as we know it. The chance of such an event is small (about one in 1-2,000 in a person’s lifetime, by our best estimates): but the consequences are extreme.

References

Sagan, C. Foreign Affairs, Winter 83/84, 257-292, 1983
Watson, F. Between the Planets, Blakiston Co., Philadelphia, 1941

TAMAKI CAMPUS

Lecturer / Senior Lecturer
Experimentalists in Nuclear Physics, Biophysics or Hyperfine Interactions

Applications are invited for up to two positions in the above areas.
An especially well qualified candidate could be appointed at the Associate Professor level. The successful candidate/s (if in the first two areas) would develop collaborative research programmes using facilities such as the 14 UD Tandem Accelerator ANU, Canberra, Australia, or utilise the 3.5 MV Tandem Accelerator in the Department of Physics. Teaching in science on the Tamaki Campus will begin in 1993 and student numbers are expected to grow quickly. Initially, teaching duties will be assigned on both the main or Tamaki campuses, however with the expansion of the teaching programme at Tamaki, the balance of duties would be expected to change.

Salary: Lecturer
NZ$37,440 - NZ$49,088
Senior Lecturer
NZ$52,000 - NZ$67,080
Associate Professor
NZ$69,680 - NZ$75,920

Further information, conditions of appointment and method of application:
Professor A. R. Poletti
Department of Physics
Telephone 64-9-373-7599 ext 8853
Facsimile 64-9-373-7445
Applications quoting Vacancy UAC 171 including CV, list of publications and names of at least three referees to:
Assistant Registrar
(Academic Appointments)
University of Auckland
Private Bag 92019
Auckland
New Zealand

by 1st September 1992

The University of Auckland is an equal opportunity employer
A. I. P/N.Z.I.P NEWS

A. I. P. Annual Report 1992

This report is based on the Minutes of the 44th Council and attempts to summarise the issues which the Institute faced during 1991. Many of them are continuing concerns which pre-existed and will continue into 1993.

It was interesting to hear Dr Graeme Putt’s observation after Council, that he had not realised the extent of the organisation of the AIP and the time that so many devoted to pursuing its interests. This report cannot truly reflect the extent of the activity of such a diverse organisation and necessarily reflects the view from the centre. The branches of the AIP are the places where the interest of members is focused and it is these groups which sustain the relationship between the AIP and the discipline of physics in Australia.

The major preoccupation of the Institute in 1991 was the Strategic Plan for Physics to be written under the auspices of the National Committee for Physics. Many submissions were made by groups and individuals to the drafting committee and meetings were held in each state to permit a full discussion of issues facing Physics as a profession and as a discipline. Research directions and funding were inevitably of major importance but problems of education at both secondary and tertiary levels were widely canvassed. Many of the ills of physics as a profession are consiered to have arisen because of social and educational changes during the past decades. The Science Policy Committee has spent much of its time discussing the strategic plan and the process of its development. Drafts of the Strategic plan were circulated for comment late in the year and the plan was ready for submission by July 1992.

Education was the other serious issue for all State Branches and the Federal Education committee. An AIP education policy was written and adopted providing a basis for discussion with DEET, a basis for incorporating education policy in the strategic plan and as a basis for the proposed accreditation of tertiary physics departments. All branches are continuing attempts to interest physics teachers in the AIP, to establish links with high schools, to provide prizes and competitions for physics students and to influence the teaching policy in secondary schools. A major initiative to encourage teachers to participate in our activities was to lower the fee for Associate Membership to only $30. It must be stressed that this is not a “lower class” of membership but simply acknowledges that for many teachers their first loyalty is to teaching as a profession. Most branches now have a form of Youth Lectures for country high schools.

The Australian Physicist has had its name changed and become the Australian and New Zealand Physicist. Members of the NZIP are receiving the Physicist as part of their membership subscription and this created a need for increasing the membership rates for NZIP members. The Physicist has maintained its high standard and comments from members indicate that it is widely read. Some articles have come from New Zealand but more are required to balance the largely Australian content. More topical items relating to New Zealand are required to maintain the interest of the members of the NZIP, Professor Ron MacDonald will step down as editor of the Physicist after an inspirational term in a very demanding job.

The Science Policy committee, prompted by the Victorian Branch sponsored a questionnaire to all members, distributed with the Physicist. About 750 people replied. Members were asked for basic information about their careers and education and whether they would be willing to assist schools with physics education. These names have been extracted from the data and sent to State Branches for them to use. Another aim was to obtain names of physicists working in industry but who were not members of the AIP. It was suggested that the questionnaire be used as a chain letter and passed on to physicists in industry. Many replies were received and the information is in the process of being collated.

The Melbourne Congress was held in February 1992, so that, while it falls within that year, most of the organisation took place in 1991. Some 800 people took part including over 250 secondary school teachers who attended sessions held jointly with the Science Teachers’ Association of Victoria. This represented a major outreach by the AIP to teachers in secondary schools. It is important to the health of physics as a profession and a discipline that physics teachers see themselves as part of the physics community.

The Congress also featured many collaborative sessions with other organisations, most of whom are cognate societies. This collaboration is important both to the AIP and to the discipline of physics as it maintains links between the physics community and in the past, to postgraduate students. These groups often include those who are members of other professional societies or who could not become members of the AIP but who practice in the specialty area. The AIP attempts to represent the wide range of interests of physicists, their areas of expertise, provide updates in developments in the discipline, education policy and the politics of science in Australia. Particular interests need to be balanced against general concerns and a strong Institute maintained. The next congress will be held in Brisbane in July 1994 in conjunction with the AAPPS congress.

The Registrar reported a modest increase in membership with many graduates transferring to member status. A new brochure and membership certificate have been designed and were displayed at the congress. These will be available to existing members at a small cost. The major development supported by Council, is the proposal to accredit tertiary courses. The impetus for such a move arises partly from the Federal Government’s efforts to accredit all courses in Australia. Should the AIP not pursue this action it is possible that another body would take on that role. Most professional societies are already accrediting courses or are moving to do so. The final hope is it may be a means
of bringing pressure to bear on institutions which refuse to fund physics departments at an adequate level.

The Council supported the proposal to establish a Bragg Gold Medal, in honour of W L and W H Bragg, to be awarded annually to the doctoral thesis judged to be the most outstanding thesis in the previous year. Details will appear in the Physicist and notification will be given to tertiary institutions for the initial award to be made later this year. The medal will be of 9ct gold cast from the dies used by the South Australian branch.

Branches

All branches contributed significantly to the preparation of the strategic plan, to the final form of the Code of Ethics and to the AIP Education Policy. All documents provide the structure for influencing the development of physics in Australia. We must now use them to influence policy and support the application of physics to contemporary problems.

ACT

The ACT branch has had a full program with 10 lectures, some in collaboration with cognate societies and the Science Teachers Association. There was also a visit to the National Science Centre. The Branch organised the Physics and Physics Education part of the National Science Summer School. Branch members are very active in the organisation of the Australian Physics Olympiad Team and it is likely that the 1995 Olympiad will be held in Canberra.

NSW

Monthly meetings were held throughout the year at which attendances were good. Several education initiatives were supported including prizes to the top physics students in the state's universities, support for the Science Talent Search and support of an enrichment program for high school students. New proposals include a Travelling Fellow to give lectures to country high school students and a postgraduate students conference.

QLD

There were nine meetings with speakers covering a wide range of subjects. Dr Don Hutton was the Youth Lecturer speaking on "From Watts to (Con) Fusion" to students in 5 cities in the state. The branch supported the training of students for the Physics Olympiad and provided prizes for students in first year physics.

SA

A major initiative this year was the organisation for and presentation of the Bragg medals to high school students (bronze) and to the top physics undergraduates of the Universities (silver). This gained considerable publicity in South Australia. Some six meetings with lectures were held during the year. The Education subcommittee is organising production of posters for high school students to advertise physics as a subject of study. The branch is involved in discussions of secondary education policy in SA.

TAS

The Tasmanian branch has suffered the tyranny of distance exacerbated by the travel problems of the past few years. Two meetings were held during the year with Prof D Ivey from Toronto and Prof Roy Chisnall from England. A Professional Development Seminar for year 11 and 12 secondary physics teachers was attended by 35 people and was a great success.

VIC

The Victorian Branch held 10 meetings with speakers during the year and a visit to the Telecommunications Laboratories. This Branch has been responsible for organising the Physics Congress so much of the branch energy directed to that end. The Physics Lecture series was held with Dr A. Lee and Dr. I. Mclaughlin speaking on the "Physics of Music". The Education subcommittee is very active with participation in competitions, education policy discussions and the production of the questionnaire.

WA

Four meetings with speakers and the usual Yankeefest conference for postgraduate students were held during the year. The Youth Lecturer was Prof Robert Clark from the University of NSW who spoke to audiences in Perth and Geraldton. The branch has held a successful schools quiz night for several years, attended by a large noisy audience who thoroughly enjoyed the night. A careers night was held for physics students to discuss prospective employment.

Fix or Physics

The editorial board requires short, illustrated articles for publication in our education supplement Fix-on-Physics. Articles, hints, ideas for experiments and discussion of material relevant to teachers and students of year 11 and 12 physics are sought. Please send all contributions to the Honorary Editor (see address on Contents page).
Sound Production and Hearing in Diverse Animals

Neville H. Fletcher
Research School of Physical Sciences, Australian National University, Canberra, Australia

The vocal signals by which communication is achieved between members of the same species show remarkable similarity for animals as diverse as cicadas, frogs and humans. Likewise the auditory systems of these animals, although superficially very different, are all variations upon a single basic design. Some of these matters are discussed in detail and an explicit scheme for the analysis of auditory systems is given.

Introduction

Although modern acoustics is very much concerned with the behaviour of the human auditory system and with human vocal organs, it is not often that we stand back and take a much more generalised look at hearing and sound production in a large class of different animals. Certainly much of the classic work on human auditory systems relied heavily on studies of cats and guinea pigs, but in those cases similarity is quite close.

What I would like to do here is to explore, much more generally, hearing and sound production in animals as diverse as humans, frogs, cicadas and crickets. I will take a physicist's approach and ignore biological niceties in order to present a coherent picture.

First let us note a few unifying principles which seem to apply to nearly all animals. The first is that sound production and hearing have developed essentially as a means of communication between members of the same species. Of course hearing also serves to give warning of the approach of predators or other dangers and vocal sounds can be used to frighten off intruders of other species, but that is not the primary evolutionary purpose of these physiological abilities.

The consequences of this communication function among members of the same species are several. In particular it leads to vocal and auditory capacities which are closely matched in frequency bandwidth and in time resolution. It also requires that each species develop a coding in the emitted sound which makes recognition of the species simple, and a further coding which conveys efficiently the desired information. There is remarkably little variation in the way in which this is done over the whole range of vocal animals.

