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Division of Applied Physics, Lindfield (Sydney) NSW, Australia.

Due to the retirement of the incumbent, Dr W R Bevis, the position of Chief of the Division of Applied Physics, one of the leading physics/electrical engineering positions in the country, will become vacant in October 1994.

The Division of Applied Physics is one of five Divisions comprising the Institute of Industrial Technologies, and together with the Division of Materials Science and Technology and the Division of Manufacturing Technology, constitutes CSIRO's core research capability for manufacturing. Major research programs co-ordination occurs across these three Divisions.

The Division's primary mission is to apply its expertise in physics, engineering and related sciences to the development of the technological base of Australian industry. It also establishes, maintains and disseminates Australia's physical standards of measurement, including those for which CSIRO has statutory responsibility under the National Measurement Act 1960, and functions as Australia's National Measurement Laboratory.

The Division's total staff is around 300 and the total budget approximately A$20m.

The successful candidate will be required to have a highly developed strategic management capacity in a multi-disciplined R&D environment and excellent communication skills; a commitment to consultative planning of research with Australia's leading manufacturing companies; a commitment to the effective application of research results; an outstanding record of personal research achievement and strong leadership.

The Division's primary mission to develop the technological base of the Australian manufacturing industry, has led to a broad range of collaborative research projects with industry. These projects now attract funds from Australian companies, amounting to several million dollars annually.

The Division has a responsibility to provide leadership in measurement technology and to maintain Australia's position at the forefront of measurement science internationally.

The appointee will be responsible to the Director of the Institute for the leadership and direction of the Division's research, its effective commercialisation, and the overall management of the Division's operations. He/she will be expected to strengthen the Division's alliance with companies in the manufacturing, electrical and energy distribution sectors, with emphasis on industrial machinery and equipment, optical and scientific instruments and quality assurance technology. He/she will be expected to implement substantial R&D projects and commercialisation plans that have the potential to be of considerable benefit to Australia's economy with leading firms in the above sectors.

The appointee will be for five years, with the option of a further term, as mutually desired. Employment arrangements as either an indefinite (tenured) CSIRO employee or a contract appointment can be negotiated.

The remuneration package for this position will be in the vicinity of A$125,000, including a salary component of about A$96,000. The package includes superannuation and provision of a private-plated motor vehicle.

We invite expressions of interest and applications for the position and would also like to hear from people in the field who may wish to suggest possible candidates. Further information regarding the position can be obtained from:

Dr John Yasso, Manager, Human Resources and Finance, PO Box 225, DICKSON ACT 2602, Australia. (Tel 616 276 6510; Fax 616 276 6410).

An application stating full personal and professional details and the names of at least three professional referees should be directed to:

Dr Colin Adam, Director, Institute of Industrial Technologies, PO Box 225, Dickson ACT 2602 AUSTRALIA. Closing date for applications is 31st January 1994.

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This month's cover picture depicts the computer simulation of the channeling of a focused beam of ions through a cubic crystal. The simulation is of a cubic array of stainless steel ball bearings, occupying a spherical volume, shadowed by a light source which converges on the surface of the array. The shadow of the crystal shows 'channelled' beam and also scattered beam which forms a blocking pattern of the crystal planes and axes. The blocking pattern in this image has been illuminated to make it easier to see. The simulation is applicable to experiments done with the Melbourne MeV ion microprobe where a focused beam of H⁺ or He⁺ ions channel through thin crystals. The energy of the scattered beam provides useful analytical information about the quality of the crystal. The image was produced by Dr David Jamieson for a review paper presented at the recent International Conference: The Eleventh International Conference on Ion Beam Analysis (IBA-11), Balatonfüred, Hungary July 5-9, 1993.
BRISPHYS '94

Time is ticking by and it is now less than a year to Brisphys '94 - the conference that will combine the 11th AIP Congress and the 6th Asian Pacific Physics Conference. Last month's issue of "The Physicist" contained a preliminary announcement of the meeting, and the notice boards in your institution are hopefully carrying the colourful poster produced by Ross Dunlop's Local Committee to publicize the event.

Too few of us, I suspect, are aware of the work of the Association of Asian Pacific Physical Societies of which the AIP is a member along with many other physics societies from the region. Two of its principal activities are the oversight of the annual APPC meetings and the publication of its excellent Bulletin. The Bulletin draws on material from the publications of its member societies; the latest issue contains Ian Johnston and Ross McPhedran's article Computational Physics in the Undergraduate Curriculum, first published in the April 93 issue of this journal.

The Society's principal functions are to inform physicists of the region of ongoing activities and special events in the Asia-Pacific region and to promote collaboration and friendships among its physicists. The Congress plays an important role in promoting these aims because it is usually at these meetings that individual members of the adhering societies have the best opportunity to interact at a personal level. The Brisbane meeting provides a unique opportunity for a much larger group of Australian physicists than usual to get to know Asian colleagues who are working in their areas of specialisation.

A meeting of the organisers of Brisphys '94 was held in Brisbane at the end of September. It was attended by members of the Local Committee and by Ron MacDonald, as Chairman of the Program Committee; others, including Cliff Smith from the WA Branch, who has some strong links with our Asian colleagues, took part through teleconferencing.

One of the important issues facing the organisers is financial support for the delegates from developing countries. If Australia is to match Malaysia, the host for the 5th APPC, in the support that country provided for its visitors, strong and successful overtures will need to be made to both the public and private sectors. Australia's increasing participation in the Asian region is a theme of current Government policy, but it is difficult to find the right bureaucratic door on which to knock to secure government funding at a level approaching that provided by the Malaysian government. The meeting will certainly attract support from the international agencies such as UNESCO as did the 5th APPC, but a major contribution must be found from within this country.

