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This month's cover picture is of Professor Sir Mark Oliphant, 90 years of age, but as active and alert as ever. See our Guest Editorial on page 207. Photograph courtesy of ANU Photo Service.
The Unity of Physics

Following a brief stop in the UK recently, the topic of this column became clear. With the preparation of a Strategic Plan underway it seems appropriate to spend a little time on what I consider a crucial issue for all physicists. As it happens some of the themes in Sir Mark's guest editorial complement what I have to say.

For many physicists what seems most important is our own special research area. Quite rightly we struggle to maximise the resources flowing in that direction. Unfortunately when overall funding for science is tight, as it certainly is at the moment, there is a temptation to try to raise funding in our own area by putting down others. Occasionally such a ploy may appear to work, but in the long run it is always self-defeating! Any public squabbling over the intellectual or (in these days particularly) financial irrelevance of an area of physics will in the not so long term lower the public political perception of the worth of physics as a whole.

It is always easy to judge from outside, but the UK experience can provide valuable lessons. For many years the cost of the CERN subscription has risen more rapidly than the funds available for science in the UK. However, that subscription has had to be found out of the science budget - for reasons that may be either obscure or perverse depending on one's point of view. The resulting financial pressures on the rest of the science community have led to much ill feeling towards big science in general and high-energy physics in particular. It is my belief that as long as the science lobby is split by such internal conflict, it will be easy for the UK government to ignore the real needs. The recent absurd decision to destroy the Nuclear Structure Facility at Daresbury should be opposed by all physicists because of the ad hoc, unscientific way in which the decision was taken. If the community stays silent it will be even easier to pick off another area of physics next year.

To summarise, the key word should be solidarity. This is not to say that internally we must not be prepared to argue the case for our own areas. It is crucial that there be open, honest debate concerning the Strategic Plan. However, once we have been through that process the whole community will lose unless we are all solidly supportive of the plan which is developed.

A. W. Thomas
Honorary President

SUMMER SCHOOL

Atomic and Molecular Physics and Quantum Optics

Department of Theoretical Physics
Research School of Physical Sciences and Engineering
The Australian National University

13 - 31 January 1992

This school is the fifth in an annual series on various topics in physics intended for postgraduate and honours students of Australian and New Zealand universities. Participation of research workers with interests in this area from universities and research laboratories is also encouraged.

The aim of the school is to expose the participants to the basic concepts and modern developments in the subjects of the lectures in a manner normally not covered in text books.

For more information please contact;

The Secretary, Department of Theoretical Physics, Ph: (06) 249 2943, Dr. B. A. Robson, The Convenor, Summer School on Atomic & Molecular Physics & Quantum Physics, Research School of Physical Sciences & Engineering Australian National University, GPO Box 4, Canberra, ACT 2601
At a conference on 'Science in Australia', held in Canberra in 1952, Dr. Conant, chemist and President of Harvard University, remarked that science covered a whole spectrum of activities, from mathematics and physics to applications of knowledge of nature in all branches of engineering. Moreover he emphasized that each part of the spectrum was dependent upon every other part. For instance, the examination of a welded joint in a structure or pressure vessel with penetrating X-rays or γ-radiation, can be effective only if the properties of the fully annealed and strained samples of the material have been examined and explained in terms of its crystal structure. The unfortunate happenings at Maralinga when British nuclear weapons were tested, were possible only because of the curiosity about the structure of the nuclei of atoms of Rutherford, Hahn, the Jolliets, Meitner, Fermi, and others. In the reverse direction, very high energy particle physics is possible only because modern engineering can produce the complex accelerators and analysing equipment for the physicists concerned. Conant likened the fundamental end of the spectrum to accumulation of capital in a bank account upon which all other parts were dependent for information. He emphasized the overriding importance of continually replacing this capital as it was exploited. To reduce or discourage activity in any part of the spectrum will inevitably affect all other parts.

At that time, practitioners in every part of the spectrum were attracted to it by the challenging adventures of the mind which it presented. However, during the last 40 years or so, there has developed a change in the attitudes of governments, the public, and scientists, most rapidly in the last 10 years. This is due largely to the influence of that shadowy discipline, economics. The phantom "thing" called money, which originated to facilitate the exchange of goods and to reward human labour, has become dominant in the world's economy, with disastrous results for all but the manipulators of this inanimate tool. Fundamental enquiry into any aspect of nature must be justified by its promise of very rapid movement towards profitable application. The lengthy period before profitability of that imaginative project, the Very Fast Train, proposed by Dr. J.P. Wild in Australia, has frightened both governments and financiers into withdrawal, despite the fact that it would have helped greatly to reduce unemployment and its enormous costs.

The great British economist, Keynes, in a speech to one of the organs of the League of Nation in the 1930's, emphasized that if a promising project was proposed, and the nation had the skilled people and the materials required, there was no reason whatever why it should not be carried out. Money did not enter into the calculation, for skilled human labour created an asset the value of which was at least equal to the expenditure incurred. His words are forgotten. Now, the money must exist, or be borrowed, before the project is possible, however desirable. I am assured by a prominent Sydney banker that the amount of money his bank lends is very much greater than its total deposits. So a bank is a creator of money! (We are told by theoretical physicists that the vacuum contains enormous energy, but we still need power-stations!) The result is the bankruptcy, not only of manufacturing and other business, but of the whole country. We are in grave danger of bankruptcy in ideas, in our contributions to the capital account of natural knowledge. Scientists today bury every observation with any practical promise in the patent office. Clearly, there is something very wrong, not only with the relation between governments and the search for natural knowledge, but in the motivation of many scientists. Perhaps we should remember the oath which the young Benjamin Franklin imposed upon members of his Junto, a club which he founded in Philadelphia to discuss the problems of his time, which I shorten to: "I swear diligently to seek the truth, and having found it, impart it to others."

Professor Sir Mark Oliphant

Note: The Keynes quote is from the World Economic Conference of 1933, and the title of his paper was 'National Self-Sufficiency.'
Sir Mark Oliphant's 90th birthday was celebrated on 8 October 1991. An outstanding physicist and an inspiring scientific leader, Sir Mark is widely respected for his scientific attainments and for his forthright views on the environment, the national economy, education and other social issues.

Sir Mark Oliphant and Professor John Carver share a comment at a recent meeting

It is a pleasure on this happy occasion to recall some of the highlights of Sir Marks distinguished career. Born in Adelaide and graduating from the Physics Department of the University of Adelaide, Mark Oliphant was placed an 1851 scholarship which, in 1927, took him to the Cavendish Laboratory in Cambridge. Led by Ernest Rutherford, the Cavendish Laboratory was then at the height of its fame, rich in Nobel Prize winners and with a galaxy of "FRSs in the sight of God" amongst its research students and younger staff members. Oliphant was welcomed into this talented group of Rutherford's "boys", a group which provided most of the leaders of British physics for the next 30 years. Oliphant and Rutherford, working together, did pioneering studies of the D-D reaction, discovering helium 3 and hydrogen 3 in a series of experiments that provided the scientific foundation for future thermonuclear fusion research.

In 1936 Oliphant went to Birmingham as Professor of Physics and began to build a large cyclotron after consultation with Ernest Lawrence, the American inventor of the cyclotron. Oliphant's friendship with Lawrence and with his former Cavendish colleagues, particularly John Cockcroft, provided him with a wide range of scientific and official contacts in both  

Professor J. H. Carver, the author of this article, is the Director of the Research School of Physical Sciences and Engineering at the Australian National University in Canberra.
Britain and the United States. With the approach of war, Oliphant directed his laboratory in Birmingham to research on radar. The initial work in Birmingham concentrated on the use of klystrons but the great success of Oliphant’s group was the development of the cavity magnetron by John Randall and Harry Boot. The magnetron, which provided the power source for airborne 1cm radar, was one of the great inventions of World War II. It is interesting to recall that the very first magnetron was machined by Jimmy Edwards, one of Oliphant’s senior technicians, who played a leading role in establishing technical facilities at the Research School of Physical Sciences at the ANU.

In addition to the magnetron, there was a second major wartime development in Oliphant’s Birmingham laboratory. Working with Oliphant in Birmingham at that time were two scientists of German origin, Rudolph Peierls and Otto Frisch, who, because of their foreign background, were not permitted to be involved with the secret development of radar. Frisch and Peierls worked instead on nuclear fission and investigated the conditions in which a runaway chain reaction might occur in uranium. In the famous Frisch and Peierls report, which they presented to Oliphant, they calculated that for highly enriched U235, the critical mass for a runaway chain reaction was only a few pounds. Oliphant realized that this meant that a bomb of unprecedented power could be feasible and he took the information to the British authorities who established the M.A.U.D. Committee to investigate the matter further. Eventually Oliphant was sent to the United States to provide information to the authorities there which he managed to do effectively only after personal contact with his friend, Ernest Lawrence. With the information provided by Oliphant, Lawrence was able to persuade US officials to take the first steps leading to the establishment of the Manhattan Project.

After the war Oliphant returned to continue the building of accelerators in his laboratory at Birmingham. The formation of a new Australian National University was at that time under discussion in Canberra and Oliphant was invited to join a small number of distinguished Australians working at that time in Britain who would form an Advisory Council to plan the new institution. It was hoped in Canberra that the members of the Advisory Council, which included Keith Hancock and Howard Florey as well as Mark Oliphant, would come to Australia as foundation directors of the new research schools to be established at the Australian National University. In the event, only Oliphant accepted the appointment as a foundation director. He came to Canberra in 1950 and began the frustrating task of creating the new Research School of Physical Sciences at a time when constructional shortages and administrative delays made an enterprise of this magnitude most difficult. Although the accelerator that he had planned for Canberra was never built, he succeeded in establishing a broadly based research school which substantially raised the level of Australian research in the physical sciences. Oliphant also played a leading role in the foundation of the Australian Academy of Science, of which he was the first president. When, after relinquishing the directorship, he retired from his last ANU post as a University Fellow, many might have expected him to relax into a well-earned retirement. Instead, Sir Mark’s retirement has been as energetic, productive and varied as many a successful full-time career.

Sir Mark was an outstandingly popular Governor of South Australia. Those of us who were fortunate enough to be in Adelaide during his Governorship, enjoyed the friendly dignity of the Vice-Regal hospitality that he and Lady Oliphant offered. Adelaide must have been at that time the only capital city in the world where visiting physicists were accommodated at Government House. As Governor, Sir Mark stoutly defended the Adelaide Hills, spoke his mind on all manner of environmental issues and, on occasions, lectured his local politicians on the need to smarten up.

During the course of his career, Sir Mark has received numerous honours and awards including Companion of the Order of Australia, Knight of the British Empire, Fellow of the Royal Society, Fellow of the Australian Academy of Science, Fellow of the Australian Academy of Technological Sciences and Engineering, Hughes Medal of the Royal Society, Mathew Flinders Medal of the Australian Academy of Science and honorary degrees from the Universities of Melbourne, Toronto, Belfast, Birmingham, St Andrews and Adelaide, the NSW University of Technology and the Australian National University.

Sir Mark still comes to his Research School for a few hours almost every working day. The School is proud to enjoy the company of its distinguished founder, particularly on Founder’s Day, which was inaugurated to celebrate Sir Mark’s 80th birthday. On the occasion of his 90th birthday, his many friends and colleagues warmly congratulate Sir Mark and wish this great Australian many more happy birthdays.
ON 90TH BIRTHDAYS

In this issue we commemorate the 90th birthday of Professor Sir Mark Oliphant. We also recognize the contribution to Australian physics and science by Sir Mark. His guest editorial in this issue should make us all pause and ponder. Has science in general lost its way in the face of the drive for "commercial" return on the investment in science imposed on us by our "masters" at the Federal and State level? Universities in particular are about the pursuit and dissemination of knowledge. How far has the drive to commercialization, the demand for return at any price, perverted the basic function of a University? CRC's are supposed to be good for research. Are they good for Universities? Are changes to the ARC mission suggested in this year's budget going to lead to further movement away from the basic function of a researcher in a University? Only time will tell, but it may be that what is imposed on scientists in all establishments now will alter significantly the whole culture of research in science into the future.

Sir Mark himself was a fine role-model for both researchers and their students. When I was a member of the Faculties at ANU Sir Mark was a willing contributor to first year lecture programs on a number of occasions. He brought home to the first year class the human and humorous side of the Professor in the Research School.

When Sir Mark officially retired from the laboratory at ANU, the equipment he had put together for charge-exchange studies was, at least in part, given to my group at ANU. We acquired our first 100kV beam system, but more importantly, we acquired a number of beam optics components, particularly quadrupole lenses. While the original system has long since disappeared, except for the occasional ion pump or piece of vacuum plumbing, those quadrupole lenses designed and built by Sir Mark are still integral parts of our system.

The work and thoughts of good scientists endure longer than their equipment. The guest editorial in this issue reflects the fact that sometimes we might need the 90 years of experience of a good scientist to cause us to pause and reflect a little on where our science is likely to be when we are ourselves 90. At the time of Sir Mark's 90th birthday, the future is a little uncertain. Let us hope that, when we are 90, that uncertainty is less and science and scientists have reclaimed control and can determine their own future.