Further, since a primary purpose of communication is social contact, all auditory systems possess some form of directional discrimination as well as an obvious intensity discrimination.

At first sight the principles used appear to vary widely from one animal type to another, but we shall see that, rather surprisingly, most systems are actually variants of a particular generalised acoustical design with some features exaggerated and others suppressed.

Sound Production

For our present purposes, animals (and we are thinking here of land-dwelling animals) can be divided into two classes: those with lungs and those without lungs. All the larger animals, and in particular all the vertebrates, fall into the first class, while small animals such as insects may belong to the second class, which obtains its bodily oxygen needs by slightly forced diffusion along a series of tubes let into the side of the body.
An animal with lungs, though it may make sounds in a variety of ways, always produces its primary vocal sounds pneumatically by using air released from the lungs under pressure. Animals without lungs do not have this option and must produce sound by musculature excited vibration. Let us discuss this second class first.

There are two common ways in which sound can be excited efficiently by muscular effort. Each involves a resonant structure and an exciting mechanism. In the first strategy the exciting mechanism is a sharp pic which is drawn across the ridges of a file-like structure to produce a train of regularly spaced excitation pulses. If the pic, or more usually the file, is closely coupled mechanically to a plate or membrane with a resonance frequency equal to that produced by the motion of the pic across the file, then a vibration of large amplitude will be generated and, if the vibrating structure is not too small compared with the wavelength of sound in air, efficient sound production will occur.

This mechanism, which is used by crickets and similar insects, already meets the communication needs of the animal. The song is based on a well-defined carrier frequency, that of the plate resonance, and consists of "syllables", one for each scrape of the pic across the file, as generated by a wing or leg motion. The information content of the song can be varied by changing the number of syllables in a "word" or by changing the repetition rate of syllables.

The other common mechanism, used by cicadas and similar insects, involves a ridged plate or tympanal closing the top of an air-filled cavity to produce a simple resonant structure. If the plate is distorted by muscular effort then it buckles progressively in a series of pulses related to the ridge spacing. If the pulse rate is equal to the cavity resonance frequency then sound is generated efficiently. The same coding possibilities exist. A typical example is shown in Figure 1.

For obvious reasons of efficiency both these mechanisms suggest the use of progressively higher frequencies for smaller insects, and this is what is observed in practice. For insects a few centimetres long, the song carrier frequency is typically in the range 3 to 5 kHz, and the syllable repetition rate perhaps 200 Hz. A remarkable amount of energy is often put into the production of the song - a continuously singing cicada may typically radiate 1 mW of acoustic power, which is comparable with the power of the human voice.

In insects the song serves primarily as a mating call and only the males have vocal organs. An interesting extreme case is the green Australian hedge cicada Cystosoma saundersii. The male of the species has an enormous air-filled abdomen, about 4 cm long, which serves entirely as a resonator for the song, which has the unusually low frequency of 800 Hz with a 40 Hz syllable rate.

When we examine the production of sound by pneumatic power we find that just one mechanism is used. If the
air passage is obstructed by a flap of cartilage, or by a pair of such flaps closing together, arranged in such a way that air pressure in the lungs will blow them open, then this simple system constitutes a pneumatic oscillator. Its operation is exactly similar to that of the lips in blowing a "raspberry", and the frequency of oscillation is just slightly above the natural resonance frequency of the vibrating flaps. The existence of a cavity on the air supply side of the system is crucial to the operation of the oscillator, as is the direction of opening of the flaps - a system with a flap blown closed like the reed of a clarinet operates in an entirely different way and, for the present purpose, unsuitable way.

This pneumatic oscillator is called a larynx, and systems of this type are found in humans, dogs, frogs and even (though in a modified and dual form) in birds. Although the larynx motion may be not far from sinusoidal, the air flow through it has a strongly pulsed character and produces an exciting richness in harmonics.

It is clear that, once again, we have a vocal sound based upon a more or less regular carrier frequency, the basic oscillation frequency of the larynx. In humans this frequency itself carries valuable information - it is around 150 Hz for adult men, around 300 Hz for women, and 400 Hz or more for children.

Human speech obviously has a rich acoustic structure. Not only is the larynx sound broken up into syllables and words by changing air flow, but the distribution of energy in the upper parts of the rich pulse spectrum is varied by manipulating the frequencies of the first three resonances of the pipe-like vocal tract leading to the open mouth, by changing lip, tongue and mouth shape. The "formant" resonances are nominally around 500, 1500 and 2500 Hz, as we would expect for the impedance maxima of a cylindrical tube about 15 cm long, but can be shifted quite significantly to produce different vowels as shown in Figure 2. Human speech also involves assorted hisses and clicks but the important part of the speech spectrum runs from about 300 Hz to 3 kHz. There is not a great deal of radiated energy at the larynx fundamental and in any case it is possible to deduce what its frequency is from the regular frequency spacing between successive harmonics.

Once again there is a correlation between larynx frequency and size in different animals but, since vertebrates change size significantly during their lives, this frequency is not of dominant importance for species recognition. Instead, reliance is placed upon other features of the rich vocal sound. Some more primitive animals, however, have quite sophisticated "built-in" coding. An example is the frog, some species of which have two sets of vocal flaps, in series, one with a frequency around 100 Hz and one with a much higher frequency, say 2 kHz, giving a sound quite closely related to that of an insect.

In humans, of course, the larynx frequency can be varied by a factor of 4 or more in the artificial activity of singing, while birds do this as part of their normal vocalisation. Other pneumatically generated noises such as whooshes, which are generated by the interaction between an unstable air jet and a resonant cavity, can be used as parts of a song or speech but these are generally not the basic speech sounds of a species.

**Auditory Systems**

The basic requirement of an auditory system is that it be sensitive to sound pressure over the frequency range characteristic of the song or speech of the species and that its internal mechanism converts the air pressure variations associated with the sound into mechanical displacement of some internal structure to which nerve-cell transducers are attached.

Some animals, such as caterpillars, have sensory hairs which perform a similar function in relation to the acoustic velocity signals produced by the beating wings of predators, but essentially all genuine auditory systems seem to rely upon taut diaphragms as the primary transduction mechanism from acoustic pressure to mechanical vibration. The diaphragm or tympanum may be assisted, as we see later, by various resonators, couplers or phase shifting networks depending upon particular features that evolutionary processes have emphasised, while the complexity of the mechanical-to-neural transducer varies greatly with the sophistication of the vocal code of the animal concerned.

The upper part of Figure 3 shows a generalised auditory system from which we can consider all real animal auditory systems to be derived by suppressing one or more features. Interestingly, all the features shown are present in the auditory systems of higher mammals, including humans, but the Eustachian tubes which connect the cavity behind the tympana to the rest of the system are so narrow relative to the size of the tympana that effectively no sound energy travels along them and the system behaves like two isolated simple ears. In this and all other systems we assume that a neural transducer is connected to each tympanum to convert its motion to nerve impulses, but we forego any consideration of detail.

The isolated ear of the mammalian auditory system has a simple acoustic function, at least in outline, though its performance is rich in detail at higher frequencies. The pinna provides an acoustic pressure gain of 10 to 20 dB at frequencies above a few kilohertz, depending on shape and size, but the gain falls to not much above 0 dB below a few hundred hertz because of the transmission behaviour of finite flared horns. The tympanum itself is typically a tensioned conical membrane with a resonance frequency around 2 kHz, near the middle of the hearing range of interest. The Q value is typically less than unity, say about 0.5, so that its frequency response is broad. Taking account of the performance of the horn-like pinna we therefore have a system with a fairly flat frequency response from around 1 kHz to 3 kHz, with a

---

**Figure 3** A generalised model auditory system from which most other systems can be derived. In mammals the Eustachian tube is so narrow that the system functions as two independent ears. In simpler animals there is generally an acoustic coupling between the two ears but some other features of the generalised system may be missing.
decreasing response below 1 kHz because of the combined effects of horn cut-off and tympanum resonance, and a decreasing response above about 5 kHz because this is well above the tympanum resonance. Actually the sensitivity of the human ear is much less than would be predicted by this model below 100 Hz and above 10 kHz but this is undoubtedly due to evolutionary limitations on the neural transduction mechanism rather than to simple acoustic response.

The directional discrimination of a single mammalian ear is influenced both by the geometry of the pinna, which tends to emphasise high frequency sounds incident from along the direction of its axis, and by diffraction around the head, which produces directional maxima and minima in a more complicated way, though again favouring incidence from the ear direction. On top of this there are other complications caused by the convoluted shape of a typical mammalian pinna and, of course, the subtle psychophysical correlations between the inputs of two independent ears that are made possible by the sophistication of the mammalian brain.

**Coupled Ears**

In all the other animals I will discuss here, the acoustic pathways between the two ears are sufficiently open that we must consider them in combination. It is interesting that this is the situation in the lower animals whose response to auditory stimuli is much simpler than in mammals. By evolutionary chance it proved more appropriate to rely upon increased acoustic sophistication at the auditory periphery rather than to undertake more complex neural processing.

The simplest auditory system is that belonging to the frog, as shown in Figure 4(a). The tympana are simple extensions of the outside skin of the head, and short wide Eustachian tubes lead directly from the ears to the mouth cavity. By chance the geometry of the auditory system of insects like the cicada, as shown in Figure 4(b), is very similar, though in this case the tympana and the cavity are located in the abdomen and the cavity has no other function. Acoustic analysis of this sort of system is quite straightforward, both in relation to frequency response and to directional discrimination. While diffraction around the body of the animal will certainly have some effect, this is relatively minor compared with the effect of phase differences between the sound pressure at the two tympana for various incidence directions.

Since the cavity is reasonably large, though small in dimensions relative to the sound wavelength involved, it behaves as a simple acoustic compliance, and the tympana have maximal response near their resonance frequency, which we would expect to be tuned to the carrier frequency of the song of the species, about 1.5 kHz and 5 kHz respectively for these two cases. It turns out from the analysis that two ears coupled by a cavity in this manner can have a cardioid response with a directional discrimination of nearly 20 dB if the Q value for the tympana is appropriately chosen. For a typical frog-like case the appropriate value is around 4, which implies that the bandwidth of the system will not be large. This is, of course, exactly what is required, given the simple amplitude-modulated nature of the frog's song. An exactly similar conclusion is reached in the case of the cicada.

Since the primary purpose of the song of both male frogs and cicadas is to attract females while keeping males of the same species at a distance, this directional discrimination and frequency specificity has obvious behavioural importance. All the females have to do is to respond to the carrier frequency, check the modulation identification, and then hop in the general direction of the ear giving the stronger signal.