The form of the program is beginning to take shape and there have been valuable suggestions for themes and plenary speakers. Branches and individual members are encouraged to make proposals; representatives of the participating Asian countries and the various specialist groups within Australia have already been invited to do so. Now is the time for such input while the program is at its formative stage. If you have a suggestion the organizers would like to hear from you!
SALESMANSHIP & R&D

I have always been inclined to the view that if you can't join them beat them. This approach however now seems to be beset with much more difficulty than it once was. They are becoming better organised and much more forceful. Hardly a month goes by without a set of glossy leaflets and application forms arriving to tell me that for only a thousand dollars or so I can revolutionise my management, persuasive and sales skills and in a few days learn to dominate people, rapidly climb the management ladder, make lots of money and drive a red Ferrari. They are well written and persuasive and obviously attract enough people to keep their preachers at a standard of living which most of us would like to become accustomed.

The worrying thing is that many of our university top people seem to have been persuaded and are now collectively paying millions of dollars to develop corporate images. A current excuse is that corporations will not weigh in with big wads of money unless the universities look more like corporations. Birds of a feather flock together. No intelligent management believes this. Hiring or funding people mainly because they are like you is usually a mistake. They give external funds because they can't easily solve the problem themselves or to be seen to be associated with a worthy institution. They need someone with different skills and accept that this may mean a different attitude to life. The university corporation enthusiasts do not seem to realise, or care, that it is almost impossible to make big changes in form without seriously effecting function. If they make universities into quasi corporations the publicly perceived need for them as trustworthy independent institutions will greatly diminish. They are slow to learn what happens to organisations which come under the control of salesmen. Short term financial gain is often bought at the price of long term viability. This has happened to once invincible IBM causing its recent disastrous results. INTEL (who make a large proportion of the integrated circuits used in computers) remains under the control of scientists and engineers and has continued to prosper.

I am not attacking salesmen. They can be useful and necessary but, like the wolf, they have to be domesticated if they are to serve humanity. They are only dangerous when allowed to become dominant. Consider the damage feral salesmen, disguised as entrepreneurs, have done in Australasia over the last decade. Let us hope we will not be saying similar things about vice chancellors next century. There are already problems about the way university courses are being marketed to Asian students.

Would you believe that yet another inquiry into R&D in Australia has been launched? Of course you would. It is a reliable growth industry. This time from the Industry Commission. The terms of reference are wide; medical, defence, rural, energy, higher education, private and public funded (why do it all?) financial benefits, research linkages, impact on growth etc. Now who would you get to run such a thing? Naturally two economists, with negligible backgrounds in research matters and, to achieve balance, a third economist who does know something of research, as associate commissioner.

It is a reasonable bet, on past form, that their report in sixteen months time will be wide, shallow and ignored. Not making submissions, however, is a risk physicists can't afford to take. It is a common practice when you want to fire half the staff to hire a team of consultants to tell the workers that it is imperative for survival that your outfit be immediately reorganised in such a way that a 50% downsizing is inevitable. Not management's fault, independent experts have insisted, the bottom line demands it and so on. Now of course we all know that no government department would be guilty of such nefarious behaviour. Just suppose, however, that some bureaucrat or politician wished, naturally for the good of the nation and with no thought of personal gain, to implement a change such as halving the money that goes to physics and giving it to sociology or chopping astronomy for not contributing to the GNP, they could probably find ammunition in such a broad report, particularly if no physicists contribute. Ring Leeanne Wright for information and Issues Papers on (06) 264 3085 or fax your submission to her on (06) 253 2079. If you want further motivation, the engineers consider it a good thing.

Jak Kelly
The AINSE-White conference held in Becker House 12-15 July incorporated the 19th Australian Institute of Nuclear Science and Engineering (AINSE) Plasma Physics Conference and an Elizabeth and Frederick White Research Conference workshop on Fundamental Problems in the Physics of Magnetically Confined Plasmas. There were 91 participants. The support of the Elizabeth and Frederick White Research Conference Fund enabled three overseas speakers to be invited, Professors Amitava Bhattacharjee, John Cary and Liu Chen, who are active in theoretical plasma physics research on both laboratory and solar-terrestrial problems. One of the main goals of the conference was to try to bridge the unfortunate gap which exists in Australia between the laboratory plasma and solar-terrestrial plasma communities. Unfortunately, at least partly due to competition from other conferences in July, the participation from the Australian solar-terrestrial plasma community was disappointingly low. Nevertheless, the contributions from those who did attend, combined with the papers from overseas speakers, made the conference much broader than the traditional AINSE Plasma Conference.

As well as the effect of the White funding, the conference differed from the traditional AINSE Plasma Physics Conference in other ways. With the transfer of staff from AINSE to ANSTO, conferences will have to be sub-contracted by AINSE either to ANSTO or to the universities themselves (CSIRO having withdrawn from AINSE), with AINSE now providing only financial support rather than hosting conferences itself.

The AINSE-White conference was in fact the first such university-organised AINSE conference, and there was wide agreement that this experiment proved a success. An innovation that made possible the organisation of the meeting using only minimal staff was the use of information technology in the form of electronic mail for submission of abstracts and the promulgation of announcements. The use of a microcomputer database also proved very useful for everything from printing badges to doing the accounting. The conference was organised by the Department of Theoretical Physics and the Plasma Research Laboratory of the Research School of Physical Sciences and Engineering at ANU and the accommodation and conference dinner were at Burgmann College on the ANU campus.