R.J. MacDonald
Honorary Editor

Paul Callaghan Elected Fellow of Royal Society of New Zealand

Paul Callaghan graduated in physics from Victoria University of Wellington and obtained his DPhil in Physics from Oxford University in 1973, the subject of his doctoral thesis being the measurement of hyperfine interactions using oriented nuclei at milliKelvin temperatures. Since joining the physics staff at Massey University in 1974 his research has mainly concerned the use of magnetic field gradients in Nuclear Magnetic Resonance, to measure molecular motion and molecular organisation in polymer solutions and melts, liquid crystals, emulsions, porous solids and biological tissue. He and his research students have developed the methodology of Pulsed Gradient Spin Echo (PGSE) NMR and high resolution NMR imaging to measure nuclear spin displacements on the order of 500A° and nuclear spin density distributions on the order of 10μm pixel resolution. In the last few years he has suggested and developed several new NMR applications. These include Modulated Adiabatic Passage of Oriented Nuclei, a method of measuring very small electric quadrupole interactions; the measurement of polymer reptational tube renewal by rotating frame spin relaxation; the mapping of velocity and diffusion fields by dynamic NMR microscopy; and the imaging of boundary structure in restricted molecular diffusion via a diffractive analogue of PGSE NMR. This latter work featured in this year's June 6 issue of Nature.

Paul Callaghan has authored or co-authored over 70 papers in refereed journals and has written a book on Nuclear Magnetic Resonance Microscopy published by Oxford University Press in 1991. He is a past-president of NZIP and is currently Professor of Physics and HOD of the Department of Physics and Biophysics at Massey University. ✪
Critical Comment!

Dear Editor,

I wish to submit a critical comment on the recent contribution by David Wheeler in the column "Fix on Physics" (ANZPJ, July 1991). I am concerned with the impact of David Wheeler's activities on the practice of teaching physics, that compels me to write. He represents Foundation Studies Certificate Program at Unisearch Ltd. and his views might bring some harm to poor souls trying to cope with physics.

The Motivation for the "New" Method

David Wheeler writes:

"Physics texts (and physics teachers) generally approach projectile motion problems as exercises in x and y components. This leads to some difficulties for students as to what is actually happening. (Are there two motions? What does all the maths mean? Must I solve simultaneous equations?)"

After which he skips the questions and proceeds to expound his method of solution.

Does it mean he goes into a trouble of inventing "a new way" of solving projectile motion problem to avoid those questions? But the purpose of teaching physics is to answer the questions, not avoid them!

The solution method presented by David Wheeler can be called "triangle, protractor and rule" (tpr). Upon investigating "tpr" method one immediately sees that it is the old method (slightly rewritten) minus any attempt to explain physics and that:

- There are two motions (but they are not discussed properly).
- The maths or rather trigonometry (as presented) helps very little to understand physics.
- Two simultaneous equations are solved, but this fact is not explicitly presented to the student.

The relation between the "tpr" and standard method is immediately seen from the following

\[ s = v_0 t \left( i + \frac{gt^2}{2} j \right) \]

\[ = \left( v_0 i + \frac{gt}{2} j \right) \]

\[ = v_0 t i + \frac{gt^2}{2} j \]

Here i and j are the unit vectors in x and y directions.

This will obviously lead to the same results as the "usual" x and y coordinate method. The "tpr" method, which decomposes the projectile motion into the free motion at an angle (as there was no gravitation) and the gravitational fall, is just another mnemonic technique applicable to few special examples. It is mathematically correct but physically, unless properly understood, might lead to some confusion. The free motion component in projectile motion is just the horizontal component x and the student should understand it. It is not "tpr" decomposition that is incorrect it is rather the lack of any attempt to analyse the problem that worries me. One can not expect the students to learn a new trick for each new problem. The teacher should explain the physics thoroughly and equip the students with the computational tools applicable in various different contexts.

Mechanics of Solution

The correct steps to solve the physics problem are:

1. Read the problem. Extract all the information. For example:
   a. "Before stopping the car is moving for 16 s." Notice that the final speed v = 0.
   b. "The gas pressure increased twofold". It means: \( p_2 = 2p_1 \).
   c. "At the constant temperature".

   It means: \( T_1 = T_2 \).

2. List data. (For example: \( h = 2m \), \( S = 15m \), \( \alpha = 350 \), \( g = 9.8ms^{-1} \)).

3. List unknown. (For example: \( t, V_0 \)).

4. Draw the diagram(s).

5. Solve symbolically for unknowns. (\( t \) and \( V_0 \)).

6. Check the dimensions and units.

7. Plug in the numbers and obtain the final numerical result.

8. Reflect a while on your solution. Is it physical?

It is interesting to notice that only points 4 (inadequately, the vector s was not drawn) and point 7 were addressed in David Wheeler's article.

In Example 1 he wrote the solution (obviously as a set of two simultaneous equations):

\[ \tan 35^\circ = \frac{4.9t^2 + 2}{15} \]

Hence \( t = 1.3s \).

\[ V_0 = \frac{S}{t \cos a} \]

(Then dimensions and units here)

Hence \( V_0 = 14ms^{-1} \).

Here I keep all the physical quantities in a symbolic form. The unknown appears on the left hand side of an equation. It is expressed in terms of other (known) symbolic quantities. This expression constitutes the solution to the problem. It is necessary to check units at this stage. If you are satisfied with units and expressions, study them, look at them, think what sort of functional relationships exist in the problem. The Example at hand is obviously trivial, but my suggestions are valid quite generally. My high school physics teacher would give 90% for the symbolic solution and the dimensional analysis and a mere 10% for the numerical answer.

The difference is enormous and not trivial. The symbolic expression represents the physical law or some derivative of it. It contains information on infinite number of possible cases (e.g., dependence of \( V_0 \) on an angle \( a \), dependence of \( t \) on the horizontal distance \( S \) and the elevation \( h \), etc.). It can be analyzed without any recourse to actual numbers. One can study the functional form, local and global maxima and minima, zeros, monotonicity, etc. Whereas, if you plug the numbers right in the beginning, you reduce the function (curve, plane, to a mere point. You just reduced infinity of information to a point! This is also completely contrary to what experimental physicists do. They usually collect data at as many experimental points as possible and extract functional dependence between the studied quantities. >

Continued on page 213
Although the impact of optical fibres on communications has been evident for a considerable time and has placed the “estimates about satellite communications in jeopardy, there has been little discussion in the popular journals and science press about the impact of fibre optics in the field of instrumentation. The immunity of fibres to outside influences i.e. the isolation of the channel from electromagnetic environmental disturbances does not seem to augur well for environmental sensing with optical fibres but the use of fibre optic sensors expands space and on Monday July 8th Professor Gerry Woolsey from Armidale addressed the South Australian Branch on the topic which has been developed by the University of New England over a number of years. An appreciative audience of members, secondary teachers and students were treated to a stimulating lecture which covered the field of the properties and structure of high quality communication fibres to the detection processes that must be employed to interpret the physical changes in the light that accompany environmental changes and external stimuli.

There are basically two types of fibre-optic sensors: the first extrinsic type where the light remains in the fibre and the fibre is itself the sensor. The passage of the laser light along the fibre is modified by the stimulus environmental change which is being detected and measured. The second type is the extrinsic sensor in which the optical fibre relies on its immunity from environmental influences to convey faithfully information from a remote active sensor to a close-by detecting element. The active sensing element may be anything in which the optical behaviour (transmission, refractive index, reflectivity etc.) responds to the stimulus (temperature, pressure, elastic strain etc.) to be measured. It is desirable that the response is a reasonably sensitive function of the stimulus.

Professor Woolsey’s examples, which where accompanied by a happy combination of overhead transparencies and bench demonstrations, covered an interesting range of applications including hydrophones where the sound pressure wave changes the physical length of the fibre and the induced strain modifies the refractive index and optical path length. The fibre is used as one arm of a two beam interferometer, the other arm is a controlled constrained fibre and the technique uses bidirectional couplers to mix the two beams and produce interference fringes to monitor the effective environmental changes. The technique depends greatly on effective bidirectional optical couplers and optical circuit tricks gained from some years of development. The couplers depend on the resonant interchange of energy from the core of one fibre to an adjacent, closely coupled core. Jim Love’s favourite experiment of close-coupled resonant pendulums took its place on the demonstration bench and excited the usual questions from people to whom it was something new. There seems to be a need for lectures to have a good, hard-wearing explanation of this effect without the long mathematical development to which we have all been exposed. It is an energy interchange effect and some variational principle or minimum loss principle is surely involved.

Some time was spent on the fibre optic gyroscope as a rotation detector or ring laser. The essential feature is the operation of a Sagnac interferometer in which two overlapping beams traverse the fibre ring in opposite directions. The rotation of the ring effectively shortens the path taken by one beam when compared with the other. In the interferometer the result is a fringe shift or frequency difference proportional to the rate of rotation of the fibre ring. The experimental ingenuity required to get the light into the fibre was a feature of this exposition. It became evident that the experimental developments involved in this Armidale research and its application to gas discharges gave the lecture an authority which added greatly to the appeal of the presentation. An active researcher will always have much to add to the process of teaching in any subject and lecturers such as this make their own contributions to the wider educational process.

Medical applications of optical fibres using the Doppler effect to measure the blood flow in a vein were another direct contact with secondary school and undergraduate physics which has immediate interest and appeal.

The South Australian Branch congratulates Gerry Woolsey on his travelling lecture and demonstrations and advise that other branches looking for a stimulating, wide-ranging, general interest public lecture should perhaps look towards New England for help. From remarks he made about the cold Adelaide weather, Professor Woolsey is attracted to warmer climates.

Bill Boundy

Developments in Australian Earthquake Seismology

Dr Gary Gibson

Seismology Research Centre
Phillip Institute of Technology
Bundoora, Vic

At the June meeting of the Victorian Branch of the AIP, members were addressed by Dr Gary Gibson of the Seismology Research Centre, Phillip Institute of Technology, on the topic of Developments in Australian Earthquake Seismology. This is an area of Geophysics which has touched the lives of many people as two recent large events on the earthquake scene in Australia, at Tennant Creek and Newcastle, have focussed attention on the vulnerability of east coast cities to earthquakes. The large Tennant Creek earthquakes in January 1988, for which aftershocks are still continuing, caused some of the largest surface movements of any earthquake anywhere in the world. The Newcastle earthquake of December 1989, although of smaller magnitude, resulted in the most expensive natural disaster to hit Australia. As a result of these two events, most of Australia is now covered by earthquake building code requirements. Previously parts of Western Australia and Adelaide were the only areas subject to some form of earthquake building code.

Earthquakes have caused 2,662,000 deaths between 1900 and 1976, more than twice the number, 1,287,650 attributed to floods.

Australia has shallow earthquakes. The largest reported earthquake was on 10th May 1897, Magnitude 7, off Kingston, South Australia.

Australian & New Zealand Physicist Volume 28, Number 10, October 1991
Earthquakes in Australia are due to compression and thrusting. All along the east coast of Australia the mountains are being squeezed up. In Victoria the compression is from the south east. Recent development in earthquake seismology and engineering have been due mainly to the introduction of digital recording. Time and frequency domain studies as well as triggered recording systems have facilitated recent advances in earthquake prediction. Reliable remote station networks are now possible at greatly reduced costs. Because of the reduced cost of networks and their increased sensitivity seismic studies are now being applied to dam stability. In general dams have faults dipping down underneath. The increased pressure of a full dam of water leads to increased incidence and severity of earthquakes. Dams have a fundamental mode of vibration which helps to magnify the seismic oscillations. These oscillations are enhanced by the presence of winds.

The talk concluded with a discussion of the plane horizontal waves and the shear waves and their relative contributions in the alluvial soil of Newcastle to the destruction of unreinforced masonry.

Dr Elizabeth A Essex

Letters continued from page 211

The pedagogical implications of those two methodologies are important. The student taught the "plug the numbers first" method solves the arithmetic/trigonometric "problems" and learns absolutely nothing about underlying physics. He or she might solve hundreds of "plug the number" problems and still have no idea what is going on.

On the other hand, as long as one deals with the symbolic expressions, one is capable of extracting general physical features of the system. This is the only way to build the physical intuition (apart from doing the experiment).

Problems

Here I list some problems for projectile motion that might be quite hard to solve using "tpm" method.

1 A ball is thrown with the initial speed $v_1$ at some angle $\alpha$. What is the angle $\phi$ that will optimize the horizontal range $x$?

2 The ball is thrown in a sports hall with the initial speed $v_2 = 20 \text{ms}^{-1}$. The height of the hall is $H = 8 \text{m}$. What is the greatest horizontal distance $x$ for such a throw, if we require that the ball does not touch the ceiling. What is the initial angle $\phi$. Assume that the ball is thrown from the height negligible in comparison with $H$. Disregard the air friction.