Birds are clearly more sophisticated animals than frogs, and most species have a complicated song which covers a reasonably wide frequency range, generally starting above about 500 Hz. It is interesting, therefore, to note the rather simple acoustics of the auditory system, a design shared with some reptiles, thus indicating their common ancestry. This is shown schematically in Figure 4(c).

At the frequencies involved in birdsong, the length of the auditory canal is not small compared with the wavelength of sound and it is therefore necessary to be rather more sophisticated about the acoustic analysis. Not only must wave propagation along the canal be considered, but also attenuation of those waves through wall effects.

Once again it turns out that the response for the ear facing the sound source is greatest near the resonance frequency, but it also tends to be large near the frequency at which the canal length is one quarter of a wavelength, so that if these two frequencies agree the effect is maximal. It also happens that, at this special frequency, the response of the ear facing away from the sound can actually be brought to zero by proper choice of the loss in the canal and the Q value of the tympana. Around this frequency the response is cardiod while for higher or lower frequencies the directional pattern is less asymmetric. Of course we would not expect a real system to behave in exactly this way, but the qualitative behaviour should be very similar to that calculated.

Finally we see in Figure 4(d) a representation of the auditory system of the cricket. As in mammals it is associated with the respiratory system but, since the cricket is an insect, this system has a very different structure. The auditory system is located in the first pair of legs of the animal. Each leg contains a large tracheal tube connecting to a more or less open spiracle in the prothorax, and this trachea has a thin-walled tympanum (or rather a pair of tympana) in the leg wall just below the knee. The two tracheae are connected by a

---

**Figure 4** Specialised forms of the general model auditory system. (a) In the frog the tympana connect directly to the mouth cavity through short Eustachian tubes; (b) the cicada has a similar system but the cavity is in the abdomen; (c) the bird has a simple constricted canal connecting the two tympana; while (d) the cricket has a tubular tracheal system with tympana on the legs and open spiracles, the geometry of which varies from species to species.
short tube which generally has a central septum.

Different species of cricket have different aspects of this geometry exaggerated. In some the spiracles are large and wide open and the tracheae have the form of flaring internal horns with little interconnection. In other species the tracheae are nearly cylindrical, the spiracles are small and partly covered, and the interconnecting tube is short and wide with a thin septum. Analysis of such systems with their multiple points for sound entry and multitude of unknown parameters is a complex exercise. In particular the narrow tracheae have considerable wall loss and, since the sound wavelength at 5 kHz is small compared to the size of the animal, the effect of the legs can be important. Again however it seems clear that this system can provide substantial directionality of response.

As in man, it turns out that the neural response of many of these animals is much more restricted in frequency than we would expect from simple acoustic analysis. Such neural frequency selectivity is by no means unexpected but its mechanism is as yet obscure to those neurophysiologists studying the problem.

**Conclusion**

We have seen that systems for sound production and hearing in the animal world appear to have a common origin and a common purpose, though the reasons why they have developed show a great diversity. Understanding the acoustics of these systems is, of course, only the beginning of the story, and the interplay between the animal and its environment is important. The acoustics of these systems is, of course, only the beginning of the story, and the interplay between the animal and its environment is important. The acoustics of these systems is, of course, only the beginning of the story, and the interplay between the animal and its environment is important. The acoustics of these systems is, of course, only the beginning of the story, and the interplay between the animal and its environment is important. The acoustics of these systems is, of course, only the beginning of the story, and the interplay between the animal and its environment is important.

Now we put the tympana across the ends of the tube, noting that this means that the acoustic flow through each tympanum is equal to that into the associated tube end. If $p_1, U_1$ and $p_2, U_2$ are acoustic quantities for the left and right ears respectively, then

$$p_1 = (Z_{11} + Z_i)U_1 + Z_2 U_2$$

$$p_2 = Z_1 U_1 + (Z_{22} + Z_i)U_2$$

If sound comes from a direction at an angle $\theta$ to the left of straight ahead, then there is a phase delay at the right ear given by

$$p_2 = p_1 \exp \left[ \frac{j (\omega t/c) \sin \theta}{2} \right]$$

and, using the symmetry relations in (4) and (5) in (6) and (7), we easily find the response of the left ear to be

$$U_{1L} = (Z_{11} + Z_i) U_{12} \exp \left[ -j (\omega t/c) \sin \theta \right]$$

$$p_{1L} = \frac{Z_1}{Z_{11} + Z_i}$$

The linear motion of the left tympanum is given simply by

$$\chi_L = -j U_{1L} / \omega A.$$  

This response is greatest at the frequency for which the denominator of (9) is smallest, which is a compromise between the resonance frequency of the tympanum $(Z_{11}/Z_i)$ and the half-wave resonance of the tube $(Z_{11}/Z_{12})$. Directional response is greatest for sound from the left $(\theta = 90^\circ)$ and can be made to vanish at one particular frequency by appropriate choice of the damping coefficients $R$ and $\alpha$.

In general there will be a response minimum for the left ear for sound coming from somewhere to the right of the animal $(\theta > 0)$ but this will not be an exact null. Figure 5 shows calculations for a realistic case. The system therefore shows some useful frequency discrimination and directionality.

Exactly the same analysis can be used for cavity-coupled ears, such as those of cicadas and frogs, at frequencies for which the distance between the ears is only a small fraction of a wavelength.

In this case

$$Z_{11} = Z_{12} = -j \rho c \nu / V_0$$

where $V$ is the volume of the cavity. The frequency response and directionality are similar to those of the tube coupled ears provided the cavity volume is appropriately chosen.}

*Continued on page 7*
A Partnership Model For The Twenty First Century - A Pilot Programme

Barbara J. Lynch
Wesley College, Glen Waverley, Melbourne, Australia

In an attempt to forge strong links between Wesley College Melbourne (Glen Waverley Campus), business and industry, an innovative partnership programme with CR Limited has been designed and implemented. It is suggested that the development of this partnership will establish a pattern for broader cooperation involving many of the nation's businesses and schools and so enhance the education of young people towards the Year 2000. Such partnerships are seen to be mutually beneficial to the College and to Industry. After the first year, evaluations have shown that students, staff and parents of the College as well as staff in CRA Ltd count the partnership as very successful.

Introduction
Wesley College is an independent, coeducational, multi-campus school. It encompasses three educational sites and two outdoor recreational properties. The student population currently numbers 2,600 and there are 250 teachers. By the year 1992 it is planned that numbers of students will exceed 3,000. The Glen Waverley Campus of the College is currently a Beginners to Year 10 campus of approximately 1,100 students. A new Senior College for Years 11 and 12 will open in 1992.

In Australia there are indications from business and politicians that education should provide more opportunities to develop enterprise, flexibility and skills. The College saw the potential for educators to work closely with business and industry and has been able to initiate such a partnership. By its nature, a partnership must be beneficial to both parties. Such an association can be a very powerful force. Since this proposal was seen as breaking new ground, the College was mindful of the need to begin with a number of carefully chosen initiatives. These would produce little disruption to the company's operations and yet would provide valued enhancements to the students' education. Many of the activities lend themselves to the Primary area in particular, the years when conceptions of Science, Mathematics, Technology and Industry are formed.

It was agreed that if it were successful, the partnership, model developed and the associated benefits would be in general transferrable and available beyond Wesley College. It was also suggested that CRA could well benefit from extending the model to schools in states where the company has a high profile, in say, the mining industry. This would enhance CRA's image in the community, particularly if it were part of an integrated education policy.

Activities
The programme has four major thrusts.

Scientist/Technologist-Residence Programme
Wesley College Glen Waverley began this programme in 1987. The objective was to allow the students to meet with working scientists and technologists from a number of discipline areas, see and work with their equipment and measuring devices, discuss the nature of their work. In this way the students gained a great insight into the nature of these different discipline areas. This programme was followed by a Career Panel discussion in which students could gain information about their own future career paths.

CRA has provided personnel for the Scientist-in-Residence programme in the areas of Technology and Industrial Design, Physics, Chemistry, Mathematics, Computer Science, Geology and Engineering. The time commitment was a total of 1 day per year for 4 scientists and 1 evening per year for 8 scientists.

Professional Development of Wesley Staff
The new courses which are being designed for the final two years of schooling in Victoria under VCE are putting a deal of emphasis on placing the central and related ideas into context. Teachers have little experience of such contexts and hence value the opportunity to visit appropriate sites and to discuss aspects of the course content with experts in the field.

Individuals or groups of teachers visit various CRA operations and discuss the nature of these operations with CRA personnel. CRA personnel provided valuable insights into the more complex areas of the new curricula. The time commitment was not onerous since CRA judged each application on its merits.

Equipment, Specimens, Posters and Photographs
In order to provide adequate hands-on experience to its students, a school needs a deal of equipment, much of which may be regarded by industry as rather unsophisticated. At the same time, the school needs enough pieces of such equipment to cater for a whole class. Equipment such as a discarded circuit board (operative or inoperative) can be a valuable teaching tool. The same applies to such items as electron guns from broken oscilloscopes, analogue meters which have been replaced by digital ones, or examples of ore samples. In fact, there are many examples of items which an industry would discard but which a group of students could use to extend their knowledge and understand of a subject. Similarly, posters for classrooms help to enhance the learning environment and photographs or slides can be used in the learning process.

It was proposed that CRA offer discarded and even broken equipment as well as ore samples, posters and photographs to Wesley College students to be used to enhance their learning. Staff of CRA needed to be sensitive to the possible use of discarded equipment but there would be little cost to the company.

Student Work Experience
Wesley's broad-based curriculum model means that
students are given the opportunity to study not only core subjects such as English, Mathematics, Science, Social Education, Informational Technology, but also Creative and Visual Arts and Communication Subjects. Choices of subjects which will influence their future careers are not made until the end of Year 10. Thus, it is important that students have access to as much information as possible prior to making this crucial subject choice. One way in which students may gain real information for career choice is through work experience. CRA offered work experience to a small number of selected Year 10 students.

**Evaluation of Programme**

It was considered essential that an evaluation procedure be integral to the pilot programme. Only then could the model be developed and modified and generalised. The evaluation aimed to provide information on the following:

- Did the students/teachers enjoy and gain value from the sessions?
- Was the content appropriate and relevant?
- Were the logistical details satisfactory?
- Were teachers and presenters adequately briefed?
- Should the programme be continued?

Classroom observation, questionnaires and comments were collated from students, teachers and parents. CRA Limited also devised evaluation questionnaires for its participants. The criterion for success was that 75% of returns should show unconditional satisfaction.

As a result of this evaluation, it was agreed by both Wesley College and CRA Limited that “the first twelve months of the cooperative programme had been a success”. Staff were keen to be involved, their enthusiasm did not waver and all benefited from their individual contacts.” It was also agreed that the programme should continue for another 12 months and that during that time there should be an increase in the numbers of student contacts with industry and an increase in the number of staff visits. The only concern expressed about the programme was that it depended heavily on goodwill and commitment of already busy staff in each organisation to spend the extra time needed to ensure success.