Another departure from tradition was the decision to give more emphasis than in the past to other areas of plasma physics than the traditional basic high-temperature plasma physics and fusion energy theme. In recognition of this, the name of the AINSE component was changed from AINSE Plasma Physics Conference to AINSE Plasma Science and Technology Conference. The largest technological application area in evidence was plasma processing, which has become extremely important in the electronics industry. Dr John Keller from IBM's East Fishkill facility gave an invited talk in this area, and Dr Hajime Kuwahara gave an invited talk about research at Nissin Electric in Japan. There were also CSIRO contributions on the plasma physics of arc welding and the potentially very important area of safe disposal of chemical wastes. The most novel application was the proposal made at the conference by Professor Alfred Wong of UCLA to break the catalytic cycle by which chlorine atoms in the stratosphere deplete ozone by injecting electrons from high-flying balloons. This concept was supported by experiments reported for the first time at the conference, and was picked up in the Australian press.

Fusion energy related plasma physics was still strongly represented of course, and a review of the world effort in this area was provided by an Australian, Dr Barry Green, on the International Thermonuclear Experimental Reactor (ITER) design team. He called for greater national and international collaboration by Australia in fusion physics, particularly with the Japanese.

Another highlight of the conference was the report of the first results from ANUs large helical axis stellarator, or heliac (H-1) and the tour of the H-1 laboratory on the Monday night. The Monday night tour and poster session were followed by a reception sponsored by the Research School of Physical Sciences and Engineering.

Flinders University has agreed to host the 20th AINSE Plasma Physics Conference in Adelaide in February 1995.

Robert Dewar
Theoretical Physics ANU
NATO Advanced Study Institute on DENSITY FUNCTIONAL THEORY
Tuscany, Italy, 16 - 27 August, 1993

Density Functional Theory (DFT) was developed nearly 30 years ago by Walter Kohn and coworkers to solve the quantum mechanical problem of inhomogeneous electronic systems. The main quantity of interest in DFT is density, instead of wave functions. Many body effects are carefully included in a one body form amenable to easy computations via local density approximations. The theory is highly successful in describing the ground state properties of metals, semiconductors, surfaces, atoms, molecules, clusters, nuclear matter and many other physical systems. There are still however problems that need attention, e.g. excited states, band gaps in insulators and how to treat strongly correlated electrons in condensed matter. In recent years a computational scheme which combines Molecular Dynamics (for the nuclei) and the density functional theory (for the electrons), the so-called Car-Parinello method is one of the most promising techniques in computational condensed matter physics. It has been used recently for a variety of structure related problems.

The Institute took place in the remote hills of Tuscany, about a 2 hour drive east of Pisa and about 5km from the nearest village. The participants of the workshop were accommodated in an elegant hotel, Il Ciocco, which serves as a permanent training base for the Glasgow Rangers and the Olympic basketball teams of Italy and Greece.

Apart from culinary treats, we were served a large portion of first class physics. The Institute comprised 5 courses (53 lectures), 8 lectures on special topics and two poster sessions with over 50 contributed posters. 105 scientists participated in the Institute (including 3 from Australia) and over 50 graduate students from European and American Universities.

The session was opened by the Nestor of the field, Professor Walter Kohn, who gave a personal “Overview of density functional theory”, connected historical threads with current developments and pointed out outstanding problems.

The scientific content of the Institute was broadly divided into topics dealing with fundamentals of the theory, such as exchange-correlation functionals, the scaling properties of functionals, current density functional theory and orbital magnetism, superconductivity and itinerant magnetism via density functional theory.

The Australian contingent was John Dobson (Griffith University), Mukunda Das (ANU) and Marek Michalewicz (CSIRO, Melbourne). Bob Jones, who is one of the most prominent exponents of DFT in studies of the structure of molecules and small atomic clusters is also an Australian who has spent the last 23 years in Europe (Forschungszentrum Jullich, Germany). John gave lectures on “Metallic Surfaces”, Mukunda gave a special lecture on “Density Functional Theory of Vortex Matter”, Marek, at an afternoon session presented a video “UniChem: Molecular Chemistry in a Supercomputing Environment. CSIRO experience - the first six months” showing some applications of the commercial DFT programs. The proceedings of the NATO ASI containing all lectures will be published by Plenum. It promises to be a very valuable account of the current state of the field. We enjoyed the Italian experience immensely and derived great pleasure from visiting a place with such great cultural, historical and artistic tradition. We are pleased to report that Italian hospitality, culinary and wine making traditions are admirable.

Marek Michalewicz
CSIRO Supercomputing Support Group
Mukunda Das
Theoretical Physics
RSPhyS&E, ANU

THINGS YOU SHOULD KNOW ABOUT GOING TO PRINT

For full colour printing (the cover of the Physicist) the best print quality is obtained from large format (6cm x 6cm or similar) colour slides. Even 35mm slides will result in a higher quality printed image than a colour photograph (unless the slide has been made by copying a colour print). Colour laser prints and colour photographs should be supplied in their original form and not as copies on colour slides. If you are using a photographer, especially for full colour printing, have transparencies made!

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“Bromide quality” is an expression that means that we would like as high a resolution as possible for the figures and illustrations that are published in the Physicist.
Another Sun Dog!

Dear Editor,

You may be interested to hear that I saw a so-called “Sun Dog” in the evening sky in Canberra some months ago. I would not have known what it was except for the photograph in the February 93 issue of the Australian and New Zealand Physicist. It was in fact very beautiful, light yellow in the centre, changing to a darker yellow on the edge and then to gold, about 30 degrees to the left of the real setting sun in the western sky. I’m glad that you put explanations of these natural phenomena in the journal, things that ordinary people can see.