3 Two bullets were fired horizontally from the identically aimed rifle to a perpendicular target 50m away. Because of random differences in the charges, the initial speed of one bullet was $320 \text{ms}^{-1}$ and of the other one was $350 \text{ms}^{-1}$. What is the vertical distance between the bullet marks on the target?

4 A bullet was fired at an angle $\alpha = 60^\circ$ to horizontal with a speed $240 \text{ms}^{-1}$. It hit a a point 500m above the horizontal level. What is the horizontal distance to this point? What is the time of flight?

5 A bomber plane is diving along the straight line at an angle $\alpha$ to the horizontal, with the velocity $v$. The pilot intends to throw the bomb at the height $H$ and hit the target. What is the horizontal distance from the target at the moment of bomb release? Disregard the air resistance.

6 The artillery is standing on the hill of height $1 \text{km}$. The shells are fired with the initial velocity $v = 700 \text{ms}^{-1}$ at an angle $\alpha = 30^\circ$ to the horizontal. What is the horizontal range of artillery? Disregard the air resistance.

The problems 2-6 are taken from the Ukrainian Collection of Problems for High Schools by S.U. Gonczarenko.

Marek Michalewicz
Gordon Godfrey Workshop on Strongly Correlated Electronic Systems

JOHN DOBSON

Quantum Hall Effect phenomena. Later lectures from Dung-Hai used the language of field theory to discuss duality of vortices and particles, and to introduce the 'Quantum Hall Liquid' as a self-dual phase.

The lecture series by Alan MacDonald (Indiana U) was nicely complementary to Lee's series, also covering quantum Hall effect, anyons and high-Tc superconductivity from a more microscopic approach stressing many-body wave functions. These two lecture series, and the discussion between the two speakers, were really an eye-opener for me. One point on which both speakers seemed to agree was that anyons are probably not relevant to the known high-Tc superconductors, but are quite useful in describing the Fractional Quantum Hall Effect.

We are lucky to have here in Australia what is arguably the world's leading experimental group on high-magnetic-field effects in two-dimensional systems. Bob Clark, the group leader and recently-appointed professor of experimental physics at UNSW, gave two lucid lectures on experimental aspects of the Fractional Quantum Hall Effect (FQHE) and magnetic-field-induced Wigner crystallisation. He presented relevant theory at a very satisfying level, too. We also had the opportunity one lunchtime to visit his laboratory and see remarkably clean FQHE data coming off the rig.

Another lecture series hinging on high magnetic fields was given by Mare Rasolt (Oak Ridge National Lab) who has discovered that a new superconducting phase should exist at very high magnetic fields. This is quite remarkable since a high field is usually assumed to be detrimental to superconductivity, both in its effects on orbital and on spin configurations. After two lectures in which the conventional wisdom on superconductors was carefully and critically presented, the new high-field theory was presented. The predicted effect has the best chance of observation in certain semiconductors.

Quite different in subject matter but equally elegant were the lectures by Peter Fulde (Max-Planck Institut, Stuttgart) on electronic correlation in molecules and solids. Starting from a local-orbital, chemical style of approach, he moved on from finite-sized model systems to Kondo effects in f-band metals and to heavy-Fermion superconductors. In his final lecture he advocated a new type of expansion around the highly-correlated limit where conventional diagrammatic perturbation theory is cumbersome or impossible because the operators involved are spin-like and their commutators are therefore not commutative, invalidating Wick's theorem. His solution to this problem, involving cumulant expansions and the Mori projection operator technique, was surprising to me as I had heard of such approaches for dynamic response but not for total energies and groundstate properties. His method also stimulated interest among those working on Hubbard and Heisenberg problems.

A subject dear to my own heart is the Density Functional Theory, which provides, in principle, a simple but useful approach to many-body systems in which the density, rather than many-body wavefunctions, is the stock in trade. Wally Geldart (Dalhousie U, Canada) gave a three-lecture series on this subject. A true showman, he managed to throw the graduate students into quite a spin by extolling the amazing virtues of the general Hohenberg-Kohn density functional. Only in his second lecture did he bring them down to earth by pointing out that, in practice, we only have very crude approximations to this remarkable animal. He followed with an interesting critique of local density and density-gradient approximations, an area in which he has made significant contributions.
PHYSICS EMPLOYMENT IN 1990
How are physicists faring in a time of recession?

John R. Prescott

This is the twelfth in the series of employment surveys carried out by the author for the Australian Institute of Physics. They are based on positions advertised in the Weekend Australian and in the Higher Education Supplement of the Australian on Wednesdays. The general principles of the surveys were set out in considerable detail in the first report in the series (Prescott 1980) and the data for the first decade were summarised in 1988 (Prescott 1988). These references can be consulted for the historical data, for detailed discussion of some of the ground work which led to the ideas behind the surveys and for an indication of changes both in the surveys themselves and the employment patterns that they reveal.

In general, the positions are those for which a degree in physics or applied physics or a diploma in applied physics is a suitable training, even though this may not be explicitly stated in the advertisement. In many cases further training would be expected, e.g. for teaching in secondary schools or where a higher degree qualification is stated or implied in the advertisement.

Most of the advertisements in The Australian call for an honours degree or post graduate qualifications. Positions for which an ordinary degree or diploma in physics would be a suitable qualification are mostly to be found in the local press. For example, twenty or so positions were advertised only in the Adelaide Advertiser in 1990 (down from about 40 in 1989). In the past, these ‘local’ advertisements in the main metropolitan dailies have accounted for as many positions again. However, in the 1983 recession the number of such places fell disproportionately and, if the evidence of the Advertiser is anything to go by, the same will be true for the present one. This will be discussed further below; and “recession” provides an underlying theme for the present survey.

A number of firms recruit new graduates at interview sessions on campus and do not advertise, and it is known that Western Australia is marginally under-represented. The present survey, therefore, really represents a lower limit to the opportunities for employment for physics graduates, although it probably accounts for most of the positions which would be regarded as for ‘professional’ physicists, in the sense that the A.I.P. would recognise.

No positions are included that call for membership of the Institution of Engineers, Australia, even when it is clear that a physicist would make a suitable appointment. It is not uncommon for an advertisement to state alternative qualifications. For example an increasing tendency has been noted for the position to be described as ‘physicist/engineer’ or vice versa. Acceptance of alternative qualifications may either represent an increased recognition of the possibilities of physics graduates or, taking a different view, that there are not enough physicists and engineers with the relevant qualifications to go round.

One of the observations arising from these surveys in recent years has been that the number of physicists produced in Australia is not enough to satisfy the demand for graduates; and the evidence has been fairly convincing. There is still a widespread, but false, impression to the contrary. Student advisers will be familiar with the fact that many students are not familiar with opportunities and that it is never too early to put the claims of physics as an employment opportunity as well as a satisfying profession. As will be shown, the demand for physicists has remained firm in spite of the economic climate.

The statistics for 1990 are shown in the table, where they can be compared with those for the previous four years. The data for 1983 (the previous recession) are also included. The total number clearly shows the effects of the current recession and is down significantly from 1989. The DEET Skilled Vacancy Survey also shows this pattern for scientists as a group. From the point of view of science in general and physics in particular, the fall-off first became evident after the middle of the year, whereas the demand for trades was already falling at least six months earlier and has fallen much faster and further.

Figure 1 shows total job advertisements from the ANZ Bank Employment Advertisement Series, data for ‘Trades’ from the DEET Survey and data taken from the present surveys. The ordinate scales show the monthly numbers from the ANZ Series on the left and for annual physics employment on the right. They are normalised to each other in mid 1985. The DEET figures, which are relative, are normalised at the same point. In order to show recent trends, the data for the first quarter of 1991 (at an annual rate) are also included.

While the economic picture revealed by these data is bad, they nevertheless offer some unexpected encouragement to those who hope to follow a career in physics. The figures shows that the demand for physicists remains remarkably steady whether the economy is growing or falling. Further, comparison with other DEET survey figures show that the job market for physicists is much better than for most other classifications of employment (including accountants!). The table and figure 1
allow a comparison of the 1990 recession with that in 1983. It appears that in 1990-91 it is deeper and may well last longer.

One of the more interesting features of the job market for physicists has been the stability over time of its structure as expressed, for instance, by the relative proportions of each class of appointment. During the recession of 1983 the total number of positions fell hardly at all, but there was a rearrangement of the proportions within the total, largely because of a reduction of the number of positions offering in commerce and industry and by strong recruiting by the Defence Science and Technology Organisation (DSTO). Judged by the standards of the physics employment surveys, the current recession is deeper than the one in 1983 because recruiting is down in all areas except CSIRO and for research in Higher Education.

The firm demand for physicists in CSIRO is something of a surprise and, what is perhaps even more surprising, the proportion of indefinite term appointments has gone up in a quite spectacular fashion: almost three quarters of the jobs on offer were permanent, compared with the long term average of about one third. This is because of a new Industrial Award with tenure (permanent employment) provisions, which has dramatically reduced the number of temporary or contract appointments. It is now assumed that an appointment will be permanent unless a special case is made for it to be temporary. Since about November, advertisements for positions in CSIRO have indicated the term of appointment only when it is not indefinite. CSIRO has also adopted a new, more attractive advertising style.

The fields of appointment within CSIRO are also of some interest. About 25% were for atmospheric physics and/or water resources, about 20% for wool research, 10% for mineral resources and, in addition, a wide variety of positions for very practical projects were advertised.

Advertising for Defence (mostly for the various Laboratories of DSTO) was down considerably. This was also due in part to a change in policy which limited recruitment, not to a numerical establishment, but to a dollar figure. It was noted in passing that DSTO were seeking a new Chief Scientist. It will be interesting to see whether DSTO takes new directions in consequence.

Other Commonwealth Government recruiting covers a great diversity of fields, but is also down. Apart from Hospital and Medical posts, State Government organisations do not advertise much in the national press; they were down to about 60% of the 1989 figure.

With the abolition of the binary system of higher education, the distinction between Universities and Colleges of Advanced Education has formally disappeared. In Higher Education the table distinguishes between academic appointments that involve some element of teaching and those that are mostly for research. The 'teaching' category will become of increasing significance in the not very distant future as retirements deplete the academic ranks. This time had not yet come in 1990, as evidenced by the fall in tenurable appointments to 32, which is barely 50% of the 1989 figure. There were eight Chairs including four(!) at ANU. Including limited term appointments, teaching posts fell from 116 in 1989 to 79 in 1990. ▶
These figures should give rise to serious concern because I do not believe that they represent even replacement numbers, let alone the new staff that ought to be employed to take account of the additional student places provided by the Dawkins universities. Teachers in institutions of higher education will need no reminding that their teaching loads have gone up.

On the other side of the coin, research-type appointments in the universities are steady, reflecting a considerable number of ARC-supported posts - a big plus for the ARC. It is also interesting to see a significant number of postgraduate awards for specific purposes, often with a premium stipend. These, of course, do not count as 'jobs' for the present survey although the pay is sometimes comparable.

The category, Technical and other, contains a wide variety of positions, mostly at the first degree level, and all 'professional officers', including those appointed to assist with specific research projects. However, this category was also down to 40% of its 1989 level. A number of organisations, particularly DSTO and Telecom, advertise both general and specific jobs. It may be indicative of undersupply of physics graduates that the "general" advertisement has become more common in recent years and is still appearing even in recession conditions. The formal job count includes only advertisements for specific positions.

The entry for physics Teaching shows yet another fall, first noticed in 1987 and stands at about half of the long term.

### Advertised Positions in *The Australian*

**All jobs advertised in *The Australian* for which a degree in Physics or Applied Physics or a diploma in Applied Physics provides a suitable starting point. All subdivision figures are percentages.**

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<td>38</td>
<td>35</td>
<td>78</td>
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average. This covers only the independent schools but the situation in the state schools is believed to be similar. It was suggested last year (Prescott 1990) that some of the smaller schools are no longer offering physics at year 11 level and/or that larger schools are teaching fewer classes and it was suggested that the higher salaries of the commercial world vis a vis science were having an effect on student expectations and choices. One wonders whether the recession will result in any change of attitude.

Private Industry/Commerce is down but, rather surprisingly perhaps, not as much as in 1983 nor as much as some other areas. In part this is due to vigorous recruiting by Telecom, OTC and other firms concerned with communications. BHP was not offering quite so many opportunities in 1990 and very few were being sought for Sales.

The category, Industry and Commerce, together with Geophysics has been a fairly sensitive indicator of the state of the economy throughout the present surveys. For the first time both these categories seem to be resisting the trend. In passing, it should be mentioned that 'geophysics' is included, not withstanding that it is usually classed with the Earth Sciences in Australia. These positions are not included in the formal count, even though 'physics' is often listed as a sufficient qualification. It is interesting to note a slight shift in emphasis from oil to minerals.

Overseas positions are, of course, only those advertised in Australia. They are mostly in New Zealand and our other immediate Pacific neighbours. Since the journal that carries this article is now published jointly with the New Zealand Institute of Physics, it may be noted that eleven out of twenty eight Overseas positions were in New Zealand.