**Conclusion**

Education and the economy are closely linked. A thriving economy can only exist when the education system addresses the challenge of a changing world environment. Whether the changes be in the technologies we use, the business practices we employ or our trading partners, it is the future generation of young people who will be called upon to respond.

Australia’s future economic performance will depend on how effectively its human resource base is developed. There is much evidence that Australia needs a greater range and depth of skills in leadership, management and industrial relations to be competitive in the modern economic world. Young Australians need to understand work ethics, to be creative, able to seize opportunities, take risks, discover niches and enhance their flexibility.

Partnerships such as that described can only help towards the achievement of these goals.

**Acknowledgments**

I wish to acknowledge the great assistance of the Head of Science at the Glen Waverley Campus, Mrs D. Dunwoody, without whose dedication and commitment, this programme would not have been the resounding success that it was. I also acknowledge the work of Mr Kevin Collins at CRA Limited who directed the traffic within the company.

---

**Bibliography**

[This section would contain a list of references and sources cited in the text.]

**Figure 5(b) Calculated polar response of the left ear at 3kHz and 4kHz. The straight-ahead direction (\( \theta = 90^\circ \)) is upwards on the page. [From Fletcher & Thwaites 1979]**

**AN OFFER TOO GOOD TO REFUSE!**

You too can become a member of the Australian Institute of Physics! You will also receive your own copy of the Australian & New Zealand Physicist which includes regular supplements of Fix-on-Physics. Remember, membership fees are tax deductible. Contact the AIP Registrar: Dr. Robert Leckey, Physics Department, LaTrobe University, Bundoora VIC 3083.

All information contained in this supplement may be copied and used in a teaching situation without permission from the Australian & New Zealand Institutes of Physics.
A Computer Interface designed especially for the Physics Teaching Laboratory.

The Series 6500 from PASCO scientific

There are many reasons why this interface should be in your school laboratory, including:

- **Real Time Interface**— Connects directly into your computer buss. You observe data instantaneously as the experiment unfolds, just like with an oscilloscope.

- **Optional Power Amplifier**— Turns your computer into a function generator and a low voltage power supply. You use your computer to control the experiment as well as to monitor the results.

- **PASCO Quality**— Physics education has been our only business for over 26 years. As a designer and manufacturer, we carry over 550 quality products for your physics teaching laboratory.

For more information: FAX 1-916-786-8905

---

For IBM® and Apple II® Computers (and compatibles)

Only

AU$1,011*  NZ$1,418*
PHYSICS ENROLMENTS IN AUSTRALIAN SECONDARY SCHOOLS
Trends & Implications

JOHN DE LAETER & JOHN DEKKERS

A recent survey of physics enrolments in Australian Universities (Jennings and De Laeter, 1991), showed that third year enrollments have been relatively stable over the period 1968-1990, and that enrollments towards the end of the 1980s had returned to the levels reached in the mid 1970s, after a decline in the late seventies and early eighties. The enrolment trends are similar in all States, and parallel physics enrolment trends in the USA (Ellis and Mulvey, 1989). Sabine (1991) has recently expressed concern over the reasons why such a relatively small number of academically-able secondary school students opt to study physics at the tertiary level.

In the United Kingdom there has been a 4.6% decline in the number of first year University students choosing to study physics in 1990 as compared to 1989. This is a reversal of the steady increase in enrollments that has occurred since the mid-1980s (UCCA, 1991). In 1986 there were 2044 physics entrants as against 2768 in 1990. The UCCA data also reveals a similar enrolment decline in some other science and engineering areas in the U.K., but a marked increase in the European Community student enrolments in physics. A similar trend was noted in 1991 A-level (secondary school) enrolments in which the number of UK students decreased by 4.3% from 1990, despite the fact that the overall number of students sitting A-levels increased by 1.7% in 1991 as compared to 1990 (UCCA, 1991).

A comparison between the situation in University physics and chemistry enrolments is possible since Stern (1991) has recently provided information on the number of third year chemistry students in Australian Universities from 1968-1991. Chemistry enrolments have shown a small but steady growth over this period, from 870 students in 1968 to 1242 in 1991. This represents a growth of approximately 1.9% per year over this period. The number of third year physics students in Australian Universities has averaged 490 per year over the past decade compared to an average of 1063 per year chemistry majors.

The number of students opting to study physics at the tertiary level must be influenced to some extent by the number of students studying physics at the upper secondary school level. It is also of importance to examine enrolment trends for physical science enrolments at the upper secondary school level to provide a quantitative basis for the discussion which often takes place on this topic in scientific, educational and political circles.

J. R. De Laeter is at the Curtin University of Technology, Western Australia, and
J. Dekkers is at the University College of Central Queensland.

Figure 1 National year 12 public examination subjects in chemistry, physics and alternative science (1976-90)

The Table on the next page gives the national Year 12 Public Examination enrolments in physics and chemistry from 1976 to 1990 (Dekkers et al. 1991), and this data is presented graphically in Figure 1. The data reveals that there has been a steady increase in both physics and chemistry enrolments from 1976, but that the increases in physics have not matched the increases in chemistry. An examination of the gender balance in Figure 2 shows that the proportion of males is greater than females in both science subjects, that the proportion of females in both subjects has increased over the period 1976-1990, and that a higher proportion of females opt to study chemistry than physics. However a greater number of males study physics than chemistry, and this has been a consistent feature of the enrolments from 1976 to 1990.

Figure 3 shows the Public Examination enrolments in physics in each State and Territory from 1976-1990. Most of the States show steady increases over this period. The largest enrolments occur in New South Wales and the smallest for the Northern Territory (from which statistics are only available since 1986). Prior to 1977 the Australian Capital Territory enrolments were combined with New South Wales. It should be noted that students in Queensland do not sit for a Public Examination, as ratings are awarded on the...
### PHYSICS ENROLMENTS IN AUSTRALIAN SECONDARY SCHOOLS

#### NATIONAL YEAR 12
#### PUBLIC EXAMINATION
#### SUBJECT ENROLMENTS IN
#### PHYSICS AND CHEMISTRY
#### 1976-1990

<table>
<thead>
<tr>
<th>YEAR</th>
<th>GENDER</th>
<th>PHYSICS</th>
<th>CHEMISTRY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>Male</td>
<td>18656</td>
<td>17562</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>5123</td>
<td>7177</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>23779</td>
<td>24739</td>
</tr>
<tr>
<td>1977</td>
<td>Male</td>
<td>19130</td>
<td>18412</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>5563</td>
<td>8263</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>24693</td>
<td>26675</td>
</tr>
<tr>
<td>1978</td>
<td>Male</td>
<td>19572</td>
<td>18808</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>6131</td>
<td>9303</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>25703</td>
<td>28111</td>
</tr>
<tr>
<td>1979</td>
<td>Male</td>
<td>19663</td>
<td>19060</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>6586</td>
<td>10214</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>26249</td>
<td>29274</td>
</tr>
<tr>
<td>1980</td>
<td>Male</td>
<td>19155</td>
<td>18672</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>6404</td>
<td>10723</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>25559</td>
<td>29395</td>
</tr>
<tr>
<td>1981</td>
<td>Male</td>
<td>18289</td>
<td>17591</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>6230</td>
<td>10512</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>24519</td>
<td>28103</td>
</tr>
<tr>
<td>1982</td>
<td>Male</td>
<td>18693</td>
<td>17973</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>6857</td>
<td>11324</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>25550</td>
<td>29297</td>
</tr>
<tr>
<td>1983</td>
<td>Male</td>
<td>20296</td>
<td>19569</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>7426</td>
<td>12138</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>27722</td>
<td>31707</td>
</tr>
<tr>
<td>1984</td>
<td>Male</td>
<td>20835</td>
<td>19707</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>7483</td>
<td>12234</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>28318</td>
<td>31941</td>
</tr>
<tr>
<td>1985</td>
<td>Male</td>
<td>21128</td>
<td>20519</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>7890</td>
<td>13411</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>28918</td>
<td>33930</td>
</tr>
<tr>
<td>1986</td>
<td>Male</td>
<td>21783</td>
<td>20797</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>7596</td>
<td>13500</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>29379</td>
<td>34297</td>
</tr>
<tr>
<td>1987</td>
<td>Male</td>
<td>22576</td>
<td>21510</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>8308</td>
<td>14614</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>30884</td>
<td>36124</td>
</tr>
<tr>
<td>1988</td>
<td>Male</td>
<td>24919</td>
<td>23415</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>9284</td>
<td>16341</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>34203</td>
<td>39756</td>
</tr>
<tr>
<td>1989</td>
<td>Male</td>
<td>25064</td>
<td>23414</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>10078</td>
<td>16615</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>35142</td>
<td>40029</td>
</tr>
<tr>
<td>1990</td>
<td>Male</td>
<td>25453</td>
<td>23067</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>10455</td>
<td>17530</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>35908</td>
<td>40597</td>
</tr>
</tbody>
</table>

**Figure 2** Male/Female enrolments in Public Examination physics, chemistry and alternative science subjects (1976-90)

The basis of moderated school assessments during the final two years of secondary education. Global enrolment statistics are presented for each State, in that students from both Government and Independent schools have been included.

The national enrolment trends for students in Year 8 and Year 12 for the past two decades are shown in Figure 4. The combined data for all States and the Territories are included, however, the trends are relatively uniform across the country (Dekkers et al. 1991). The bimodal distribution for the Year 8 enrolments depicted in Figure 4 has enrolment peaks in 1975 and 1984. The Year 8 enrolment in 1990 is approximately the same as in 1971-1972. On the other hand the Year 12 enrolment pattern is distinctively different in that, after a relatively steady growth from 1970 to 1977, enrolments were roughly constant from 1978-1982.

**Figure 3** State and Territory Public Examination enrolments in physics (1976-90)
PHYSICS ENROLMENTS IN AUSTRALIAN SECONDARY SCHOOLS

Figure 4 National enrolments for Year 8 and 12 Secondary School students (1970-90)

followed by a dramatic growth from 1983-1990. The Year 12 enrolments in 1990 were 2.6 times the number in 1970, whereas the overall growth in Year 8 enrolments from 1970 to 1990 was only 3.2%.

To understand the reason for these trends, the nature of the retentivities over the last two decades must be examined. Until 1975, the male retentivity from Year 8 to Year 12 was always greater than the corresponding female retentivity. In 1976 the retentivities for males and females were approximately equal at the combined value of 35.3%. However since 1976 the female retentivity has exceeded the male retentivity, and the gap has continued to widen, so that in 1990 the female and male retentivities were 69.8% and 58.2% respectively. The constancy in Year 12 enrolments from 1978-1982 was caused by the increased retentivity of females being balanced by a decreasing retentivity of males. However since 1983 the retentivity of both genders has progressively increased, until the combined figure in 1990 was 64.0%. It is obvious that in any year the national enrolments at Year 12 are influenced by the national enrolments at Year 8 which occurred four years earlier. As Figure 4 shows, the enrolments in Year 8 have been decreasing since 1984. Therefore if Year 12 enrolments are to continue to increase, there must be a further increase in retentivity to compensate for the lower number of students available to proceed to Year 12.