Allan Mortlock
Capital Scientific Instruments, Canberra

ANZP or Not?

Dear Editor,

If it is the Australian and New Zealand Physicists contribute, then editorial should talk of Australian physicists. We get touchy about that when we send Australia a steady stream of education articles, physics articles, academics, race horses, drug barons etc.

Good to see an editorial and a president’s column fostering communication between physicists and the public. Makes a change from academic waging about lack of money for their research. If they had got involved in the former a lot earlier there would have been better support for science.

John Campbell
University of Canterbury, NZ

Magic or Science

Dear Editor,

Since aphorisms and their authors soon become part, it might be useful to discuss the origin of the statement “To the uninitiated all sufficiently advanced technology is indistinguishable from magic,” quoted by you in your column in the October 1993 issue.

In New scientist (10 April 1993, page 3) the editor of that magazine stated that “Arthur C. Clarke once pointed out that the products of advanced technology would be indistinguishable from magic to people from less sophisticated cultures.” This brought a rejoinder from a reader (New Scientist, 4 September 1993, page 52), who brought to light the fact that Agatha Christie made a similar but broader statement in her book The Hound of Death (1933); the reader (Noel Ethridge) suggested that the “magic” aphorism should be known either as Christie’s Law, or the Christie-Clarke Law.

By chance I read the October issue of ANZP on the same day as I opened a letter from Arthur C. Clarke. With it he had enclosed a copy of a communication to the editor of New Scientist, dated 13 September, which apparently has not been published. In it he says that he is annoyed to be misquoted, and that “Clarke’s Third Law” states that “Any sufficiently advanced technology is indistinguishable from magic.” This he published in his book Profiles of the Future in 1982.

Further, Clarke writes that “I never believed that the concept was original, but merely tried to formulate it as concisely as possible.....quite recently I came across an even earlier version than the Agatha Christie one......unfortunately I’m now quite unable to locate it.” As Agatha would have liked it, the originator of the aphorism remains a mystery: but for a quote from memory, ANZPs editor did remarkably well.

Duncan Steel
Anglo-Australian Observatory & University of Adelaide

Worthwhile Reading

Dear Editor,

I think that the headline (Editorial ANZP October 93) “Missing 90% of Universe Found in Canberra” is one of the best I have ever read.

Joe Wolfe
UNSW

SCHOOL OF PHYSICS

SENIOR LECTURER/LECTURER/LECTURER, LIMITED TENURE

Applications are invited for these three staff positions created on the occasion of the appointment of Professor Keith A Nugent to a Chair of Experimental Physics. Creative experimentalists are sought with a proven record of research in one or more of the fields of x-ray optics, visible optics, scanning probe microscopy, lasers, atom optics, atomic and molecular beams or related areas. Candidates for the continuing positions must be able to demonstrate the ability to attract research funds as well as a high level of research achievement.

Each of the positions involves research, supervision of postgraduate students, as well as lecturing to undergraduate students. A genuine interest in undergraduate teaching is essential and evidence of success in teaching in the English language may be required.

The positions are available from 1 January 1994.

Salary: $A41,000 - $A48,686 p.a. (Lecturer, Level B); $A50,225 - $A57,793 p.a. (Senior Lecturer, Level C)

Further information and a position description: Professor K A Nugent (6E) 344 5457 or the Head of School, Professor A G Klein (6E) 344 5450; fax (6E) 347 4783

Applications close: 1 December 1993

Reference number: Senior Lecturer: 6E/40/258; Lecturer: 6E/40/259;

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More than a Degree

Australian & New Zealand Physicist Volume 30, Number 11, November 1993
New Basic Physics Derived From LASER PLASMA INTERACTIONS

HEINRICH HORA

The invention of the laser in 1960 verified Einstein’s theory of stimulated emission and opened a new chapter in physics. The ability to concentrate electromagnetic radiation into spaces as small as a wavelength and chop it into pulses as brief as the oscillation period, has produced intensities 24 orders of magnitude greater than that of the sunlight falling on the earth and has allowed the energy density focussed on a solid to reach about an MeV per atom.

It is not surprising that at these vastly increased power levels new phenomena should be found. We will discuss here some present examples and indicate the directions in which the field may develop in the future. The examples chosen are of high intensity interactions between laser radiation and gaseous materials or condensed matter, where the radiation very rapidly converts the atoms into electrons and ions to form a high temperature plasma. The interaction conditions differ by orders of magnitude from those of normal plasma physics and the new highly nonlinear results reflect this great difference. Many of these phenomena were theoretically expected but because of their nonlinearity much greater precision is required in specifying the initial theoretical conditions than is necessary in linear systems. It is hence much more difficult to theoretically predict results with accuracy.

Laser Phenomena

Laser irradiation of gaseous or solid targets initially revealed the classical behaviour of heating, ionization and gas dynamics with temperatures up to 100,000 degrees (10 eV). For slightly higher laser powers (above a MW) however, the plasmas unexpectedly generated ions with energies 1000 times higher than expected from gas dynamics. The dielectric response, including absorption, was no longer the classical value but became an intensity dependent nonlinear variation which could include relativistic effects. The theory of self focusing of laser beams by ponderomotive forces and relativistic self focusing were consequences of such behaviour.

The most ambitious practical application of laser-plasma interactions is the generation of clean, low cost and inexhaustable nuclear fusion energy. The aim here is to use laser irradiation to both heat and compress a pellet or capsule of high density deuterium and tritium to ignite exothermal fusion reactions, where the fusion energy released is much greater than the laser energy applied. There were two main problems, firstly the interaction of the laser radiation is extremely complex, with unexpected and poorly understood instabilities, pulsations and anomalies, and secondly the achievement of sufficiently high gains requires the ignition of a small core of the pellet which spreads the reaction to the surrounding material by a fusion detonation wave.