Across the board, for some 30% of the positions, a PhD was a stated or preferred requirement - some 190 positions. About half these positions were permanent. As has been the case for the past few years the annual output of Australian Physics PhD's is about sixty. As pointed out last year, this implies a rough balance between supply and demand and, as noted above, great opportunities for physicists in the not too distant future.

An interesting development over the past two or three years has been the increasing demand for scientists to construct mathematical models. Such posts are not just for computer programmers; in most cases a solid background in physics and/or mathematics, often at PhD level, is an obvious requirement. There was quite a variety of topics, ranging from smoke dispersion in building fires, through thixotropic flow to remote sensing. The majority of the posts were in atmospheric physics or water resources. In round figures, there were fifty posts for modellers.

A list of all positions surveyed, classified by fields, and giving the employer, the job classification, a brief job description, whether a PhD is specified, whether the position is indefinite or limited term, and the month of the advertisement, will be sent to all Australian physics departments, to careers officers in tertiary institutions and to government employment agencies. Copies are available to interested persons from the author.

Thanks are due to Dr R.A. Akber for suggestions that have materially improved the collection of the data and have made possible the publication of this survey much earlier than in recent years.

References


CONFERENCE REPORT continued from page 214

In addition to the lecture series there were a number of one-off talks. Sam Bose (Drexel U, Philadelphia) presented RPA calculations on a model structure consisting of a stack of two-dimensional electron-gas layers. He showed that the acoustic plasmons arising in such systems of separated polarisable regions can give rise to strong intra-layer Cooper pairing, with possible relevance to the now-famous layered Cuprate high-Tc super-conductors. Suryo Behera (Orissa U, India) used the slave Boson method to solve Hubbard models and hence discussed Hall effect phenomena in strongly correlated systems.

Matthias Troyer (ETH Zurich, Switzerland) discussed Monte Carlo simulations of low-dimensional quantum spin systems. David Nielson (UNSW) discussed the possible appearance of charge density waves in structures formed from two-dimensional electron gas layers. This workshop differed from the usual conference in that most of the talks were pedagogical in intent. Nevertheless, because of the difficult subject matter, it is quite likely that some of the talks went over the heads of the students in the audience. Even so, the excitement of the field was apparent even in the more difficult lectures, and this stimulated attendees to try further readings from a typed list provided by the speakers.

The whole affair was well-organised, including a harbour cruise, a conference dinner and a number of other nice little touches such as ceramic mugs with attendee's names blazoned on the side, to replace the usual styrofoam affairs.

Congratulations to David Nielson and his colleagues from UNSW and Mukunda Das from ANU, who jointly did most of the work.

My week away reminded me what an exciting and current field condensed matter theory really is, involving many beautiful concepts reminiscent of high energy physics, yet having direct application to today's high-technology industries. This is well understood overseas, as evidenced by the volume of work coming out, and we need to get this point across to Australians, particularly to potential students! The Correlated Electrons Workshop and an earlier Condensed Matter Workshop held at ANU in 1989 should help in this regard, and I hope to see more such gatherings before long.

Those who wish they had attended can remedy the situation by contacting David Nielson on phone (02) 697 222 or fax (02) 662 7471 at the UNSW Physics Department for information about the proceedings volume, which will be published shortly by Nova Press.
Charles Norman Watson-Munro, who had a very varied and distinguished scientific career, both in government laboratories and in universities, died peacefully in hospital, in Melbourne, on August 10, 1991.

Charles was born in Dunedin, New Zealand, in 1915. After a brief period in England from 1919-1921 his family returned to New Zealand, living first in Lyall Bay and then Lower Hutt, where Charles received his early education. The family was not affluent and whilst at high school Charles helped out, for example, by selling honey from door to door. His university studies at Victoria University, Wellington commenced part-time, while he was a lab. boy and apprentice instrument maker. He graduated Master of Science with first class honours in 1937. The same university, later in his career, was to award him a D.Sc.

Whilst studying at University Charles joined the Department of Scientific and Industrial Research (D.S.I.R.) and worked on a variety of physics problems. He continued with D.S.I.R. after his graduation and worked till 1939 in the field of geophysics. At the start of the Second World War, he joined a team engaged in radar development and, after a period at Massachusetts Institute of Technology from 1941 to 1942, returned to New Zealand to become the Director of the New Zealand Radar Development Laboratory. In 1944, with the rank of Major, he took part in amphibious operations in the Solomons with U.S. marines using New Zealand radar equipment. His wartime work on radar was recognised with the award of an O.B.E. in 1946.

In 1944 he was sent to Canada to work on the development of nuclear energy. Whilst there he played a major role in the building of the first nuclear reactor in that country. During this period he met his wife-to-be, Yvette. In 1946 he transferred to the Atomic Energy Research Establishment at Harwell in England, and, as Principal Research Officer, was responsible for the design and construction of the first nuclear reactor in Britain. He returned to New Zealand in 1948 as Deputy Head of D.S.I.R. and in 1951 became Professor of Physics at his alma mater, Victoria University where he carried out research on cosmic rays. He moved to Australia in 1955 to take up the position of Chief Scientist with the Australian Atomic Energy Commission and was responsible for the construction of the reactor at Lucas Heights and for the development of the laboratories at that site.

His love of research and his interest in the new field of thermonuclear fusion led him to take a substantial reduction in salary to become Professor of Physics (Thermonuclear), later renamed Plasma Physics, at the University of Sydney in 1960. During most of his twenty years on the staff of this University he worked with a series of low temperature linear plasma devices, the SUPPER machines. At the time of his retirement in 1980 the research tokamak, TORTUS, designed to investigate high temperature plasmas, was nearing completion. His contributions to the research activities of the School of Physics extended beyond plasma physics. He was the prime mover behind the successful work in solar energy which led to the formation of the Department of Applied Physics within the School. His involvement with solar energy research continued after his retirement through his appointment as Energy Consultant to the Science Foundation for Physics from 1981 until 1985.

Charles had exceptional organisational and administrative skills. He was without peer as a committee member and made a substantial impact on many activities of his University through this medium. He also contributed greatly to the development of Australian science by serving on numerous Government committees and by representing Australia overseas. He was, for example, a Councillor of the Australian Institute of Nuclear Science and Engineering from its inception in 1958 until his retirement, and its President from 1967 to 1968. He served on the Australian Research Grants Committee from 1969 to 1973, on the Australian Ionising Radiation Committee from 1974 to 1978, on the National Energy Advisory Committee from 1977 to 1980, and on the National Energy Research, Development and Demonstration Council from 1978 to 1981. He was a Fellow of the Australian Academy of Science and represented Australia on the International Fusion Research Council from 1968 to 1980.

Charles will be long remembered by those who were fortunate enough to know him. His loyalty to his staff was legendary. His concern for the future of his students led, through his worldwide network of friends and colleagues, to the launching of many careers. He had a well developed sense of mischief and a healthy disdain for bureaucracy, particularly that located in Canberra. He was a non-judgmental man. For him the important thing was to tackle problems and to get things done. In his youth he was a dedicated mountaineer and throughout his life he continued to scale mountains, both literally and figuratively, encouraging others to do likewise.

Charles' health deteriorated markedly over the last few years of his life, particularly after the death of Yvette with whom he enjoyed a close and loving relationship. His friends were saddened to see him become physically, a shadow of his former robust self. He is survived by his son, Tim, and three grandchildren.

Assoc. Prof. J. A. Lehane  
Australian & New Zealand Physicist Volume 28, Number 10, October 1991
COOLING AND TRAPPING OF IONS
Towards A Better Atomic Clock

P. E. Ciddor

Laser spectroscopy has evolved recently to the point where studies can be made of the ultimate simple system - a single atom or ion at rest in a field-free space for an indefinite period. The scientific knowledge to be gained from such a simple system is immense; it includes ultra-precise values of transition energies and some quite fundamental tests of quantum mechanical concepts. There are several excellent reviews of research in this area, including an article in the recent issue of the Physicist; see Further Readings for details.

On a more practical plane, a single unperturbed atom constitutes a superb frequency reference for a clock. If the system is modified to consist of a few atoms, the interactions between them can be studied in remarkable detail, and quite novel quasi-crystalline structures are observed.

This article outlines a new research project in the CSIRO Division of Applied Physics whose objectives are somewhat different from those of the other Australian groups working in this area. It is aimed at strengthening our existing expertise in both laser technology and microwave frequency standards. This project is expected to be the Division's major activity in standards-related research for some years, and will involve the appointment of new staff, in addition to substantial redeployment of existing staff. A major and attractive feature of the project is the planned collaboration with other CSIRO groups and particularly with several university groups in Australia.

Current Atomic Clocks

The Division of Applied Physics operates two hydrogen masers, which are among the most stable frequency standards in the world, and also has several commercial caesium clocks. The practical aim of the new project is to develop a better atomic clock than the masers. The principle of any atomic clock is simple - take one atom, probe it with light or radio waves of variable frequency, and when the atom responds by absorbing or emitting some radiation you know that the frequency or your source matches that of the atom. The practice is a little more complicated. Atoms generally move about very rapidly, with the result that their absorption frequencies are shifted and broadened by Doppler effects. Also, single atoms don't absorb or emit much light, so you may need a small cloud of them. Making an oscillator with a stability that matches that available from suitable atoms is very difficult. Most current atomic clocks use a beam of caesium atoms and a combination of electric and magnetic fields to detect when a hyperfine transition (at about 9 GHz) is induced by a signal derived from a quartz-crystal oscillator. Hydrogen masers are active devices that oscillate at a resonance frequency of about 1.4 GHz (the famous 21 cm line or radio-astronomy). In the optical part of the spectrum, frequency standards consist of lasers tuned to absorption or fluorescence lines in small molecules (typically iodine, methane or carbon dioxide, depending on the wavelength region).

Limitations of Present Clocks

Both caesium clocks and laser clocks are subject to offsets and line-broadening arising from Doppler effects of the first and second order, and various schemes are used to reduce the effects of the molecular motion. Present technology yields clocks that are reproducible to a few parts in 10^9 in the microwave region of the spectrum, and to better that 1 part in 10^10 in the visible spectrum (the short-term stabilities are even higher). However, devices using isolated atoms or ions are expected to improve on these figures by a factor of 100-1000; indeed, experimental results at several laboratories indicate that these improvements are practicable.

Why are such extreme accuracies needed? The demand at present comes from two main applications. One is long-distance communication, particularly computer networking, which requires accurate synchronization of the sending and receiving systems; this can only be achieved by having absolute frequency references at each end, with as high an accuracy as possible. The second demand comes from precise navigation and surveying, both terrestrial and extraterrestrial. Frequency metrology shares with thermometry the characteristic that

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industrial demand is always ready, and indeed, anxious, to apply advances in available technology.

**Trapped Atoms or Ions as Frequency References**

The new devices that have been investigated in recent years are akin to the caesium clocks or laser frequency standards, in that the atomic system is used as a passive resonator, rather than an oscillator. They will therefore require the development of oscillators that are quiet enough to match the precisions available from the atomic references. This will be one of the major themes of the CSIRO project, and may involve extensive research on improved microwave oscillators.

The key to improved frequency stability and resolution is to minimize all perturbations of the atomic resonator. If ions are used, this requires that they be confined in a region of minimal electric or magnetic fields, and for either ions or neutral atoms it is necessary to reduce the velocity as much as possible. Also, the interaction time between the radiation and the atomic system must be long, so the system must be confined within the beam of radiation for a long time, and, of course, the transition used must be very narrow, which implies that it must have low probability.

All these conditions are best fulfilled by a neutral atom with a transition in the optical spectrum, and several groups in standards laboratories overseas are exploring such systems. There is also some work on the spectroscopy of such systems going on in Australia, and we hope to interact with the relevant groups. However, we intend to start our project with an ionic, rather than atomic, system, and to study a microwave, rather than optical, transition. Our choice of a microwave transition follows from the immediate need for improved RF standards and the great technological difficulty of relating optical and microwave frequencies with adequate accuracy. However we do not rule out a later move to an optical standard. The decision to use an ionic system is based on the relative ease with which ions can be trapped and manipulated by electric and magnetic fields. It is certainly possible to slow ions and to confine them by irradiating them with three pairs of counter-propagating laser beams, and we may investigate this scheme (sometimes known as 'optical molasses') later in the project.

**Ion Traps**

The first step in producing an isolated small cloud of ions is to trap them in a small volume, typically less than a millimetre in diameter. The pioneering work of Paul and Deutsch in this field was recently recognised by the award of a Nobel Prize. Of the various traps that have been developed, the most popular at present is the Paul trap, in which RF and DC electric fields are applied to hyperboloidal electrodes. This scheme avoids the use of magnetic fields, which can produce significant Zeeman shifts. There have been several major advances in the design of such electrical traps in the last few years, but there is scope for further improvements. Trade-offs are available between the number of trapped ions with each other and with the confining fields. (A cloud of about ten thousand ions, is commonly used to improve the statistics of detection of the transition.)