In terms of the proportion of students at Year 12 studying physics, there has been a considerable decline over the period 1970-1990. For example in 1980 28.9% of the Year 12 population studied a Public Examination physics subject, whereas in 1990 the corresponding proportion was 21.2%. The corresponding proportions for chemistry were 33% and 23.6% for 1980 and 1990 respectively. Dow (1971) noted this effect in an examination of science enrolments in the 1960s, whilst De Laeter et al. (1980) reported a similar trend for physics in the 1970s. Thus the decline in the proportion of students opting to study Public Examination Physics is a long-term phenomenon.

However there are a number of factors which need to be taken into account in assessing the reasons for this trend in physics enrolments:

- The retentivity in student numbers from Year 8 to Year 12 has more than doubled in the period 1970-1990. This means that the Year 12 cohort now comprises students with a much wider range of ability than in the past, not all of whom are suited to study a Public Examination Physics subject.
- The dramatic increase in female retentivity over the past two decades has been the most important factor in the changing mix of Year 12 enrolments. Since the proportion of females opting to study physics is low, this inevitably leads to a declining proportion of Year 12 students studying physics. However it is noted that the proportion of females studying Public Examination Physics has increased from 21.5% in 1976 to 29.1% in 1990.
- The introduction of “alternative” science subjects has provided students with another option for studying science at the upper secondary level. This is demonstrated in Figure 1 where the data reveals that alternative science subjects have become increasingly popular since their introduction in 1979. Figure 2 shows that these subjects are studied by a greater proportion of females than is the case for physics. Furthermore many of these alternative science subjects contain a significant amount of physics oriented material. For example, Physical Science which comprises both physics and chemistry content, is available in the ACT, Victoria and Western Australia, and in 1990 the subject had a total enrolment of 1004 students. General Science is a subject available in the ACT, Queensland and New South Wales with a total student enrolment of 9872 in 1990. There are also a number of alternative science subjects in the ACT which contain a significant amount of physics. Enrollment details of these alternative science subjects are given by Dekkers and De Laeter (1992).
- The introduction of a number of school assessed science subjects, which are taken by students who do not wish to study a Public Examination science subject. Data listed by Dekkers et al. (1991) indicate that over 8000 students were enrolled in these science subjects in 1989 and that approximately 45% were females. The prominence of these subjects has increased significantly since 1985 when only approximately 4500 students were enrolled. Whilst it is true that the physics content of these school assessed subjects may not constitute a large component, nevertheless an increasing number of upper secondary school students are being exposed to some physics-oriented material.
- A comparison with the Year 8 cohort reveals that there is a greater proportion of Year 8 students studying a Public Examination Physics subject at the end of the 1980s than two decades ago. In fact 9.8% of the Year 8 cohort studied a Public Examination Physics subject in 1976 as compared to 13.5% in 1990. There was a decline in the proportion in some States in the 1970s, but the last decade has seen a significant increase in the proportion of the Year 8 cohort who study physics in Year 12. If Alternative Science subjects which contain a significant amount of physics are included in the evaluation, the increase would be even more pronounced.

One of the most important issues facing Australia today concerns the question of how to become part of the post-industrial revolution which has swept the Western World in the last 25 years. Whilst many developed countries have become participants in this technological revolution, Australia has become an end-user of technology and is increasingly dependent on overseas products. Australian society has, by and large, failed to understand the forces of technology that are at work in the world today, and how to adapt educational, political and commercial thought to meet this challenge. Lowe (1991) has pointed out that society has always been significantly shaped by technology, and that we live in a world in which scientific progress and the spread of new...
Postdoctoral Research Associate

The Applied Optics Centre is a joint research institute linking the Department of Physics and Electrical Engineering at the University of Auckland, which performs research and development in various areas. The Centre seeks to appoint a research associate to assist with industry funded research and development, and to contribute to the established research programme in nonlinear fibre optics and laser physics. The position, which is tenable for two years will also involve some limited teaching duties in the Physics Department.

Applicants should have a PhD degree in some area of experimental laser physics or optics, and should send a letter of application and resume, including the names of three referees to:

Professor J. D. Harvey
Physics Department
University of Auckland
Private Bag 92019
Auckland
New Zealand

Fax: +64-9-373-7445
e-mail: jdh@phyvc.auckuni.ac.nz
from whom further details can be obtained.

The position is available from 1st October and applications received before 1st September will receive full consideration.

Acknowledgements

The authors would like to thank the Educational Authorities from the various Australian States and Territories who have provided the data on which this article is based. We would also acknowledge discussions with Associate Professor J.A. Malone. We would like to thank Mrs L. Dale for typing the manuscript.

References


Lowe, I. (1991), Seljos 26:2


188

Australian & New Zealand Physicist Volume 29, Number 8, August 1992
New Thermocouple Monitor

The new model SR630 thermocouple monitor from Stanford Research Systems provides 16 independent input channels, each separately configurable for 7 different types of thermocouple or as a DC microvoltmeter. The front panel reading for each input can be displayed with 5 digit resolution in Celsius, Kelvin, Fahrenheit, millivolts or volts.

Measurements are made 12 times per second and digital filtering is used to reduce noise. Up to 16 channels may be sequentially scanned with dwell times of 0.5 to 9999 seconds. Programmable audible alarms for each channel alert the user to exceed temperature deviations and a rear-panel relay is closed with the alarm to provide a shutdown capability.

Standard IEEE-488, RS-232 and printer ports provide fast and easy communication with computers and printers. The printer interface supports two types of output - a continuous graphic strip chart and a data printout which logs the time, date and temperature or voltage for each scanned channel. Four rear-panel outputs are included which provide voltages proportional to the temperatures of the first four input channels.

Model SR720 LCR Meter

For more information, please contact:
Paul Wardill
Coherent Scientific Pty Ltd
116 Burbridge Rd
Hilton SA 5033
Phone (08) 352 1111
Fax (08) 352 2020

New LCR Meters

Stanford Research Systems have released two economical LCR meters for fast and accurate measurement of inductance, capacitance and resistance at test frequencies up to 100kHz. Measurement accuracy is 0.05% for the model SR720 and 0.2% for the lower priced model SR715.

Five selectable measurement frequencies, drive voltages from 0.1 to 1.0 volts and internal or external DC bias provide the flexibility required to measure a wide range of components. Measurement rates of 2, 10 and 20 per second are available and up to 10 measurements may be averaged to yield a single result. Measurements can be continuous or triggered from a front panel keypress, a computer interface command or a parts handler. Binning of measurements is provided and up to nine different instrument configurations may be stored in non-volatile memory. The RS-232 interface is standard and the IEEE-488 interface is available as an option.

The instruments include a built-in Kelvin test fixture ensuring accurate measurements. Fixture compensation is performed quickly and easily from the front panel and adapters are available to allow measurement of almost any component.

With prices starting below $1900, the SR715 and SR720 meters are ideally suited for laboratory, engineering and production environments.

For more information, please contact:
Paul Wardill
Coherent Scientific Pty. Ltd.
116 Burbridge Rd
Hilton SA 5033
Phone (08) 352 1111
Fax (08) 352 2020

Handbook of Chemistry and Physics
73rd Edition

CRC Press has just published the 73rd edition of its bestselling title "CRC Handbook of Chemistry and Physics".

This up-to-date source of reliable information provides a broad range of critically evaluated data in a convenient one-volume format. The editors have aimed to provide the most accurate information available.

The Editorial Advisory Board of world-renowned experts plays a crucial role in ensuring that the "Handbook" adequately addresses the needs of their respective fields and that the data is absolutely up-to-date.

Also, extensive references direct you to other compilations or databases that contain additional information.

This edition features 33 new or completely revised tables, comprising some 230 pages. Indexes have been reformatted for easier use and the volume is in a larger format with 100 more pages than the previous edition.

New topics featured are thermodynamics and atomic and molecular properties. This includes thermodynamic properties as a function of temperature, enthalpy of combustion, fusion and vaporization, heat capacity of liquids and gases at 25°C, and viscosity of aqueous solutions.
Other fields of importance are organic and inorganic compounds, biochemistry and nutrition, analytical chemistry, nuclear physics, polymers, geophysics and astronomy, and health and safety guidelines.

This excellent publication is available through CRC's Australasian agent, D A Books and Journals, 640 Whitehorse Road, Mitcham, VIC 3132 Phone (03) 703 4411 Fax (03) 873 5679 •

**PRODUCT NEWS**

If you need fast and flexible beam characterisation of lasers, laser diodes, fibre optics or other light sources, call us at Spectra-Physics for complete details of Big Sky systems.

**New Optics from Spectra-Physics CAG**

The new Components & Accessories Group at Spectra-Physics (formerly Spectra-Physics Optics Corporation) have released several new optics with exceptional performance. These include:

- Routing Optics for Pulsed YAG, YLF lasers; super high damage threshold dichroic mirrors and beam splitters for 2nd, 3rd & 4th harmonics.
- Ultra-low dispersion Ti:Sapphire routing mirrors
- Graded reflectivity Optics: now available to laser system designers for the first time. Improves laser performance by minimising edge diffraction effects & maximising laser mode volume in gain media.

Call Spectra-Physics to discuss custom design capabilities.

**Dewpoint Monitoring**

The Vaisala high temperature dewpoint monitoring system reduces the energy consumption of dryers and improves product quality.

ECON 200 is a system for measuring dewpoint and humidity. ECON 200’s dewpoint temperature accuracy of ±0.5°C, wide operating temperature range of 0...150°C, and its rugged construction make it ideal for monitoring process conditions in paper machine hoods and other such demanding applications. With accurate dewpoint measurement and control, product consistency and quality improves, and energy intensive equipment can be operated more efficiently.

ECON 200 consists of three parts:
- Dewpoint probe which contains Vaisala’s DEWCAP™ sensor, and two process temperature sensors.
- Service unit which cleans the sensor at regular intervals
- Control and interface unit which reads the signals, controls the service unit and calculates the relative humidity and mixing ratios.

The new Vaisala DEWCAP™ sensor measures dew formation via changes in surface acoustic wave frequency. The sensor is not susceptible to corrosion or acids, and the cleaning process prevents dust and other impurities from affecting the sensor’s accuracy or reliability.