Heinrich Hora was at CERN and is now associated with the University of NSW and the University of Central Queensland, Rockhampton.

*This article was the Edward Teller Lecture delivered on the occasion of the award to Professor Hora of the Edward Teller Medal For Achievements in Fusion Energy.
Many laboratories contributed to finding solutions, but it was the Lawrence Livermore Laboratory in particular, and John Nuckolls(1) in particular, who made the main contribution to understanding the physics involved. Nuckolls unravelled the complexity of the interaction using indirect drive and by introducing spark ignition to produce sufficiently high gains. There is some promise of the commercial success of these methods early next century, given support for the necessary engineering developmental program. An alternative scheme, [Chapter 13 of Ref.2] is based on numerical modelling of this process, applying smoothing techniques to suppress pulsations using short time coherence and the superposition of fields. These ideas have been experimentally confirmed by underground nuclear tests during the Centurion-Halite project. This scheme clarified the main problem of the interaction process, namely pulsations in the 10 to 30 psec range. These methods were initially directed towards smoothing the laser irradiation in the lateral direction to give uniform intensity profiles and to avoid self-focusing and other instabilities. These numerical calculations and the experimental work of Maddever and Luther-Davies in Canberra make the prospect of direct drive with smooth interaction and low reflectivity a more realistic one.

The second problem in achieving sufficiently high gains may be overcome without using the complex and very sensitive methods involved in spark ignition. The early very inefficient volume compression and burn results, led us to consider a volume ignition mechanism similar to that of a Diesel engine. A decreased optimum ignition temperature of 4 keV was indicated, due to self heating of the reaction products and an even lower temperature of 1.5 keV, if the self-absorption of bremsstrahlung was included. The equivalence of this simple and safe volume ignition to that of spark ignition has now been demonstrated and some interlinking of the processes has been possible.

An earlier question was whether the laser ablation of pellets could produce an ideal adiabatic compression, free of stagnation and shock waves. This problem was experimentally solved in 1985 by Yamanaka, Nakai, Yamanaka and coworkers (3) who measured high fusion gains.

The Equation of Motion Including Nonlinear Forces

A central problem in laser plasma interactions has been to find the correct equation of motion for the plasma. The problems arose from the very strong inhomogeneities in density and temperature that occur in laser irradiated plasmas. Most early theories were based on homogeneous collisionless plasmas. One of the crucial problems of laser interactions was including collisions. We have shown how dispersion functions, with a pole change from minus infinity for no collisions, to nearly plus infinity when collisions are included. The poles of the optical constants, especially near the critical densities, yield very steep gradients for the quantities near these poles. Neglecting collisions leads to fundamentally different results for resonances and other phenomena. A quantum modification of the collision frequency at high electron temperatures appears to be necessary, although all of the consequences of this fact have by no means been worked out. Prior to 1966, the effects of inhomogeneities and collisions on the equations of motion, were not so dramatic. Spitze's derivation for the equation of motion from the Boltzmann equation predicted a force density in a plasma, with an ion mass m_i, ion density n_i and a net velocity v of the space charge free and thermally equilibrated plasma of:

\[ f = m_i n_i \left( \frac{\partial v}{\partial r} + v \cdot \nabla v \right) = -\nabla P + \frac{1}{e} J \times H + F \]  

(1)

which is determined by the thermokinetic force f_\text{th}, given by the negative gradient of the gas dynamic pressure P, the Lorentz force due to electric currents in the plasma, magnetic fields B and additional forces F due to gravitation etc.

If the currents and magnetic fields are caused by the high frequency field of a laser, the Lorentz term appeared to be the ponderomotive force

\[ \frac{1}{c^2} J \times H = \frac{1}{4\pi} \nabla \cdot E^2 \]  

(2)

This force was first derived in 1846 as electrostriction by Kelvin and later by Helmholtz as a ponderomotive force using elastochemical analogues to understand the electric field E. Erich Weibel (1957) showed that electrons in high frequency microwave fields obey the same field gradient forces (2) found by Kibble (1986) from Lagrangeans.

When considering inhomogeneous plasmas the gradient of the density is essential, as expressed in terms of the gradient of the optical refractive index n. The forces (2) in a plasma with one dimensional geometry become (4)

\[ f_{\text{nl}} = -i x \frac{E^2}{\omega_0^2} \frac{\omega_0^2}{\omega_0^2} \frac{\partial}{\partial x} \frac{1}{\nabla n(x)} \]  

(3)

as the averaged nonlinear force in the plasma due to the propagation of light of frequency \( \omega_0 \) with an amplitude \( E_0 \) of the electric field and using the plasma frequency \( \omega_p \). This force is identical to the ponderomotive forces (2) from the...
NEW BASIC PHYSICS DERIVED FROM LASER PLASMA INTERACTIONS

WKB approximation and stands for the Lorentz terms in (1) which now expresses the dielectric explosion (Figure 1) of a plasma density profile resulting from laser irradiation. This predicted dielectric explosion was discovered numerically as the generation of a cavity by Shearer, Kidder and Zink (5), based on the nonlinear force formula (3) driving thick blocks of plasma to the observed keV ion energies, and producing the characteristic cavity density minima (Figure 2).