The residual thermal and RF-driven motions of the ions result in significant Doppler effects. As shown by Dicke, the first-order effect, which results in a broadening of the clock transition, can be eliminated by confining the ions to a region whose diameter is less than half the wavelength of the probing radiation. The second order Doppler effect, or time dilation produces a downward shift of the resonant frequency. This systematic error in the clock frequency can be reduced to 1 part in $10^4$ by slowing the ions to temperatures of a few kelvin. Such low temperatures have in fact been achieved by a technique called "laser cooling". This technique involves irradiating the ions with a beam of light from a laser that is tuned to slightly below the frequency of a resonance line of the ion. A simple explanation of the cooling process is given here; a more elaborate theory accounts for the unexpectedly low temperatures achieved when standing light waves are used instead of travelling waves. The laser light can only be absorbed by an ion that is moving towards the source of light at the velocity that Doppler shifts the light into resonance. After a short time the ion emits the excess energy (i.e. it fluoresces) at the frequency of the line-centre.

However, this re-emission occurs in a random direction, and so over many such fluorescent cycles there will be a nett loss of momentum along the axis of irradiation. This loss is very small, typically about $10^{-6}$ of the momentum of the ion, but in one second the ion may undergo $10^6$ to $10^7$ such cycles of absorption and emission, losing most of its momentum in the process. One function of the trap is to confine the ions so that these repeated absorption cycles are possible. As the ions are slowed they will resonate with higher frequency light, so it is desirable to provide either a frequency-chirped beam or light with a relatively large bandwidth, perhaps a few megahertz. Cooling in the two orthogonal directions could be achieved by filtering the laser beams, but in practice collisions between the ions suffice to reduce the motion in all directions. This process is remarkably effective; temperatures below $10 \mu K$ have been reported for atoms cooled by this technique; these temperatures are far below those found anywhere else in the universe, even in interstellar space.

In RF traps containing many ions the mutual repulsion of the ions forces some of them into regions where they are driven by the applied RF field. There is much work being done to design traps that optimise the balance between number of ions and the resultant heating of the ion cloud. Nevertheless, with present trap designs, the potential accuracy of a clock based on laser-cooled ions is about $1 \times 10^3$ in the microwave region, and perhaps $1 \times 10^4$ in the optical region. While it is difficult to grasp such extreme accuracies, there is no doubt that use will be found for them, provided oscillators of sufficient quality can be developed.

**Research Topics**

I shall mention some of the problems that are of immediate interest and that offer particular scope for innovation.

1. The design of ion traps is a relatively new field and we already see scope for novel approaches. We expect major support for this work from Dr. Brian James of Sydney University's Plasma Physics Department.

2. Most previous work has relied on tunable dye lasers pumped by large argon lasers, but recent developments in diode lasers make their use very attractive. We have some

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3. Non-linear optical materials are the key to frequency doubling and mixing; this is relatively unfamiliar territory for us, but fits well into our general interests.

4. Ultra-stable microwave frequency sources are an ongoing theme or our standards work, and innovations based on cryogenically-stabilized cavities are possible, based on Dr. David Blair’s work at the University of Western Australia.

5. Laser cooling is a recent and powerful technique that is still not fully understood. There are certainly avenues for research in this field.

**Conclusion**

We have already discussed collaboration with several groups in Australia, and have made contacts with overseas workers. This report will, we hope, strengthen the ties between CSIRO and academia in optics, laser physics, and the relevant fields of electronics. Its establishment has been warmly welcomed by the external committee that advises the Division on its Standards activities, and also reaffirms the commitment of CSIRO to a vigorous research program in support of its statutory responsibilities for the national standards of physical quantities.

**Further Reading**


Dicke, R. H. (1953) The effect of collisions upon the Doppler width of spectral lines *Phys. Rev.* 89 3472


Thermal Mapping from a Road Safety Perspective

What is Thermal Mapping?
Thermal mapping is a process by which the road surface temperature pattern is surveyed under a variety of weather conditions. Using a vehicle equipped with an infrared thermometer and data logging equipment, road surface temperatures are measured and recorded at regular intervals of distance, not time. Results are displayed using multi-coloured temperature graphs called Thermal Fingerprint and color coded temperature maps called Thermal Maps and are evaluated in a detailed technical report.

What is the objective of thermal mapping?
The objective of thermal mapping is to develop an understanding of the road surface temperature patterns that will develop under the influence of various weather conditions. This allows the maintenance engineer to relate one section of roadway to any other section within his mapped road network.

When is thermal mapping carried out?
Thermal mapping is carried out during the winter months when foliage is no longer present on deciduous trees. Data is collected during the night after pavement temperatures have stabilised (cooling has reduced to a moderate rate) which occurs approximately six hours after sunset and continues through to sunrise. Data is collected under constant weather conditions so that the effect of weather can clearly be determined by comparing data from nights with differing weather conditions (data is segregated by weather class).

What are the spatial and temporal relevancies of thermal mapping?
Thermal mapping information represents the pattern of road surface temperatures that develops on a winter's night, and is therefore only applicable during those times. Each road network may be divided into separate climatic domains and thermal mapping is conducted and related separately for each domain. Thermal mapping can only be applied to those roadways that have been surveyed in a thermal mapping contract.

Where can thermal mapping be applied?
Thermal mapping can be applied to any road network that experiences freezing conditions during the winter months. Thermal maps have been developed for urban, county, and state level authorities in both maritime and continental climates. It is most effectively utilised in environments that have frequent freeze/thaw cycles, however authorities in cold continental climates have found much use during the early and latter stages of their winter season when temperatures are frequently near freezing.

What influences a road's surface temperature pattern?
There are several factors that influence the development of a road's surface temperature pattern. Road topography, surface structures, urban heat island effects, traffic flow, road construction, and altitude and local topography all influence the radiation balance of a road surface. Weather conditions determine the magnitude of the influence of each one of the above factors. In addition, weather conditions affect both the radiation balance and sensible heat transfer characteristics of a road surface.

How is weather related to road surface temperatures?
Weather plays a very important role in the development of the road surface temperature profile during any given winter's night. Weather conditions assist in determining the amplitude of temperature extremes that may be found along a stretch of road. Wind plays a key role in transferring sensible heat from one location to another, further influencing the temperature profile. Clouds act as re-radiation bodies, reflecting and self-radiating heat back toward the surface. The major impact weather has on the road surface temperature distribution is in the magnitude of absolute temperatures. A cold air mass may drop surface temperatures well below freezing whereas a warmer air mass may elevate surface temperatures above the freezing mark.

Can thermal mapping be applied towards the installation of road ice detection/prediction system?

One of the many uses of thermal mapping information is to assist the maintenance engineer in locating sensor sites more effectively. Used in conjunction with the engineer's specific past experience, sites can be located in areas that will provide the greatest possible amount of information that can be gained by using a road sensor system. The thermal maps, if incorporated into an ice prediction system, can also be used to display forecasted road temperature patterns.

Are there any restrictions to thermal mapping?
As with any technology there are some restrictions in the use of thermal mapping.

Road Surface Sensors used in conjunction with Thermal Mapping techniques

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PRODUCT NEWS

mapping technology. The information only applies to the roads surveyed during the winter months. Each weather class has its own thermal map, thus the maps can only be applied to their own weather type. Should weather conditions change during the night, there will be a short transition period from one map to another, however the process is easily interpreted. Thermal mapping is only applicable to night-time road surface temperature patterns and can, therefore, not be applied to daytime conditions (although many of the principles hold true during both day and night). No two weather conditions are identical, and thus their impact on road surface temperatures will have minor differences. Thermal mapping is intended to display the average pattern of road surface temperatures for a given weather condition and outline how minor changes will impact the road surface temperature profile. Thermal mapping is most effectively used in regions that experience frequent freeze/thaw cycles. During extended periods of time when temperatures fall well below, or rise well above freezing, thermal mapping information may not be required. However the technology has proven to be invaluable during times when temperatures are hovering near the freezing mark. In maritime climates, this may occur at any time during their winter season which may last between four and five months. In continental climates, this condition occurs in the first and last few months of the winter season. This still constitutes a long period when thermal mapping can be effective and allows resentment winter maintenance engineers with decisions on their roadways.

For more information on Thermal Mapping please contact:
Vaisala Pty Ltd
Unit 4, 8-12 Sandilands St
South Melbourne. VIC 3203
Phone: (03) 696 5699
Fax: (03) 696 5776

Electrophoresis Power Supply

The Bertan Model 2341 high voltage power supply is the ideal choice for capillary zone electrophoresis application. The Model 2341 has a 0-3kV output voltage, programmable 0-400μA load current, user selectable via input logic signal compatible with TTL, open collector and relay logic. If polarity reversal is commanded during HIGH VOLTAGE operation, the unit will automatically turn off, wait for discharge, reverse polarity and then resume high voltage operation at the new polarity but at the same voltage magnitude. (Dual voltage magnitude setting capability, for positive and negative output, can be provided on custom models). The polarity reversing time duration will be less than 1 second, measured from the time of switching to 90% of final voltage.

Specifications include 24 V DC (+5% -2%), input voltage 2A maximum input current, 0-30 kV externally programmable +/- 0.01% voltage regulation input line change 0.05% peak to peak ripple, 0.01% stability per hour, 0.02% stability per 8 hours.

The model 2341 can be economically and quickly modified to satisfy custom applications.

For detailed specifications contact:
Oxford Scientific Pty Ltd
10 Mariel Avenue
Rydelmere NSW 2116
Phone: (02) 638 1244
Fax: (02) 638 0878

High Performance 3-Axis Magnetic Field Sensor

Barlington Instruments (UK) have introduced the MAG03MC, a compact, portable sensor for the measurement of the direction and intensity of static and alternating fields in 3-Axis. Output is in the form of three analog voltages which are proportional to the strength of the fields measured (±10V = ± 100μT).

For further information contact:
Alphatech International Limited
PO Box 33-878
Takapuna
Auckland New Zealand
Phone: 64 9 770 392
Fax: 64 9 309 8314

Leading Edge Discriminator

Utilising the most advanced technology, the Philips Scientific Model 6908 Discriminator boasts a 300 MHz continuous repetition rate capability. The updating feature ensures deadtimeless operation for coincidence application. The most distinguishing feature that sets this unit apart from all others in the market is the variable threshold capability of 1 mV to 100 mV with an operating bandwidth of 300 MHz. Other features include a 15 turn potentiometer to control output width adjustment for 2 ns to over 50 ns. The updating feature ensures a deadtimeless operation for coincidence application, while the double-pulse resolution is an astonishing 3.3 ns for counting applications. The outputs are the current source type with two pairs of negative bridged outputs and two complements. When only one output of a bridged pair is used, a double-amplitude NIM pulse (-32 mA) is generated for driving long cables with narrow pulse widths. The outputs have transition times of less than 1.5 ns and their shapes are virtually unaffected by loading the outputs in any combination.

For full detailed specifications contact:
Oxford Scientific Pty Ltd
10 Mariel Avenue
Rydelmere NSW 2116
Phone: (02) 638 1244
Fax: (02) 638 0878

FieldMaster Laser Power Meter

The FieldMaster is the most popular laser power meter from the range manufactured by Coherent.

It is suitable for measuring both pulsed and CW lasers, providing the energy/power of the laser in a digital or analog form. It is a compact unit which is portable and inexpensive.

There is a complete range of heads suitable for measuring CW lasers from microwatts to kilowatts or pulsed lasers from picojoules to joules covering the electromagnetic spectrum from the UV to the IR. There are also special heads for excimer and copper vapour lasers.

FieldMaster Laser Power Meter

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The design of the detector head means that upon connecting the head to the FieldMaster all the calibration information is automatically loaded from the head to the console. Thus several heads can be purchased, used with the same console, and are readily interchangeable.

For further information contact Teresa Rosenzweig at Coherent Scientific.

**Optical Beam Profiler**

Melles Griot has introduced a precision optical beam profiling system. This scanning slit profiler is designed for the precise measurement of laser beam widths, and analysis of beam intensity profiles. It provides real-time displays of beam profiles as well as temporal analysis of beam positional drift and peak intensity fluctuations. The instrument can measure beam diameters from 20 μm to 8.5 mm with 0.2 μm resolution, along any axis transverse to the direction of the beam. Systems are available with either Silicon (350-1000 nm) or Germanium (600-1800 nm) detectors.

The optical beam profiler features user-friendly beam analysis software and an integral high resolution screen. It is ideally suited to determining the divergence, width, profile and pointing stability of laser beams. It can also be used to fine tune the performance of an optical system.

For further information contact Paul Wardill at:

Coherent Scientific
138 Greenhill Road
Unley SA 5061
Phone: (08) 271 4755
Fax: (08) 271 1202

**New, Compact, High Power Red/Infrared Krypton Ion Laser**

The Innova 330 is the newest member of the Innova 300 family - the new generation of intelligent ion laser systems by Coherent. It is designed specifically to provide high red and near-infrared powers from a small frame laser (1 meter cavity). This powerful red/near-infrared capability is very useful in avoiding low-wavelength absorption in materials and also for reducing fluorescence interference in Raman spectroscopy.