For further information, please contact

Vaisala Pty Ltd
ACN 006 500 616
Unit 4, 8-12 Sandilands Street
South Melbourne VIC 3205
Phone (03) 696 5699
Fax (03) 696 5776
Toll Free (008) 33 5840 •

**Big Sky Automated Beam Analysis Software**

Spectra-Physics are pleased to announce their appointment as exclusive Australian distributors for the range of automated laser beam diagnostic and analysis systems from Big Sky Software Inc of Montana, USA. Their Beamcode and Beamview packages provide complete solutions to the problem of monitoring beam spatial intensity via innovative hardware and software designs.

**Vaisala High Temperature Dewpoint Monitoring System**

Moderate power in a diffraction limited, single mode beam which is wavelength tunable up to 20nm is now available in the SDL-8800 series laser diode. This index-guided single-mode laser is placed in an external cavity with frequency-selective feedback to provide both coarse & fine tuning capability.

The package includes an SDL-5400 laser with TE-cooler, broadband AR-coated collimating lens and a high quality diffraction grating. With spectral linewidth of less than 1 MHz, potential applications include spectroscopy, trace element or isotope detection and fibre sensors.

For more information on this equipment call or write to:

Spectra-Physics Pty Ltd
2-4 Jesmond Road
Croydon VIC 3136 Australia
Phone (03) 723 6600
Fax (03) 725 4822 •
Prompt Critical

Green Cheese and Vodka

The annual production of vodka in the old Soviet Union used to be five billion bottles: quite intoxicating for a population of 275 million. In one of his delightful collection of tales, “Five Billion Vodka Bottles to the Moon”, the great Ukrainian radio astronomer, Josef Shklovsky, estimated that if all those Soviet vodka bottles were lined up side by side they would stretch for 400,000 kilometres - the distance from the Earth to the Moon.

Whenever Shklovsky’s fertile mind was relaxing he would come up with some interesting new way of estimating and presenting information about his country, often at great risk to his liberty. Once, in a radio interview, Shklovsky, who was quite a prolific writer, was engaged in conversation with a Soviet female author. Using the estimation techniques familiar to astronomers and physicists, Shklovsky calculated that at the time there must be one and a half million Soviet citizens in prison camps. A man behind a newspaper in the corner of the room suddenly let the paper fall and exclaimed “Where did you get that figure? It’s a state secret!”

Shklovsky was lucky not to be denounced and sent off to a gulag himself, courtesy of the state organ he whimsically describes as the Ministry of Love (KGB).

Worse still, Shklovsky boldly courted disaster by writing many short essays describing, none too flatteringly, people and events around him. Luckily his scripts were never discovered and seized, so we can now enjoy an inside glimpse of conditions endured by Soviet scientists during the years of communist rule.

Shklovsky’s tales are best compared to Freeman Dyson’s “Disturbing the Universe” or the late Richard Feynman’s “Surely You’re Joking, Mr Feynman”. They are vignettes of a brilliant scientist’s lifetime experiences, shedding light on people and their foibles which, in many instances, have had the potential to alter the course of history. Only a few Westerners ever had much opportunity to pry deeply behind the old Iron Curtain and discover what made Soviet science tick.

For many, their best insight came from Aleksandr Solzhenitsyn’s novel “The First Circle” which revealed how dissident scientists were forced to work under detention in special institutions engaged upon projects considered vital to state security, like improved eavesdropping equipment. Luckily Shklovsky managed to avoid this form of scientific slavery.

Some of Shklovsky’s tales match any told by western authors. His desperate description of Stalin’s brefage is wryly titled “My Contribution to Criticism of the Cult of Personality”. Some, like the story “Anniversary Arabesques”, verge on the unbelievable.

Shklovsky’s description of elections to the Soviet Academy of Science is rather scathing. His scientific eminence took him as far as becoming a corresponding member of the Academy, a sort of junior membership. Yet it must be conceded that the attainment of the highest accolades in our own country may sometimes depend more on who you know rather than what you know.

There are many gems in this 268-page collection. I particularly liked his many encounters with the great Andrey Sakharov, and those with his Western hydrogen bomb counterpart, Edward Teller. There is even an illuminating allusion to the Petrov affair.

“Five Billion Vodka Bottles to the Moon” by Josef Shklovsky was translated by Mary and Harold Zirin and is published by W.W. Norton & Company. It costs A$47.50 in hardcovers.

Colin Key
Book Reviews Editor

Consequently the need for beam refinement to give an increased spatial coherence led to the use of unstable resonators.

After a brief introductory chapter, chapter 2 provides a review of the laws of light beam propagation, with particular emphasis on their formulation for application to the optical resonator. This is followed by an extended account in chapter 3 of the theory and properties of the modes of an ideal (passive) resonator. Chapter 4 deals with the basic concepts which underlie the analysis of real resonators, that is those containing an active element. There is an extended discussion of important resonator configurations and their applications in chapter 5. This serves to demonstrate how the principles are applied to the optimization of some important practical resonator systems. Finally, in chapter 6, the simplest causes of waveform aberrations and the methods for their correction are discussed. An extensive list of references, to facilitate access to original sources, is provided at the end of the book.

To summarise, this book gives an extensive discussion of the laser resonator problem and will be a valuable resource to laser physicists as well as those scientists and engineers who wish to apply laser beams. It will certainly be an asset to the library of a research institution.

R.C. Tobin
Department of Physics
Monash University

Reviews

Laser Resonators and the Beam Divergence Problem

Yu Ananev
Adam Hilger, Bristol 1992
xix + 442 pp., UK£70 (hardcover)

This monograph, by a noted contributor to the field, provides a timely and comprehensive treatment of the principles of laser resonators. The topic has received considerable attention right from the early stages of laser development. It began with the theory of a stable passive resonator, for which the modes of oscillation and their beam patterns are calculated without reference to the effects of the non-linear amplifying medium. That theory is most successful for low gain lasers, such as the helium-neon, for which the ratio of resonator diameter to length is small. However, experience with higher gain systems soon revealed the shortcomings of the passive resonator approach. For example, the pulse duration for certain high gain lasers is too short to permit the formation of the resonator modes.

Superstrings and the Search for the Theory of Everything

F. David Peat
Cardinal, London 1991
362 pp., A$16.95 (paper)

According to superstring theory, all matter is made up of tiny pieces of string. The large number of observed subatomic particles are just the different patterns of vibration and rotation of these pieces of string. The theory has supersymmetry which is a symmetry between bosons and fermions. The strings are supersymmetric, hence the name superstrings. One of the states of the string is the quantum of gravity so that superstring theory includes gravity as well as the other interactions of physics. In this sense superstring theory can be described as a theory of everything. However its natural mass scale is roughly 10^19 GeV and on this scale all the subatomic particles are massless. So in this sense, superstring theory is a theory of nothing. ▲
BOOK REVIEWS

David Peat has written an exciting account of the development of superstring theory and has included a limited discussion of its defects. He traces the history from the dual resonance models of the strongly interacting particles through the bosonic string, which needed 26 dimensional spacetime, to the inclusion of fermionic strings and how the superstring theory of Green and Schwarz solved the problem of anomalies, the quantum violations of conservation laws. He also describes the unification of the interactions in physics, tracing through the unification of electricity and magnetism by Maxwell into the single theory of electromagnetism, through the unification of the weak and electromagnetic interactions by Weinberg, Ward and Salam to the grand unification of all interactions.

All this is done with a minimum of mathematics. The simpler mathematical ideas needed, such as complex numbers, are introduced and described in detail. Inevitably, only the flavour is given of the complicated ideas of both physics and mathematics.

Almost one third of the book deals with the twistor theory of Roger Penrose. I think it would have been a better book if the author had left out the material on twistor theory. The initial basic ideas of strings and twistor theory are simple and attractive, but the superstructure required for twistor theory seems far too elaborate for its limited success in physics so far.

This book provides a good introduction to superstrings and twistor theory for readers of the Australian and New Zealand Physicist. The last chapter is a very useful guide to suggested additional reading.

The book was originally published in 1988, and while there has been a lot of work done since then on superstrings, there has not been enough progress to diminish the usefulness of this book.

L.J. Tassie
Theoretical Physics Department, IAS
Australian National University

High-Temperature Superconductivity: An Introduction

Gerald Burns

What has been missing from the flood of literature on high-temperature superconductivity is a publication that brings together the vast amount of experimental results, separates out the important, and assesses these results in the context of BCS and other theories. This excellent book does just that, in an accessible and readable manner.

The introductory chapters give an excellent, and comprehensive, review of conventional superconductors, addressing topics that include Ginzburg-Landau theory, BCS theory, strong-coupled superconductors and tunneling. This is done from an experimental point of view, and in a manner that concentrates on the physical ideas underlying the theory. The following chapter gives a complete overview of the cuprate high-T_c structures. The author emphasises the physical significance of the Cu-O planes in these materials, which result in the observation of highly anisotropic normal-state and superconducting properties. The following chapters present discussions of normal state properties, superconducting properties and vortex behaviour, J_c, and applications. One of the great strengths of this book is that it brings together the results of many different experiments, e.g. photoemission spectroscopy, tunneling spectroscopy, specific heat, Raman, magnetic measurements, NMR etc., in a convenient text, and examines their physical significance as part of the total high-temperature superconductivity picture. Though this book is aimed at the graduate/postgraduate level, it has much to offer the more senior researcher, as each chapter has an excellent set of notes discussing the more technical points, including references to review, and original papers.

If you’re about to buy a text on high temperature superconductivity, then I recommend, without hesitation, you buy this one. It is an excellent text and is most reasonably priced at US$19.95.

Stephen Collofotti
CSIRO Division of Applied Physics
Lindfield

Introductory Special Relativity

W.G.V. Rosser
Taylor and Francis, London 1991 xi + 263., UK£19 (softcover)

This is a very comprehensive introduction to Special Relativity. Unlike the more traditional expositions, it does not set out from the classical experiments of optics such as that of Michelson and Morley to justify the constancy of the speed of light. Instead Rosser follows the more unusual ‘dynamical’ path wherein after a careful and illuminating discussion of the bases of Newtonian mechanics, he redefines the momentum of a particle to include beside the Newtonian expression mu, the additional ‘relativistic’ factor \( \sqrt{1-u^2/c^2} \).

This modification leads to a new dynamics which for the case of charged particles in electromagnetic fields is shown to be in close agreement with experiment. The properly relativistic task of relating world views in different inertial frames is then developed utilizing radar measurements and Bondi’s K-calculus. Thus in a series of chapters spacetime concepts are slowly and carefully built up with experimental reinforcement always a prime consideration. In this way all the usual relativistic novelties are displayed to the beginner. Rosser also includes some unusual ones which are not normally found in introductory texts, such as, for example, the visual appearance of moving objects. All of this makes for a very valuable book, in my view.