When the one dimensional geometry was extended to higher dimensions difficulties occurred. An example is the case of laser radiation obliquely incident on a plasma. Here the equation of motion has to be generalized so that the nonlinear force becomes [6].

\[
f_{nl} = \frac{1}{c} \mathbf{j} \times \mathbf{H} + \frac{1}{4\pi} \mathbf{E} \cdot \nabla (\mathbf{H}^2 - 1) + \frac{\mathbf{H}^2}{4\pi} \mathbf{E} \cdot \nabla (\mathbf{H}^2 - 1) + \frac{\mathbf{H}^2}{4\pi} \mathbf{E} \cdot \mathbf{E}
\]

(4)

where all vectors on the right hand side correspond to the oscillation of the high frequency field of the laser and \( \mathbf{n} \) is the complex refractive index, including the intensity dependent nonlinear modifications of the dielectric response and of the absorption. When the last term is differentiated, three terms appear. Schluter’s 1950 derivation of the equation of motion reproduced one of the three nonlinear terms which did not appear in Spitzer’s derivation from the kinetic theory. We showed from momentum conservation that all the terms in our solution (4) must be used to describe the force density for non-transient collisionless plasmas. When collisions are included, the non-ponderomotive terms appear, determining the ordinary radiation pressure by absorption, for example perpendicularly to the density gradient of the plasma.

While our Eq. (4) was the final formulation for the time-independent solution, there were several years of controversy about the transient case before it was decided which terms were needed. We finally (1985) found the following solution [7].

\[
f_{nl} = \frac{1}{c} \mathbf{j} \times \mathbf{H} + \frac{1}{4\pi} \mathbf{E} \cdot \nabla (1 - \frac{1}{\omega} \frac{\partial}{\partial t}) \mathbf{E} \mathbf{E} \mathbf{E} (\mathbf{n}^2 - 1)
\]

(5)

which is algebraically identical with the formulation using the Maxwellian stress tensor for the vacuum \( \mathbf{T} \),

\[
f_{nl} = \nabla \cdot \left[ \mathbf{T} + (1 - \frac{1}{\omega} \frac{\partial}{\partial t}) \mathbf{n}^2 \mathbf{E} \mathbf{E} \mathbf{E} + \frac{1}{4\pi \omega} \frac{\partial}{\partial t} \mathbf{E} \times \mathbf{H} \right]
\]

(5a)

The correctness and final generality of this equation of motion was first derived from the algebraic structure of the terms (1985) and later confirmed by Rowlands from Lorentz and gauge invariance.

Nonlinear Principle

Even given the complete and general formulation of the force density in plasma theory, there remained the problem of understanding how the dielectric gradients produce the high plasma velocities by dielectric explosion in laser plasma interactions. The WKB approximation shows that the electric laser field amplitude, \( E = E_0 / |n|^{1/2} \), in a nearly collisionless plasma, increases to very high values. For example, if the absolute value of the refractive index \( n \) takes values of 1/10 or 1/100 (or much less in the plasma), the dielectric explosion is then due to the negative gradients of the increased \( E^2 \) values, and therefore the ordinary radiation pressure is increased dielectrically by a factor 10 or 100 (or more).

This appears immediately in numerical calculations and in experiments by several groups. It is due to the generation of density minima near the critical plasma density from very high intensity laser interactions. The Borchard experiment [8] used a laser beam focused into a low density gas which, due to the action of the nonlinear force, emitted electrons radially from the beam with energies from 100 eV to 1 keV, about half the maximum quiver energy of the electrons which the nonlinear force converts into translational energy. ▽
This energy conversion can generally be understood in terms of the nonlinear force. Single particle motion analysis, using the usual transverse electric and magnetic laser fields, however, produced discrepancies. These fields do not exactly satisfy the Maxwell equations for a laser beam of finite diameter. Our derivation of the missing field components led to the discovery of the first exact longitudinal components of light in vacuum. Their inclusion in the force produced agreement with the measurements, showing that the fully exact Maxwellian solutions are essential. Neglect of the very small longitudinal components led to a completely wrong result.

This example, and others developed later, demonstrate how nonlinear physics cannot be done simply by using the next highest approximation of a second order extension. One must use the exact linear model or theory in order to arrive at correct predictions.

The old methods of using theoretical physics to predict phenomena is certainly possible in nonlinear physics, but it is much more difficult to control the correct linear ingredients and avoid approximations. If this is done however, it is a rich source of predictions and explanations. For example, Spitzer [1951] considered ion beam fusion to be absolutely impossible and magnetic confinement the best way to make progress. His mathematics was completely correct both physically and logically but his prediction, based on linear theory, was nevertheless wrong. Nonlinear physics, however, shows that ion beam fusion is theoretically possible.

The Boreham experiment [9] was an example of the application of the correspondence principle of electromagnetic interaction [10]. Contrary to Bohr's correspondence principle for the electronic states in atoms of very high fundamental quantum number, there is an easy way for an electromagnetic interaction to continuously change from a quantum interaction to a classical one [10] just by continuously varying the laser intensity of the interaction. The lower intensity results in quantum interactions as seen, for example, in multiphoton ionization [9], whereas the higher intensities result in point-mechanical behavior [8], as seen from the appearance of Keldysh quasi-classical tunnel ionization [10].

**Double Layers and Surface Tension**

Surface tension in liquids and solids is mostly due to the dipoles of molecules which are not saturated at the surface. Since hot fully ionized plasmas consist of only electrons and nuclei, dipoles of this kind are not expected and therefore nor is surface tension. Plasmas actually do behave as if they had surface tension. Nonlinear force theories developed for laser-plasma interactions can explain this unexpected behaviour.