The Innova 330 uses sealed-mirror technology which reduces Brewster window power losses, reduces cavity optical cleaning requirements to two surfaces, provides a polarised output with mode control, and is fully compatible with "PowerTrack" - Coherent's actively stabilised optical cavity. The combination of these features provides hours of hands-off operation in all applications.

For further information contact Norman Jones at Coherent Scientific.

**Non-Contact Laser Vibrometer**

Warsash Pty Ltd is pleased to announce the new line of Laser Vibrometers from Polytex of Germany.

**The Innova®330 - sealed-mirror technology and CPU control - provides 30% higher power and hands-off operation in the red and near-IR regions**

**Melles Griot Optical Beam Profiler**

which, being non-contact, do not add any mass or have any perturbing effect on the vibration mode of a structure under test, a particularly important consideration with small components, sub-systems, or fibres, etc.

Their use is not restricted to small structures, the Vibrometers can be used on displacements of up to 1000 mm and velocities of 1000 mm/s at frequencies from 0.1 Hz to 500 kHz.

In a completely non-contact manner, it is now possible to measure the velocity and the absolute displacement of a point on vibrating structure in a wide range of situations; loudspeaker cones and disk drive arms, biological tissue and space hardware, needle-probes and microelectronic components, computer disks and shafts, fuel pumps and compressors, exhaust systems and brake parts, etc.

Polytex makes it possible to measure vibration from 30 cm up to 30 meters away, through glass or water. The tripod-mountable probe and compact fibre probes are easily positioned in places where optical access is difficult.

Physically different from the electro-mechanical principles of the accelerometer, the laser vibrometry technique permits extremely low displacement measurements on biological hearing structure (e.g. 1 nm at 1 kHz), large, fast motions like auto engine valves (25 nm 60 Hz), high frequency piezo movements (0.1 Angstrom at 500 kHz) and pyroshock (200,000 g at 100 kHz), all with one instrument.

Polytex's Laser Vibrometers represent the union of state-of-the-art mechanics, optics and electronics from high-end laboratory instruments to low-cost systems for OEM and production-testing application.

Further information is available from

Warsash Pty Ltd
PO Box 217
Double Bay NSW 2028
Phone: (02) 30 6815
Fax: (02) 365 0650

_Australian & New Zealand Physicist_ Volume 28, Number 10, October 1991
New Nuclear Physics Text

The success of the electroweak theory, for example, has changed forever the description of beta decay processes and this in turn has altered the presentation of senior undergraduate courses in nuclear physics. Fermi’s theory of beta decay is still useful, but a more basic description of the event as a leptonic quark decay involving the exchange of a virtual W boson, is a very recent development. This means that mainstream nuclear physics texts, such as Harald Enge’s *Introduction to Nuclear Physics* have had their day. Even so, satisfactory replacements are hard to find.

One worth looking at is W.S.C. Williams’ *Nuclear and Particle Physics*, published by Oxford, which is pretty much what its title implies: an equal emphasis on the nucleus as an entity and on its constituent parts. It assumes completion of first courses on quantum mechanics, atomic physics and relativity theory, forming a natural extension to them.

If the particle physics content is not required, a contemporary text by N.A. Jelley, *Fundamentals of Nuclear Physics*, has been put on the market by the Cambridge University Press. Of the two, Jelley tends to offer more understandable explanations, which is the desirable quality in a text. Their treatment of gamma decay is a case in point: Jelley’s presentation is much clearer, with better examples. Williams sometimes throws in one-liners, such as “The effect of the Pauli Exclusion Principle is not sufficient” (to cause nuclear force saturation), with no attempt to explain the reason. This is exactly the sort of statement that frustrates students and is carefully avoided by Jelley.

On the other hand, Williams’ book is very attractively presented with a wealth of tables and explanatory diagrams. The summaries, especially of definitions and keywords, will terrify the text to many students. In my view it would have been great to see included either a table of nuclides or a good nucleide chart to make the text more self-contained. The same goes for Jelley’s volume.

Williams’ last two chapters deal with future developments and applications to astrophysics. These round off the presentation and will whet students’ curiosity and appetite for further study. All told, the amount of material in the book is more than enough for a two-semester course on nuclear physics.

Misprints, the bane of first editions, appear to be few in number but there may well be more lurking in places that I have not yet perused carefully enough.

Another factor which may hesitate acceptance of this book as the nuclear and elementary particle physics textbook for undergrads of the nineties, could be its price. It was quoted as £125. An inquiry of my friendly local librarian revealed English prices of £40 for the hardcover edition and £15 for the paperback. Assuming the quoted price was for the hardcover version it would appear that the paperback will cost around £84, which is dear enough. Even so, it is about what you have to pay these days for a tome of comparable size on computer software.

Nuclear and Particle Physics contains 385 pages in a large 200 mm by 250 mm format and is laid out with wide outer margins, rather like well-known texts such as Halliday and Resnick.

Colin Keay
Book Reviews Editor

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**Reviews**

**Radiation Exchange: An Introduction**

J.H. Taylor
Academic Press Inc
San Diego 1990
xii + 127 pp., US$24.95 (hardcover)

This book provides an introduction to the basic principles of radiation exchange with a main emphasis on the infrared region of the spectrum. It arose from a series of articles published by the Optical Society of America in the journals Applied Optics and Optics News.

The radiation laws of Planck, Wien, Stefan-Boltzmann and Kirchhoff are discussed quantitatively and their implications made clear through descriptions of some classical experiments. The application of these laws to remote sensing including atmospheric and astronomical studies is also discussed. The spectral distribution of radiant energy and its specification by radiometric quantities is carefully presented and the techniques for radiometric calibration are outlined.

Although the subject of radiometry is an old one and its various aspects have received attention in previous books, the value of this exposition lies in the way the ideas are explored within the context that everything radiates to some degree. The style of presentation conveys the enthusiasm of the author for his subject very effectively and succeeds in showing the relevance of the concepts to topics of current interest such as the greenhouse effect and the exploitation of solar radiation. This book is likely to be of particular interest to readers interested in acquiring a grasp of the physical basis for such applications.

Rod Tobin
Department of Physics
Monash University

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**The Conscious Universe**

Menas Kafatos & Robert Nadeau
Springer Verlag, New York 1990
x + 214 pp. dm 49.80 (paperback)

This book is the result of a dialogue... between a physicist who specialises in astrophysics,... [Kafatos], and a student of cultural history... [Nadeau]. (p.1). It begins with a review of elementary quantum mechanics and concludes with a discussion of consciousness, ecology and ethics. In between it ranges across the history, sociology and philosophy of science, Bell’s theorem and non-locality in quantum mechanics, the application of Bohr’s complementarity principle beyond physics and so on. In short, it wants to give a reinterpretation of our world in the light of the ‘quantum revolution’. The thread of ideas which holds these disparate parts together is conveniently summarised by Kafatos/Nadeau as follows:

This progress [of classical physics, 1600+] obviously could not and would not have occurred if there was not a profound commitment in the community of scientists to epistemological and metaphysical realism...[a] metaphysical presupposition reflected in the belief in the one-to-one correspondence between every element of the physical theory and the physical reality... It now appears, however, that we have reached the point in our dialogue with Nature in physical theories at which a confrontation with this hidden...
metaphysical presupposition is quite unavoidable... Bell's theorem and the experiments testing that theorem have definitely... brought it to a head... the resolution of this conflict is likely, in our view, to result in a profound new conception of the relationship between part and whole and physical theory. This new relationship 'implies without, for reasons we will explore later, our being able to 'prove', that human consciousness participates in the life of the cosmos in ways that classical physics completely disallowed. If our hypothesis is correct, our attempts to coordinate experience with reality in terms of linguistically-based social constructions of this reality may be more intimately connected to the life of the cosmos as quantum physics invites us to 'envision' it than most students of the sociology of knowledge could even begin to imagine. (pp.108-9)

The physical analysis is accurate and reasonably clear, but quite incomplete. Only Bell's theorem is focused upon the exclusion of all the other distinctively quantum characteristics, some of them of at least as great importance (e.g. the theory of macroscopic objects and measurement, the distinctive concept of spin and its connection with relativistic space-time). The fundamentality of Bell's theorem is not disputed. But leaping to conclusions from Bell's theorem alone, although an industry these days, is unsound.

The philosophical, sociological, historical, etc. analysis is (invariably) somewhat thinner given the breadth of material covered. It is also less convincing -- arguments are often loosely and vaguely constructed, concepts introduced more by metaphor than careful definition. At one point, e.g. the extension of Bohr's notion of complementarity relies on reducing that notion merely to that of a (set theoretic) complement -- with this convenient degeneracy it's no wonder complementarity can be found everywhere.

Nonetheless, the book is provocative, suggestive and shows a wide synthetic intellectual vision backed by useful references. Anyone looking for a good introduction to the issues might well wish to start here.

C.A. Hooker
Philosophy Department
University of Newcastle

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**Clusters of Galaxies and Extragalactic Radio Sources**

Ed. A. D. Kuz'm'in
Nova Science Publishers
New York, 1990
xi + 326 pp., US$114 (hardcover; includes air delivery)

This volume (number 189 in the Proceedings of the Lebedev Physics Institute of the USSR Academy of Sciences) is intended to bring some of the Soviet astrophysical work to a wider Western readership. Originally published in Russian in 1988, it has been generally well translated. The book contains nine articles by various authors, covering a range of topics concerned with clusters of galaxies and (non-cluster) extragalactic radio sources.

It begins with a useful overview of the principal observational and theoretical aspects of clusters of galaxies. While suffering somewhat from lack of recent references (the latest is 1988, but the peak is at 1982-84), this article sets the scene and at the same time does a competent job of showing where the Soviet references fit into the overall development of the topic.

Two brief articles on low-frequency radio observations of clusters, and their radio spectra, are of some interest but do not present compelling new data. Then follow two long and strongly theoretical articles. The first is concerned with self-consistent dynamical models of clusters, including the galaxies, the intracluster medium and the gravitational potential well. The second deals with the outflow of gas from galaxies in the form of a galactic wind, relevant to the production of the intracluster medium. Both articles (by the same author) use advanced analytical methods with some approximations, rather than numerical simulations. No doubt this is at least partly due to the difficulty of access to computers for scientists in the USSR. While it makes the result suitable mainly for specialists interested in constructing mathematical models of these systems, it also makes for a treatment complementary to the recent 'Clusters of Galaxies' symposium from the Space Telescope Science Institute. It is unfortunate that no examples of applications of the theory either to observations or to simulations are shown.

An interesting article on the diffusion model for cosmic rays in our Galaxy does present both theory and observational data, in showing that the model can account for observed features of the cosmic rays and the radio and gamma-ray backgrounds.

The book concludes with several articles concerned with low frequency (86 and 102 MHz) observations of extragalactic sources made at the radio observatories operated by the Lebedev Institute. Both variable baseline interferometry and interplanetary scintillation methods are used. While again serving to bring some of the Soviet work to attention in the West, most of these articles would sit better in a research journal. Overall, the book is a useful addition to the subject, and in its mathematical level takes a different approach from that of most other published works on the topic. One difficulty in its acceptance will be the high price.

J. G. Robertson
School of Physics
University of Sydney

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**Radio Frequency Heating of Plasma**

R.A. Cairns
Adam Hilger, Bristol, 1991
viii + 161 pp., UK£35 (hardcover)

Radio frequency (rf) heating of plasmas is a rich and fascinating subject. It is also of practical importance for controlled fusion research. The professed aim of the author is to provide a readable introduction to the subject which describes the physical mechanisms involved as well as some of the main experimental results. He certainly succeeded in achieving this aim in an amazingly short volume. The book consists of an introductory chapter which covers topics applicable to all rf heating and current drive techniques such as propagation, mode conversion and particle diffusion, followed by a chapter on each of the subjects of Alfven wave heating, ion cyclotron heating, lower hybrid heating, electron cyclotron heating as well as current drive.

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**FIX on 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 11-12 physics are sought. Please send all contributions to the Honorary Editor (see address on Contents page).
The introductory chapter serves only as a reminder of the subject and refers the reader to the existing excellent books. Each of the other chapters consists of a brief description of the physical mechanism and some examples of the available experimental results. The author does not claim that the bibliography is comprehensive but he includes sufficient recent references to lead the reader to the relevant literature. I am impressed by Dr. Cairns' ability to provide reasonably detailed descriptions of many physical mechanisms without going into the complicated mathematical manipulations required for a complete treatment. However, I do not agree with the assertion that the book is accessible to non-specialists with only a general background in plasma physics. In my opinion an advanced course on plasma waves is a minimum requirement.

W.N. Hugass
Department of Physics
University of New England

Coherent Detection at Millimeter Wavelengths and their Applications

P. Enrenz, C. Laurent, S. Gulkis, E. Kollberg and G. Wiemesser (Eds)
Nova Science Publishers
New York 1991
xvi + 465 pp., US$85 (hardcover)

This book is described as one of the Les Houches series. It contains the lectures presented at the Winter Workshop held at Les Houches, France during March 1990. Other volumes in the series cover such diverse topics as hadronic physics, granular media and complex dynamics. Unfortunately the book does not reveal the background to the series.