Comparing Rosser’s development to the more traditional approach, I cannot but feel that it lacks some of the aesthetic appeal of the conventional development. Indeed the ad ad hoc appearance of the factor \( \alpha \) in the proposed new dynamics reminds me of the introduction of a. In my view.

Manifold Theory

An Introduction for Mathematical Physicists

Daniel Martin
Ellis Horwood Ltd., Chichester 1991 423 pp., AS$109.95 (hardcover)

The stated aim of this book is to give a comprehensive account of basic manifold theory suitable for a first year research student in theoretical physics. However few students entering postgraduate research on completion of an honours degree in physics or theoretical physics would have sufficient knowledge of linear algebra and of analytical topology to find the book easy reading. Perhaps anticipating this likely lack of prerequisite knowledge, the author has provided two introductory chapters on linear algebra and two appendices on topology. With the aid of these well written remedial sections, any determined student with a good undergraduate training should be able to master the remainder of the book and thereby appreciate the elegance and beauty of manifold theory.

To ease the transition from thinking in terms of local co-ordinates to thinking globally, the author frequently complements his modern “geometric” treatment with an historical note on the methods adopted in older books on differential geometry. This dual coverage makes for greater intelligibility, as does the provision of many examples and exercises taken from relativity, electromagnetism, Hamilton mechanics and Lie groups.

While this book would be a valuable addition to any physics or mathematics library, its cost is likely to deter its purchase for personal use.

G. Derrick
Department of Theoretical Physics
University of Sydney
BOOK REVIEWS

This is Bohr-like in its approach, Van Fraassen' modal interpretation (MI) is a way of spelling all this out formally in detail. Along the way there are lucid technical and conceptual expositions, e.g. of Gleason's theorem and its implications for the Luder' projection rule and the no-hidden-variables theorem, or of the Stone Representation Theorem for Hamiltonian dynamics.

This is no trivial task because of the ways QM pure states and mixtures are differently related to associated possibilities yet intimately related to each other. The MI has gone through many developments over 20 years to meet these demands and emerges a detailed and interesting EIQM. Moreover, van Fraassen does not shirk explicitly facing awkward cases. An entire chapter is of course devoted to Bell's theorem and the Einstein-Podolsky-Rosen (EPR) paradox, but another chapter is devoted to the problem of QM identical particles, the Fermi-Dirac, Bose-Einstein statistics difference and the principle of identity of indiscernibles (a problem most physicists and philosophers prefer to avoid).

On the other hand, not all the mystery disappears either. Van Fraassen is forced, for example, to acknowledge that interacting quantum systems, even of the spatially dispersed EPR sort, have an irreducible stochasticity. For an isolated EPR system S the possible observable values associated to S are specified by S's pure state and evolve deterministically whereas the corresponding values for the interacting components are specified by the corresponding mixtures found by the usual density matrix expansion and evolve non-deterministically. "Obviously, the holism of the total state introduces here a radical holism also for what really happens: what is really true of the system as a whole does not supervene, in any respect, on what is true of the subsystems." (p.398)

There is also the characteristic EIQM defect of relatively uncritical acceptance of the descriptive predicates specifying kinds of data, e.g. momentum, spin. The sheer physical complexity of measuring natural quantities is necessarily omitted since MI starts with them as given; this contrast, for example, to Bohr's subtle analyses of the different kinds of measurement situations, or on the surprising results QM gives for some natural measurement processes (see Araki, H. and Yamas, M., Phys.Rev. 129, 1960, 622; cf. Hooper, Phil.Sci. 38, 1971, 224). In MI, for example, the whole weight of spin statistics differences turns on some asserted relations among descriptive predicates (pp.477-9), which evidently cannot be further explored. And there is no discussion of the nature of the profoundly non-classical bounded QM properties like spin (strangeness, etc.).

Like the search for physical understanding of the ideologically tighter quantum symmetries compared to classical physics, the idea is the brute assertion of the relevant mathematics.

And of course these features do derive from QM mathematics. But the mathematics drove both Bohr and Einstein to strive to understand more deeply, if divergently, thereby raising many issues, evoking the nature of objectivity itself (cf. Hooper, C. A., Brit. J. Phil. Sci. 42, 1991, 491). Characteristically, van Fraassen concludes his book with a defence of the rejection of metaphysics. Perhaps he is right. There is certainly no abler defence of EIQM. For friend, foe and agnostic alike, the book is recommended for its clear, concise and detailed expositions and arguments. Still, there is Bohr and Einstein.

C.A. Hooker
Philosophy Department
University of Newcastle

Quantum Mechanics: An Empiricist View
by Bas C. van Fraassen
xvi + 541 pp., AS44.95 (paperback)

This book provides the most thorough and lucid empiricist interpretation of quantum mechanics (EIQM) known to me.

Empiricism is a philosophical doctrine which insists that the only source of knowledge is observation (read: experimental data strings) and that theory is essentially required to do no more than be empirically predictive or explain observations accurately. Defence of EIQM can be by deceit or hard work. One way to put this into practice is to reduce a theory T to an abstract mathematical apparatus A (a mere instrument) and a collection of data strings D and show that A can be used to model the patterns in D. Provided only that A is consistent, this reconstruction removes all awkward questions, indeed all questions, about what sort of world T describes and why T applies to our world. For QM this approach has proven especially attractive to many scientists since all paradoxes vanish effortlessly. But this is 'understanding' in the sense of deceptively deep: the deep issues of understanding the quantum world have not gone away, just been suppressed. It is significant that, for all their deep disagreements, neither Bohr nor Einstein took this route. And neither does van Fraassen, at least in some significant respects.

Rather, he wants to work out in detail how QM could be a theory about dynamical quantum states as structured possibilities; possible data strings are associated to quantum systems in virtue of their dynamical states, but they are assigned actual properties only in specific (viz. measurement) situations. "...the dynamical state is linked only to statistical distributions on the ensemble at the end of measurement interactions it could enter, and not under other conditions." (p.293)

Introduction to Percolation Theory
Dietrich Stauffer & Amnon Aharony
Taylor & Francis, London, 1992,
xs + 181 pp., UK£30. (hardcover)

When a system contains a degree of randomness, either in its composition or its connectivity, then properties of the system can undergo a dramatic change at a threshold level of randomness. Perhaps the simplest example is a network of resistors, a fraction f of which are fault and non-conducting. If these resistors form a square grid and if f < 1/2, then there will be at least one conducting path across the network, otherwise not.

Percolation theory, the study of such problems, is a fairly young branch of statistical physics, but one which deserves a place in present day courses on the subject. While there are many reviews of different aspects of the topic, Stauffer's 1985 book has been one of the few treatments at a student level. The present volume, by Stauffer and Aharony, is a revised and considerably enlarged version of the original, which retains the descriptive and pedagogical approach.

The intimate connection between percolation and thermal phase transitions has provided much fruitful cross fertilization, and forms a major theme of the book. Techniques such as scaling and renormalization, applied originally to phase transitions, can also be successfully applied to percolation problems. Another major theme of the book is the fractal nature of percolation clusters, and the consequences this has on physical...
BOOK REVIEWS

properties. Stauffer's love of computer simulations, an area in which he has made many contributions, comes through strongly. There are details of computer algorithms and a FORTRAN code, which could be useful in a course on Computational Physics. Another new feature is a set of exercises: some fairly simple, others more in the nature of "mini-projects". I enjoyed reading this book and can recommend it to readers seeking an introduction to the subject and an overview of recent developments. Unfortunately the price of the new hardcover volume will make it less accessible to students than was the first paperback edition.

J. Oitmaa
School of Physics
University of New South Wales

Principles of Nuclear Magnetic Resonance Microscopy

Paul T. Callaghan

"There is clearly a need for this excellent book dealing with a new kind of microscopy which in the words of the author "gains its value in the range of contrast available..." and that "the signatures in the image include the chemical shift, the nuclear spin relaxation times, the dipolar couplings and the spectrum of the translational motion..."

One of the exciting aspects of all nuclear magnetic resonance phenomena is the fact that a very wide range of physical processes and properties must be used to excite and observe these resonances. To understand and to use and especially to create innovative advances in the applications of NMR the research and the student must have command of these. In the initial chapters Paul Callaghan succinctly pinpoints the background of quantum physics, classical mechanics, statistical mechanics, electromagnetism etc., on which he later builds.

In a clear and readable way he then explains spin manipulation, the influence of field gradients, and various pulse sequences, all of use in NMR imaging on other scales as well as the microscopic. The latter half of the book is devoted specifically to high resolution NMR imaging. Readers who are already familiar with NMR imaging techniques will find that it is this part which contains new ideas, extending their understanding of the applications. There are extensive references to the literature and many beautiful examples of microscopic images given in the text.

Especially because of the existence of "add-on" microscopy options for standard NMR spectrometers, this book should be widely read by all who use or may use NMR as a tool.

Although much of the material is of interest more to the specialist NMR researchers than to general readers, the technical part of the text is accessible to students of physics, chemistry and engineering, and the applications sections will be appreciated by biologists who will constitute the main user group of NMR microscopy.

A.L. McCarthy
School of Physical Sciences
Flinders University

Biomagnetism

R. S. Wadas
Ellis Horwood, New York, 1991. viii + 170 pp., A$68.00 (hardcover)

The subject of this book is magnetic phenomena in biology in the broadest sense, and a major theme is the effect of magnetic fields on biological processes and organisms. For such an ambitious subject, this is a rather small book, and Dr. Wadas' selection and arrangement of material is at times puzzling. For example, not until the last of the six chapters does the author present empirical data on known magnetobiological phenomena such as the effects of magnetic fields on the blood system, the heart, on cellular respiration, DNA synthesis, and on the growth of plants. There is no reference to the extensive epidemiological literature on human exposure to d.c. and low frequency magnetic fields. Biomagnetism as it is generally understood, that is, the study of magnetic fields originating in biological systems, and in particular in the human body, is dealt with in only a few pages of rather dated material.

A weakness of the book is its thinness of literature citations (only 92 in total). This has a particularly serious consequence in the earlier chapters where a theoretical approach is taken, based on the physics of magnetism at the atomic and molecular level. The first two chapters deal with magnetic parameters of substances and energy relations for atomic interactions, and make an argument for the possibility of a magnetic influence on chemical reactions and, by implication, on metabolism. At times it is not clear whether the author is reporting established scientific fact or advancing an untested hypothesis.

The main contribution of this book is the collation of information on diverse aspects of magnetism in biology in a single volume. In addition to the subjects mentioned, the book covers paramagnetic biological molecules (hemoglobin and others), the effects of magnetic fields on uncompensated spins, on biological liquid crystals, and on biological electric currents, and experimental methods for examining magnetic properties of materials. However it is its success, for this reader at least, is diminished by its idiosyncrasies of structure and content, and by its limited survey of the literature.