The space charge quasineutral theory is correct only for homogeneous plasma. It uses the old two fluid theory of the nonlinear force. A semi-microscopic derivation of the nonlinear force shows that the laser light is pushing or pulling the whole illuminated region of the electron gas. The ions within this space charge neutral region attempt to follow the electrons because of the electrostatic attraction between ions and electrons. This inertia effect makes it necessary to use a genuine two fluid model instead of the earlier simpler two-fluid theory of Schulte and Spitzer. This genuine two fluid model uses separate electron and ion fluids coupled only by Maxwell's equations. The Poisson equation only in one dimensional system. Generally, a three dimensional treatment of the genuine two fluid model results in non-linear fluid models in laser produced plasmas.

The electric fields $E_x$ from the Poisson equation in plasmas are well known as ambipolar electric fields and are given by the gradient of a pressure. The electromagnetic field driven ponderomotive potential is often also a pressure which causes electric fields in the same way, but usually the nonlinear force is not conservative and (so-called "ponderomotive") potentials appear only in very special simplified conditions. Our genuine two fluid model revealed general electrodynamics, including collisional damping, in any inhomogeneous plasma which contains the ambipolar field but which is generally very complex and includes nonlinear force effects and oscillations given by the locally varying Langmuir (plasma frequency and collisional damping).

With laser plasma irradiation, a new type of resonance was predicted for perpendicular incidence of laser radiation. This was sought for a long time because resonance absorption (Forsterling-Denisov) works at oblique incidence only and is polarization dependent. We further derived strong second harmonic emission in very low density laser irradiated plasma which was in agreement with observations. From this work came a very general understanding of the internal electric fields and double layers in laser produced plasmas and even of the hydrodynamic derivation of the laser driven, very large amplitude, Langmuir oscillation with Langmuir pseudo-

---

*Figure 3* Amplitude $E_x$ of longitudinal oscillations of the electric field driven by $10^{16}$ W/cm$^2$ Nd glass laser pulse incident from h.s. on a plasma slab generating an inverted double layer at the cavity near 5 micrometer [12].
These considerations also apply to the degenerate electron gas in a metal where electrons tend to leave the ion lattice, not due to thermal energy as in a plasma but due to their Fermi energy of a few eV. They are arrested by the electric field that they generate as a surface double layer, resulting in the work function of a few eV. A surface tension results in the same way as in Eq. (6). In cooperation with Pease [p176 of Ref.2], we derived values of the surface tension of metals which are in good agreement with the experimental values. The values calculated from this swimming electron layer model were positive, in contrast to the jellium model of surface tension which when applied to metals can give erroneous negative surface tension values.

The Containment Force of Hadrons in Nuclei and Phase Transitions into Quark Gluon Plasma

The surface tension for metals as given by this plasma model for a degenerate plasma, can be extended to where a plasma is no longer defined by compensating charges, namely in a nucleus [13], by substituting for the temperature T a Fermi energy. Charges are present and Hofstadter’s experiments showed that the charge distribution in a nucleus is constant in the interior, and decays over quite a long distance of about 3.5 fm to zero at the surface of the nucleus.

We can use the Fermi energy simply to define a similar “plasma like” surface tension and surface energy for the nucleus in conjunction with the hadron mass and the Compton wave length $\lambda_C$ for the nucleons:

$E_C = \frac{(3/\pi)^{2/3}}{4} \frac{\hbar^2 n^{3/2}}{2m} \frac{1}{(\lambda_C/2)^{1/3}}$ (subrelativistic) \hspace{1cm} (7)

$E_F = \frac{(3/\pi)^{2/3}}{4} \frac{\hbar^2 n^{3/2}}{2m} \frac{1}{(\lambda_F/2)^{1/3}}$ (subrelativistic) \hspace{1cm} (7a)

which changes from the subrelativistic branch into the relativistic one at a nucleon density of $(\lambda_C/2)^{-3}$. We note that the relativistic Fermi energy is independent of the particle mass and is therefore the same for nucleons or quarks etc.

The internal energy $E_i$ of the bismuth nucleus is mainly determined by the Fermi energy and to an extent by Coulomb repulsion, a dipole surface energy and a volume energy, giving in total 4.17 GeV. The surface energy $E_S$ of the bismuth nucleus using the Fermi energy as mentioned in Eq. (6) produces a value of 4.14 GeV, confirming that our plasma surface tension model leads to a stable nucleus at a measured nucleon density. We also derived a Debye length of 3.64 fm for the Hofstadter decay of the charge density in good agreement with the measurements.

It is interesting that the ratio

$E_S/E_F = \text{const} n^{1/6}$ \hspace{1cm} (8)

Figure 5 Hadrons (protons p and neutrons n) at less than nuclear density $n_{n_u}$ where the surface energy $E_s$ is less than the internal energy $E_i$. Equality is reached at the known density of the nuclei explaining how the surface energy exactly compensates the internal energy to produce a stable nucleus.

We thus see that a very applied area of classical physics such as laser produced plasmas can be generalised to describe such diverse phenomena as surface tension in plasma and metals, the work function of metals and the phase transition between hadron and quark matter when forming nuclei.

Acknowledgements

I am very grateful to Dr C. S. Taylor [CERN] for valuable comments. Support from Dr E. J. N. Wilson all of CERN is gratefully acknowledged.

References

NEW BASIC PHYSICS DERIVED FROM LASER PLASMA


WORKSHOP ON RARE EARTH MAGNETS AND APPLICATIONS

CHARLES STURT UNIVERSITY

Wagga Wagga NSW

6 - 8 February 1994

Prior to the 18th Condensed Matter Physics Meeting, a Workshop on Rare-Earth Magnets will be held. The workshop will bring together physicists, material scientists and engineers in an informal environment to discuss the latest advances in rare-earth permanent magnets and their applications. Topics being covered include NdFeB magnets, new permanent magnet alloys, novel processing techniques, magnetism theory and models, permanent magnet machines and numerical techniques for machine design.