Six of the lectures deal with millimetre-submillimetre receivers and sixteen with applications. After a general chapter on detection, there are lectures on schottky and SiS mixer receivers and one on Josephson junction detectors. The only chapter on the generation of these wavelengths describes the quantum well diode. There is no discussion of waveguide propagation, however there is a chapter on gaussian optics. The book covers a broad range of applications with a slight bias towards astronomy. Topics include ground-based, balloon-borne and satellite radiometers to measure the composition of the atmosphere of the earth or other planets or to study interstellar molecules or the cosmic background. Another chapter describes the measurement of electron cyclotron emission from fusion plasmas.

As expected in a collection of lectures presented at a workshop, some speakers have prepared their material very well for inclusion in a volume like this, some less so and others very poorly. Most of the chapters on detection and the chapters on gaussian optics and radio interferometry fall into the first category. The chapters on applications were generally well-referenced and did include up-to-date sources. One clear member of the last category was the final chapter on applications from the point of view of industry which concentrated on the space industry and was utterly unconvincing. The appearance of the second chapter on Josephson junctions was puzzling because, apart from the introductory two pages and the necessary changing of reference numbers, was word for word identical with the first on the topic despite the fact that the author for the first came from Denmark and the three authors of the second came from France.

In general a collection of lectures like this provides background material that would be lacking in a conference proceedings on millimetre-submillimetre waves. I feel that the book would be a worthwhile addition to the library of a group where there may be newcomers to the field of millimetre-wave applications, but I could not describe it as a necessary addition to a personal library.

G.F. Brand
School of Physics
University of Sydney

Luminescence of Wideband Semiconductors

M.D. Galanin (Ed.)
Proceedings of the Lebedev Physics Institute of the Academy of Sciences of the USSR, Vol. 182
Series Ed. N.G. Basov
x + 234 pp., US$111 (incl. air delivery) (hardcover)

This book is a quality translation of the Russian original which was published in 1988. It is in the same style as previous members of this series and comprises four comprehensive research papers on luminescence processes in ZnS, La$_2$S$_3$, and La$_2$O$_3$S, InP, and ZnO semiconductors. The author common to all the multi-author sections is Academician A.N. Georgobiani. Although the research paper format is used in each of the separate sections of the book, extensive literature reviews are presented (particularly in the study of infrared photoluminescence from ZnS) and consequently, a total of 480 references are cited. It is pleasing to see that the books in this Series are progressively broadening their reference base to include a wider range of citations to work from outside the USSR.

This book will be of primary interest to research physicists and chemists who are working on the optical and electronic properties of semiconductors. The provision of ample experimental detail in each of the four papers is a welcome feature of the publication.

T.J. Quikenden
Department of Chemistry
The University of Western Australia

Psychoacoustics - Facts and Models

E. Zwicker & H. Fastl
Springer-Verlag, Berlin 1990
x + 354 pp. DM 98 (hardcover)

In this text Zwicker and Fastl have managed to present a mine of information on the general area of psychoacoustics in a way which is informal enough to be almost an introduction to the subject. Thus whereas the book is intended primarily for research scientists and engineers, the uninitiated reader as well can gain much useful information and often quite painlessly just by casual browsing. This is due mainly to the simple way in which the authors summarise individual topics in clear and concise introductory paragraphs and also to the essentially non-mathematical nature of the subject itself.

Strange though it may seem, even for a trained physicist entering this area for the first time, psychoacoustics can be like a new world. Here the intangible landscape of hearing sensations is explored with the aid of precisely controlled physical stimuli with real objective knowledge and understanding of this evanescent world coming via ingenious experiments on human subjects. Towards this end Zwicker and Fastl prove to be excellent guides amongst a bewildering list of psychoacoustic experimentation. Setting out from a discussion of stimuli and experimental procedures, they cover in about 15 chapters the broad areas of information processing, frequency resolution, pitch and loudness, together with all their important ramifications. A significant D-
The reader to the basic definitions and concepts which are made use of later in the book. Chapter 3 then begins to look in more detail at the basic theory, where the use of perturbation theory is dealt with. The Helmholtz integral formulation and the associated Green’s functions are used extensively, as one might expect; the author gives references to other texts in this matter, but if ever a second edition of this book is produced the author might like to give some consideration to including a short section introducing these concepts and equations to the reader. This could be done in the main body of the text, or as an appendix, but I believe it would make a worthwhile addition.

Subsequent chapters deal with Kirchhoff’s theory, and in polarized waves, and then the book passes logically on to discussions about multiple scattering and finally modern numerical techniques used to deal with the problems of scattering. The author chooses not to discuss all aspects at great length, but always gives adequate references where her own discussion is (generally intentionally) brief. In this sense the book serves in some places as something of an extended review of the literature, rather than a complete treatise, but in these cases this appears to have been its intention. Nevertheless, there is always sufficient information for the reader to look further if he/she desires.

Generally, I found the book to be a worthwhile one, with no obvious errors, and one which I could happily recommend to workers in the various fields which deal with the various types of wave scattering.

W.K. Hocking
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University of Adelaide

Fluoride Glass Fiber Optics


From time to time a truly Great Result is handed down to those who worship at the Altar of Experiment. There was such an occasion in the mid 70s at Rice University in France when an appeal was made to the experimental method for a low symmetry crystal in the complex fluoride system. Prayers can be answered in strange ways. What Michel Poulain got in fact was a new kind of glass, rather than just another crystal to use as a laser host.

This book covers fifteen years of progress with fluoride glasses in USA, Japan, and France since that fateful experiment. It is fitting that the book opens with a chapter by Marcel Poulain who was there at the time when brother Michel was blessed with the initial result.

The progress reported is extraordinary. Ten years of painstaking effort have seen the optical loss of fluoride glass fibres reduced from 1000 dB/km to less than 1 dB/km. Those who draw trend-lines rather than approach the Altar of Experiment complain that there has been little improvement in the last two years. Poulain agrees that classical synthesis techniques will not allow the necessary ultra-high purity levels to be achieved, and he sees merit in vapour phase processes for which preliminary results are available. In the meantime there are the tantalising results on very short lengths of fluoride fibre, where at 2.5 micron wavelength a scatter loss well under the silica minimum has been measured.

But the exciting accomplishment, of more interest to Physicists, is in the area of active fibres below zero loss) where fluoride glasses can now offer a real alternative to silica as a laser host, especially for Rare Earth ions. Indeed in the search for a practical optical amplifier at 1.3 micron, only the fluoride host using Praseodymium is showing promise. Unfortunately this work is too recent to be covered in the book, but don’t despair, the chapter by Quimby on Active Phenomena is an excellent introduction.

Finally, why no contributions from the British? They published their own book last year- Fluoride Glass Optical Fibres (by P.W. France). Buy both books and you just about cover the whole Earthling effort.

Gavan Rosman
Photonic Section
Telecom Research Laboratories

Symmetry Principles and Magnetic Symmetry in Solid State Physics

S.J. Joshua
Adam Hilger, Bristol, 1991 xiii + 270 pp. £19. 50 (paperback)

This book consists of two separate parts followed by the appendices (about 55 pages) presenting useful, albeit ‘usual’ tables. Part I (about 110 pages) is intended for beginners in the field of applications of group theory to solid state physics, whereas Part II (about 65 pages) is intended for graduate students and researchers >
entering the field. It is a concise volume which presents an easy reading. Its main advantage is the set of exercises with solutions.

However, several misinterpretations occurring in the book reduce its value as an introductory textbook. Most important ones concern, for example, (a) the definition of the Euler angles (z'x'y') - it disagrees with the results in Table A.1 based on a more common definition (z'y'x'); (b) the fine structure splitting - it should not be included in the Hamiltonian (6.2) (N.B. summations at the spin-orbit coupling and the crystal field term are missing in eq.(6.2)); (c) the splitting of the 4f level in cubic field in Fig.6.4 - it is quoted after Tinkham without proper context thus ascribing the action of the spin-orbit coupling to that of the cubic crystal field; (d) the statement (p.94 & p.95) that 'for crystals the wavevector k is restricted to the first Brillouin zone' - then how about the Umklapp processes?; (e) the factorization of secular determinants for diamond (as well as zincblend) structure given as a direct sum of representations, eq.(6.36), and the determinant, eq.(6.37), do not match.

Selection of "the original (classical)" references for citing, apart from "the important" ones, seems unsuitable for beginners. Moreover, only four out of 56 references in Part I date after 1980. Part II deals with rather narrow aspects and thus will appeal to a small readership only. All 88 references quoted in Part II pre-date 1977.

Relaxed approach to terminology and the deferral of definitions of some concepts used in earlier chapters may be confusing for beginners. Succinct explanations of the physical nature of some of the concepts involved (e.g., magnons, excitons) and a list of abbreviations used in the book would be helpful.

Overall, this volume may be recommended to lecturers as a useful source of exercises, whereas beginners may find it useful as a 'starter' presenting an overview of basic concepts, although caution is required in some points.

Czesław Rudowicz
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City Polytechnic of Hong Kong

Relativistic Quantum Mechanics of Leptons
and Fields
Walter T. Grandy, Jr.
(Fundamental Theories of Physics
Vol. 41) Kluwer Academic Publishers
Dordrecht, 1991
xii + 438pp., US$99 (hardcover)

In the preface the author observes that this work is meant to fulfil a dual purpose - firstly to serve as a text at the advanced graduate level, and secondly as a monograph on the interaction of point particles with classical fields. In this reviewer's opinion, the second of these aims is dealt with more successfully than the first, this being a rather solid volume, and generally containing more material than most graduate courses would encompass. For this purpose the classic book of Bjorken and Drell probably provides a more accessible source. For the researcher however, the book contains a wealth of information which is not readily found elsewhere.

The format is after some rather terse mathematical preliminaries, to introduce the Dirac equation and discuss in detail its various properties and solutions. Then the electromagnetic field is introduced, and various solutions of the Dirac equation are worked through. The next major section of the book deals with the Lagrangian formulation, Green's functions and the quantum theory of radiation. All of this material seems to be dealt with thoroughly and comprehensively. The final three chapters deal with, respectively, The Two-Body problem, Dirac Scattering Theory, and Quantum Electrodynamics.

In summary, this volume will serve very well as a research tool, or for students wishing to advance their knowledge past the usual material. The index is very good, and I noted only one relatively harmless typo.

A.J. Davies
School of Physics
University of Melbourne

Mechanics
Florian Scheck
Springer-Verlag, Berlin, 1990
xiv + 431 pp., DM 68.00 (paperback)

Since I began teaching classical mechanics based upon Goldstein's popular textbook I have been searching for a modern and more relevant text. There are two reasons for this: first is my own dislike of Goldstein's book (a dislike which is universally shared by students); and second is the changing syllabus and motivation for teaching mechanics to third year physics students. That search may now be over.

The word chaos, and the response to its popular persona by universities, has had its largest impact in the teaching of classical mechanics. After the enthusiasm for popular science lectures and endless beautiful fractal pictures subsides, we ask was there any substance to this buzzword of the 80's? Well the answer is undoubtedly yes, but to see that substance we must remove ourselves from the physical beauty and plunge into the mathematical intricacies of what used to be called nonlinear systems. Rather than ignoring nonlinearity because it was too difficult, we now dive in because strong nonlinearity and chaos come together, and the words too difficult are now replaced by interesting and exciting.

This new book by Scheck covers the standard territory of classical mechanics: Newtonian, Lagrangian and Hamiltonian mechanics, the mechanics of rigid bodies, and the treatment of continuous systems. The approach is a little more mathematical than that of Goldstein, but often more thorough and concise. The great advantage of this book over the standard mechanics textbooks is the remaining two chapters.

Chapter 5 presents a treatment of the modern formulation of differential geometry in a manner which immediately illustrates the connections between mechanics. This helps to bridge the gap between the mechanics taught to physicists and the full mathematical rigour of Abraham and Marsden's, Foundations of Mechanics.

Chapter 6 contains the first treatment of stability and chaos that I have seen in a book which is designed to be used as an undergraduate text. It starts with linear stability analysis, and then considers the long term behaviour of more typical mechanical systems. The sections on deterministic chaos and the quantitative measures of chaos are a nice description of the tools of trade for
the study of chaotic systems, with some well chosen examples: the quadratic map (which he refers to as the logistic equation). The Liapunov characteristic exponent and idea of generalised dimensions are introduced in a way that well illustrates these new concepts to students.

If this is not the new textbook that I have been waiting for, then it certainly is a step in the right direction.

Gary Morris
University of Science
University of New South Wales

Strained-Layer Superlattices: Materials Science and Technology
Semiconductors and Semimetals
Volume 33
T.P. Pearsall (Ed)
ix + 411pp, US$87.50 (hardcover)

Although the title uses the word "superlattices", meaning alternating layers of dissimilar crystalline materials, the book reviews the more general case of any combination of dissimilar materials with mismatched crystal lattice constants.