G.J. Sloggett
CSIRO Division of Applied Physics

Graphics and Animation in Surface Science

D.D. Vvedensky and S. Holloway
Adam Hilger, Bristol, 1992 x + 117, UK £27.50 (hardcover)

This book arose from a one-day conference on Graphics in Surface Science held in May, 1990 at the Surface Science Interdisciplinary Research Centre at the University of Liverpool. It has clearly brought together people from a range of areas and this book demonstrates the variety of ways in which animation can assist in surface science.

The seven chapters are contributions from different authors and in this format there is some overlap between the chapters, however the editors have ensured that this does not detract seriously from the book. This book is the first time I have seen addressed the problems that one encounters when trying to produce high quality three dimensional images, and furthermore, to animate them. The various contributions explain how printers of different qualities can be used to achieve high resolution colour graphics, and the additional problems one encounters in trying to transfer images from a computer console to either a TV image or to a video recorder. The amount of data involved with each image is enormous and some consideration is given to the methods of packing data for an image to reduce this memory overhead.

Apart from the general material presented in this book, perhaps one of the most valuable resources is the list of contacts who can supply software free of charge to accomplish advanced graphics. I was pleased to note that one of the programmes I was most interested in obtaining, was available from the University of Melbourne through INTERNET.

While the title appears to be restrictive in that it refers to surface science, I would recommend this book to anyone who wishes to model or animate solids using computers.

D.J. O'Connor
Physics Department, University of Newcastle

194

Australian & New Zealand Physicist Volume 29, Number 8, August 1992
BOOK REVIEWS

Heat Conduction Using Green's Functions
J.Y. Beck, K.D. Cole, A. Haji-Sheikh and B. Litkouhi
Hemisphere Publishing Corporation 1992 xxviii + 523pp., UK £56 (hardcover)

This is a very interesting and unusual book. It provides everything a practical scientist or engineer might require for solving linear heat conduction problems. It is an exhaustive treatment from the Green's function perspective and is a treatise on both classical theory and modern developments.

This reviewer is very impressed. The book comprises twelve chapters on various aspects of Green's functions involving various geometries and methods of derivation, including the Galerkin approach applicable to non-standard geometries. In addition there is an introductory chapter on the basics of heat conduction plus ten appendices dealing with useful formulae. The final appendix details an index of solutions by means of a specially designed numbering system.

In view of the fact that the linear heat equation has been and continues to be the single most important partial differential equation in science and engineering in terms of its sheer range of applicability, this monumental contribution by four authors is not only worthwhile but constitutes an indispensable reference manual for both undergraduate and research students alike interested in heat conduction.

The present reviewer is slightly disappointed that his own book in this area (J.M. Hill and I.N. Dewynne, Heat Conduction, Blackwell, 1987) is not included in the references, especially since the use of Green’s functions combined with the boundary integral method is an important feature of the book. However overall the four authors are to be warmly congratulated for an important and valuable contribution.

J.M. Hill
Department of Mathematics
University of Wollongong

Discrete Mathematics for New Technology
R. Garnier & J. Taylor
Adam Hilger, Bristol, 1992 xvii + 678pp., UK£ 19.50 (paperback)

As well as the more traditional calculus and linear algebra, mathematics for first year computer science students now contains a large section on discrete mathematics. There are several useful books that could be considered as texts for this latter component, and the book under review, whilst aimed at the British and U.S. markets, is also relevant to the discrete mathematics subjects taught in Australia.

The book covers the standard material of logic, proof, set relations, functions and graphs at a reasonable depth and pace, and provides exercises at the end of each section with answers in the Appendix.

The applications studied in the text include databases, codes and sorting algorithms. Whilst the book is easy to read, and the logical development of the material is pleasing, as a text for first year computer science students, the book has some deficiencies.

The most important omission from this book is any serious discussion of algorithms: how to create them, how to structure them, how to analyze them and prove that the algorithms do exactly what is intended. Students tend to find creating algorithms extremely difficult, as it often involves deciding what they do intuitively, and they also seem to struggle in explaining what a given algorithm will do with the input data. The presentation of recursive algorithms in the last chapter, without any easier ones earlier in the book, is surely asking a lot of the students!

In line with this observation is the fact that the book makes no attempt to build on the previous knowledge that the students may have; relations come before functions, which in some sense is the more logical development but not the path used in practice in Australia.

The range in the degree of difficulty of the exercises is rather small, with very few open ended questions or problems suggesting further directions that the subject might take.

Also the problems tend to be mathematically oriented, rather than applications oriented and would no doubt prompt the question “What is a computer science student going to do with this theory?” “Use it to design better algorithms.” would be one answer, but this is not even hinted at in this book.

In summary, for those interested only in the mathematics of computer science this book is a very good introduction, however, students interested in solving problems using computers would find little to convince them of the necessity for the mathematics.

P.J. Bleherhassett
School of Mathematics
University of New South Wales

New Books

Gamma and X-Ray Spectrometry with Semiconductor Detectors
K. Debertin and R.G. Helmer
North-Holland Publ., Amsterdam 1988 x+399 pp., Dfl 180 (hardcover)

Compound Semiconductor Device Physics
S. Tanii
Academic Press, San Diego CA 1992 xvi + 828 pp., US$79.95 (hardcover)

The Physics of Non-Crystalline Solids
L. Pye, W. LaCourse & H. Stevens (Eds)
Taylor & Francis, London 1992 xvi + 761 pp., UK£60 (hardcover)

Radiation Protection Dosimetry
Skin Dosimetry
H.G. Menzel, P. Christensen and J.A. Dennis (Eds)
Nuclear Technology Publishing, Ashford, Kent 1991 iv + 208 pp., UK£60 (hardcover)

Hot Carriers in Semiconductor Nanostructures
J. Shah (Ed.)

Physical Characteristics and Critical Temperature of High Temperature Superconductors
M.M. Sushchinsky (Ed.)

Electron and Atomic Collisions
I.R. McGillivray, I.E. McCarthy and M.C. Standage (Eds.)
Adam Hilger, Bristol 1992 xiv + 704 pp., UK£72.50 (hardcover)

Studies of High Temperature Superconductors
A. Narlikar (Ed.)

Electronic Structure of Solids
P. Ziesche (Ed.)

Physics of Granular Media
D. Bideau and J. Dodds (Eds.)

Polarization of the Vacuum and a Quantum Relativistic Gas in an External Field
A. Ye. Shabab

Reliability Problems of Semiconductor Lasers
P.G. Eliseev
1992

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

August 26 - 28
Fifth New Zealand National Physics Conference, University of Auckland
Dr. G. D. Putt, Department of Physics, University of Auckland, Private Bag 92019, Auckland, N.Z. Phone NZ (09) 373 7999/Fx 8828, fax NZ (09) 373 7445

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

September 14 - 18
APSEM/BECON '92 Physical Sciences in Medicine and Biomedical Engineering Conference
Contact: A/Prof. B.J. Thomas, School of Physics, Queensland University of Technology, PO Box 2434, Brisbane QLD 4001, Australia
Phone (07) 864 2586 or Fax (07) 864 1521, or Mr M. McCarthy, Department of Physical Sciences, Royal Brisbane Hospital, Bowen Bridge Road, Herston QLD 4029, Australia.
Phone (07) 253 8520 or Fax (07) 253 1369

September 28
Workshop - Materials Engineering in a Hazardous Environment
Lucas Heights Research Laboratories, Sydney, Australia
Enquiries: Conference Business Manager, Ms. Joan Watson Australian Institute of Nuclear Science & Engineering, Private Mail Bag No.1, Menai NSW 2234, Australia. Phone (02) 717 3411, fax (02) 7179268

November 12 - 14
16th Scientific Meeting of the Australian Society for Biophysics
University of NSW, Sydney
Prof. Hans Coster, Department of Biophysics, University of NSW PO Box 1, Kensington NSW 2033, Phone (02) 6974583, fax (02) 6633420

November 25 - 27
Australian Acoustical Society Annual Conference 1992, Ballarat, Victoria
Chairman of the Organising Committee, John Upton (Convener), phone (03) 370 7666 or (03) 370 7166, fax (03) 370 0352. Geoff Barnes, phone (03) 720 1266, fax (03) 720 6952

December 1 - 5
ICPE Conference on Physics Education for Development, Philippines
Prof. Geoffrey I. Opat, School of Physics, The University of Melbourne, Parkville VIC 3052, Australia. Phone (03) 344 5121, fax (03) 347 4783

December 11
Dr. Geoffrey Fletcher's Festschrift Symposium on "Electrons in Solids - The 1990s and Beyond".
Department of Physics, Monash University, Clayton VIC 3168
Phone 61-3-565 3630, fax 61-3-565 3637

1993

January 11 - 29
6th Physics Summer School: Modern Perspectives of Many Body Physics, Canberra, Australia
J. Mahanty, Dept. of Theoretical Physics, R.S.PhyS.S.E., ANU, GPO Box 4, Canberra ACT 2601 Australia
Phone (06) 249 2952, fax (06) 249 4676

February 1 - 5
8th Conference of the Australian Optical Society
University of Sydney, NSW 2006 Australia
Chair of the Organising Committee: Dr Brian James, School of Physics, University of Sydney NSW 2006. Phone (02) 692 2599, fax (02) 660 2903
email: james@physics.su.oz.au.

February 7 - 11
AMC '93 - The 29th Australian Applied Mathematics Conference
Hahndorf, Adelaide Hills, Adelaide, Australia
Conference Secretary, 29AMC, Department of Applied Mathematics
The University of Adelaide, GPO Box 498, Adelaide SA 5001
E-mail (preferred) to: amc93@maths.adelaide.edu.au

196 Australian & New Zealand Physicist Volume 29, Number 8, August 1992
Introducing a bright, new idea in lasers. Modularity.

The exclusive building-block design of the Lexel 480 Ti:Sapphire laser lets you start with a basic cw model. Then as your requirements change, add the advanced capabilities you need.

By simply exchanging pre-aligned optical modules, the Lexel 480 operates in any mode; broadband, narrowband, or modelocked pico- or femtosecond. Converting between operating modes was never easier. And versatile mounting plates for the ultrastable invar resonator allow easy integration of your own innovations.

The best news is, all this flexibility comes in a single, surprisingly affordable package. You never have to abandon your initial investment.

For details on the Ti:Sapphire laser you won’t outgrow, call us at: Lastek Pty Ltd
400 King William Street
Adelaide SA 5000 Australia
Telephone: (08) 231 2155
Facsimile: (08) 231 2169
Spectra-Physics Lasers

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

TSUNAMI UltraShort Pulse Ti: Sapphire Laser

Newport

- Helium-Neon Lasers
- Laser Diodes
- Diode-Pumped Solid-State Lasers

Spectra-Physics

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