The ability to grow thin layers of strained crystal which are not lattice matched to the bulk has freed the semiconductor device designer to vary the alloy composition, and hence electronic nature, of critical layers to improve device performance and exploit new physical phenomena. The book is an excellent review of this important rapidly developing field of semiconductor technology. It achieves a good balance between the mainstream applications which are GaAs/InGaAs for MODFETS (HETMs) and Si/Ge for heterojunction bipolar and optical devices (covered in some depth), and a comprehensive coverage of less common systems, such as PbS, PbSe and PbTe for infrared detectors and ZnSe for blue LED's and lasers, in less detail but with a plethora of references.

The presentation is easily readable, emphasising principles involved rather than extensive mathematics. The first chapter is excellent in providing the basic concepts of two and three dimensional growth, nucleation, critical thickness and strain relief. It also includes a good review of molecular beam epitaxy as the primary technique for producing these important low-dimensional structures. The chapter provides all the information for the non-expert to gain a good working knowledge of the field, and plenty to keep the 'expert' interested. This is complemented in the second chapter with reasons for pursuing strained-layer systems, through understanding of critical thickness models and several device applications. The strained channel or pseudomorphic MODFET is covered extensively.

Characterisation of strained-layer structures is treated in detail in chapter 3 with the major emphasis on Rutherford backscattering and channeling techniques. For the general reader the coverage of characterisation techniques in earlier chapters is probably sufficient, although there is a brief review of a range of common techniques at the end of the third chapter which is quite useful. The remainder of the book deals with the less common materials systems and their specific applications and growth requirements.

As is common with texts of this nature many of the specific applications examples are now dated, the most recent being 1989. However, it is an excellent book, very well focused in its contents and easy to follow.

G.J. Griffiths
CSIRO Division of Radiophysics
Marsfield

Hydrogen in Semiconductors
Semiconductors and Semimetals Vol.34
J.I. Pankove and N.M. Johnson (Eds)
xii + 629 pp., US$139 (hardcover)

Hydrogen binds to silicon more strongly than silicon to silicon. This simple fact has profound implications for the semiconductor industry because hydrogen can modify the electronic properties of semiconductors and silicon. The basis of this book in the series on Semiconductors and Semimetals. The sixteen chapters are by various authors and are each essentially self-contained on a wide variety of aspects of hydrogen in amorphous and crystalline semiconductors (mainly silicon). Each chapter begins with an introduction aimed at a "tutorial format" so that the book is useful to "graduate students, scientists from other disciplines, as well as active participants in this area of research". Not surprisingly, some authors achieve this better than others, but the aim is well met in general. The first Chapter is an excellent overview of the subject by the editors which puts the rest of the book in perspective. The various topics review research carried out in the last ten years and provide copious references to further detail. The price is not cheap but the book would be an essential addition to the library of any research group working on developing semiconductor devices at a fundamental level. It would also be an extremely useful reference book for anyone with either a theoretical or experimental interest in semiconductors in general.

C. A. Sholl
Physics Department
University of New England

Liquid Crystals - Nature's Delicate Phase of Matter
Peter I. Collings
Adam Hilger, Bristol, 1990
xiii + 219pp., UK£9.95 (softcover)

This is a book for the intelligent layman, undergraduate students or graduate students in physics or chemical physics starting a course or research work on liquid crystals. It is a delightful read. The importance of liquid crystals in modern technology should indicate that a book of this kind needs to be widely read, as much for its scientific content as to disperse the growing ignorance of advanced physical phenomena which is the hallmark of our age.

Peter Collings describes the liquid crystalline state and tells something of the history of research in this area covering the effects of electric and magnetic fields as well as their refractive properties in these materials. There is a series of attractive and thought provoking coloured photographs of polarising microscope images of the various textures and also a good section of three or four chapters on technological aspects covering liquid crystal displays, hydrotropic and polymer liquid crystals where properties are related through phase diagrams to similar structures in biological membranes etc.

The final chapters on theories of the liquid crystalline state and the biological importance of liquid crystals discuss in general terms methods of modelling and computer simulation. Monte Carlo and Molecular Dynamics methods are introduced in a clear but qualitative way. As concerns the biological domain reference is made to the cell membrane, microtubules, muscle and the properties of cholesterol in vivo.

I thus commend this book as an enthusiastic, qualitative introduction to the liquid crystalline state. The broad coverage is a limitation for those...
interested in the detailed physics but there is an adequate appendix with a list of books for further reading.

J.W. White
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Australian National University

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Handbook of Optical Constants of Solids II
E.D. Palik (Ed.)
xiv + 1096pp., US$145 (hardcover)

This is a companion volume to the 1985 book of the same title. The aim of the book is to present a single set of evaluated optical constants covering the widest possible spectral range for each material considered. The first volume covered 37 solids and this volume covers a further 48 materials of scientific or technological interest, including metals, semiconductors and insulators.

The book is divided into two parts. The first 14 chapters mainly cover methods of determining optical constants in various situations including: thin films on substrates; the attenuated total reflection technique applied to single or multiple thin films; superlattice structures and semiconductors. There are three chapters on the determination of n and k in the UV-X-ray regions and two chapters on the use of non-optical techniques in the infrared region.

The second part of the book is a collection of critiques and data for the various solids. Values of n and k are presented in tabular form and in log-log plots to show wavelength dependence for ranges as great as 10^4 to 10^7 μm. To rectify errors in Vol 1, corrected values of n and k are included for LiF, ZnS and SiO2. A weakness of the book is that, while it has an extensive table of contents, it has no index.

This book will become a standard reference for optical and solid-state physicists, not only because of the extensive data it contains, but also because the initial chapters give excellent summaries of the state of development of experimental techniques and theoretical models and the interaction between the two.

For example, Pelletier discusses the problems of inhomogeneity and anisotropy in vacuum deposited thin films and demonstrates the improvements to classical models when these factors are taken into account. As Pelletier wryly comments, "some amount of humour is necessary to use the expression optical constant in referring to the complex refractive index of a thin layer".

Palik's monumental work is far from completed. Currently, he is only completely satisfied with n and k values for about 10 materials. He wants to tabulate another 30 materials and calls for increased funding to significantly improve measurements of n and k.

David R Brighton
Materials Research Laboratory
DSTO Melbourne

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Quantum Theory of the Solid State (2nd Ed)
J Callaway
xiv + 954pp, US$149.95 (hardcover)

Callaway again offers a good solid text, a reliable 954-page panorama of a wide variety of topics. One might think that the new one-volume hardback format reflects a maturing of the subject, but too much has happened since the first edition for such pessimism to take root. This edition includes such topics as: the renormalisation group approach to phase transition theory, quantum Hall effect, electron transport in disordered systems, and various technical methods in many-body theory.

Callaway's style is orthodox and restrained. There is a (natural) emphasis on those areas of solid state theory where Callaway has contributed. High-temperature superconductivity gets a few passing mentions, but not an index entry. Callaway neatly avoids many pitfalls which await the student who attempts to apply the quoted results (for example, the Heisenberg form of the exchange interaction for effective spins) in a more general context. Callaway avoids mentioning these pitfalls, or giving any useful references to trickier points; this risks the danger of giving a lack-lustre and misleading account. A lack of references (e.g. on the Mossbauer effect) was disappointing. Elegant treatments tend to adjoin rapid overviews, and some opportunities for integrated treatment are lost; for example the fundamental role of time reversal invariance (3.6) in electron localisation (7.5) is not mentioned. I do not intend these quibbles to detract from a very useful text, whose newer sections I certainly enjoyed.

G. E. Stedman
Physics Department
University of Canterbury

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New Books
Ferroelectric Crystals for Laser Radiation Control
A. M. Prokhorov & Yu. S. Kuzminov
Adam Hilger, Bristol 1990
xix + 447 pp. UK£75 (hardcover)

The Dynamic Universe. An Introduction to Astronomy, 4th ED.
T. P. Snow
West Publishing Co, St Paul MI 1991
vii + 736 pp. US$50 (hardcover)

Ultrathin Organic Films. A. Ulman
ix + 442 pp. US$65 (hardcover)

Quantum Semiconductor Structures
C. Weisbuch & B. Vinter
v + 252 pp. US$34.95 (hardcover)

Laser Light Scattering. B. Chu
v + 343 pp. US$74.50 (hardcover)

A Formulary for Plasma Physics
A. Anders
Akademie Verlag, Berlin 1990
v + 276 pp. DM 52 (softcover)

Application of Metrological Laser Methods in Machines and Systems
G. Frankowski, N. Bramson & Z. Fuzessy
Akademie Verlag, Berlin 1991
vii + 381 pp. DM 96 (softcover)

Best of Soviet Semiconductor Physics and Technology 1987-1988
M. Levenshtein & M. Shur
Adam Hilger, Bristol 1991
vi + 370 pp. UK£63.50 (paperback)

The Road from Los Alamos
H. A. Bethe
Adam Hilger, Bristol 1991
vi + 286 pp. UK£17.50 (hardcover)

The Charm of Physics
S. L. Glashow
Adam Hilger, Bristol 1991
vi + 306 pp. UK£17.50 (hardcover)

Techniques and Mechanisms in Gas Sensing
P. T. Moseley
Adam Hilger, Bristol 1991
vi + 390 pp. UK£59 (hardcover)

A Passion for Physics
J. Freeman
Adam Hilger, Bristol 1991
vii + 229 pp. UK£17.50 (hardcover)

The Physics of Musical Instruments
N. H. Fletcher & T. D. Rossing
Springer Verlag, Berlin 1991
vii + 620 pp. DM 148 (hardcover)
CONFERENCES & MEETINGS

1991

Nov 10 - 14  Anglo-Australian Observatory - "Fibre Optics in Astronomy II"
Power House Museum, Sydney
Peter Gray or Sandra Harrison, Anglo-Australian Observatory,
PO Box 256, Epping NSW 2121, Tel (02) 868 1666, fax (02) 876 8536

Dec 2 - 4  Heat Transfer & Heat Exchanger Design Workshop, Sydney
Julie Henderson, The University of NSW, PO Box 1, Kensington 2033
Tel: (02) 697-3177 or 697-3173, fax (02) 662-6983

Dec 6 - 8  Fifteenth Scientific Meeting of the Australian Society for Biophysics, Sydney
At Professor Jan Gebicki, School of Biological Sciences, Macquarie University,
NSW 2109. Tel 02 805 8147, fax 02-805 8245

1992

Jan 5 - 11  XIII International Conference on Few Body Problems in Physics, Adelaide
Registration and contributions: Prof. I.E. McCutcheon, School of Physical
Sciences, Flinders University, GPO Box 2100, Adelaide SA 5001
Tel (08) 201 2115, fax (08) 201 2905

Jan 13 - 31  5th Physics Summer School: Atomic and Molecular Physics and
Quantum Optics, Canberra
B.A. Robson, Dept of Theoretical Physics, R.S.Phys.S.E., ANU, GPO Box 4,
Canberra ACT 2601. Tel (06) 249 2971, fax (06) 249 4676

Jan 29 - 31  Joint Australian New Zealand Condensed Matter Physics Meeting
Hammer Spurs, New Zealand
Contact: Prof. D. Beaglehole, Physics Department, Victoria University of
Wellington, PO Box 600, Wellington, New Zealand

Feb 2-6  The 28th Australian Applied Mathematics Conference,
The Mariners Lodge, Batemans Bay, NSW
The Conference Committee, 28th AMC, Department of Mathematics,
University College, UNSW, ADFA, Canberra, ACT, 2600, Australia
Phone (06) 268 8686, Email: amc@maa@maa.adfa.adfa.oz.au, Fax (06)268 8886

Feb 3 - 7  19th Australian Polymer Symposium - "Greening the Polymer Industry"
University of Western Australia, Perth WA
Mr. G.M. Ferguson, Chemistry Centre WA, 125 Hay Street, East Perth 6004,
Ph 61-9-222 3010, fax 61-9-325 7767 or Mrs. W. Fletcher, Lions Eye
Institute, 2 Verdon Street, Nedlands WA 6009. Tel 61-9-389 3389,
fax 61-9-382 1171

Feb 10 - 14  10th National Congress of the Australian Institute of Physics,
University of Melbourne
(See) Dr. G.N. Taylor, School of Physics, University of Melbourne, Parkville VIC
3052, Tel (03) 3445456, fax (03) 3474783 AARNet: UCSVC::RCHEP::Taylor

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

July 6 - 10  Fifth International Conference on Thinking - Exploring Human Potential
James Cook University of North Queensland, Townsville, Australia
John Edwards, Conference Convener, Department of Pedagogics,
James Cook University, Townsville QLD 4811, Australia.
Fax: (077) 251690 (within Australia) or 61 77 251690 (overseas)

Sept 8 - 11  ASPEN Symposium - Introductory Physics Education in University, Japan
 cite: Prof. Yasuhiro Tsuruoka, Dept. of Physics, Tokai University, 1117 Kitakaname,
Hirosaki City, Aomori 036-8574, Japan Tel 81-463-38-1211, fax 81-463-38-1812
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