The workshop format is a series of invited review talks on particular topics, followed by more focused contributed talks. There will be ample discussion time at the conclusion of each talk. Postgraduate students are particularly encouraged to present their work. There will be no poster papers. Any poster papers should be submitted to the Condensed Matter Physics Meeting.

Accommodation for the Workshop is in air-conditioned student accommodation at approximately $65 per day. Registration for the Workshop and the Condensed Matter Physics Meeting will commence at 1400 hours on Sunday February 6, 1994 and the first session of the Workshop will begin after the Sunday evening meal. The Workshop will finish at lunch on Tuesday February 8.

Further information from:
Dr S.J. Collocott
CSIRO Division of Applied Physics
PO Box 218, Lindfield NSW 2070
Tel 02-413-7130, fax 02-413-7383 or
email steve@dap.csiro.au

Prof P.G. McCormick
Department of Mechanical and Materials Engineering
University of Western Australia, Nedlands WA 6009
Tel 09-380-3122, fax 09-380-1024.
New Belt-Drive Linear Positioning Stages

Aerotech announces the immediate availability of the AT5700 series of belt-drive linear positioning stages.

With travel lengths from 6 inches to 48 (150 to 1200mm), the cost-effective AT5700 series stages provide high speed (up to 118in/sec [3m/sec]) high acceleration motion profiles for pick-and-place, scanning, gluing, test/inspection, material handling and similar applications. Up to 150lb (68kg) load is accommodated.

AT5700 stages features a durable reinforced timing-belt drive, long-life linear bearings and integral metal waycover, plus travel limit switches, cushioned end stops and standard NEMA 34 motor interface. Options include installed stepping or servo motor and X-Y combinations.

Prices start at $200 and delivery is two to six weeks.

For more information contact Lastek Pty Ltd, 400 King William Street, Adelaide SA 5000.
Tel (08) 231 2155, fax (08) 231 2169.

The new AT5700 Belt-Drive Linear Positioning Stages are now available from Lastek Pty Ltd.

devices of high power output, small size, ruggedness, reliability and low cost while maintaining flexibility to meet a wide range of applications.

The CO₂ and CO₂ radiation interacts strongly with all plastic materials. Almost all energy is absorbed to facilitate cutting, melting, drilling, joining, vaporizing or welding.

In laminates, adhesive labels etc, it is possible to cut through one layer and leave the second layer untouched. Textiles and sailcloth can be cut while fusing the edges. Paper and wood based products can be readily cut or drilled.

With sufficient power density there is no residual discoloring of edges and the cuts are not distinguishable from mechanical cuts. Typical paper can be cut or perforated at several metres per minute with a 25 W laser.

Small holes can be drilled easily in elastomeric materials, a very difficult task with mechanical tools. High temperature plastic coating such as Teflon can be removed easily with these lasers as is done in wire stripping applications.

With 100 W and 200 W models light cutting and welding of ferrous metals are possible. With Synrad's patented Laser Colour Marking (LCM) technology, anodised aluminium panels can be engraved multi-coloured.

It is ideally suited to work with CAD and manufacturing systems. Synrad is the major CO₂ laser supplier for Desktop Manufacturing Stations.

And in Synrad's range of low power CO₂ lasers the technology is widely used in many surgical procedures because of its good interaction with living tissue. The incision is self cauterizing and often heals faster than conventional surgery.

In communication and detection lower power CO₂ lasers are used for missile guidance and for short range ship to ship secure communications.

For further information contact:
Mr Ian Butler
Spectra-Physics Lasers
2-4 Jesmond Road
Croydon Vic 3136
Free Call 008 805 696.

JTT Crystals from Raymax

Raymax Applications was recently appointed as the exclusive Australian Distributor for the range of crystals and other optical material supplied by JTT International.

The product range includes non linear crystals (BBO, LBO, KTP, KDP, KD*P, AgGaS₂, LiIO₃ and KNbO₃), self doubling crystals (NYAB), EO crystals (LiNbO₃, LiTaO₃), photorefractive crystals (BaTiO₃, SBN, Fe:KNO₃) and optical UV and IR materials.


Several housing options and temperature control modules are available and the standard warranty on crystals is 6 months.

For additional information on any crystals please contact:
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Asquith NSW 2077
Tel (02) 477 5654, fax (02) 987 4858.
**New Lockin Amplifiers With Digital Signal Processing**

Digital Signal Processing has revolutionised the world of synchronous detection, offering significant performance advantages over conventional techniques. Now this performance is available in two new lockin amplifiers from Stanford Research Systems.

Conventional lockins use an analog demodulator to mix an input signal with a reference. Dynamic range is limited to around 60dB and the instruments suffer from poor stability, output drift and excessive gain and phase error. Demodulation in the new DSP instruments is accomplished by digitising the input signal with a precision A/D converter and multiplying the result by a synthesised reference. The benefits of this approach include:

- 1mHz to 102kHz frequency range with 0.1mHz resolution
- >100dB of dynamic range without prefiltering
- output time constants from 10us to 30,000s (6,12,18, 24dB/octave rolloff)
- low distortion
- 0.01 degree phase resolution

Using DSP, a small signal embedded in noise that is one million times larger can easily be measured. The new instruments outperform all analog lockins by a wide margin and offer exceptional value for money.

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116 Burbridge Rd
Hilton SA 5033
Tel (08) 351 1111
Fax (08) 352 2020.

**Optical Multimeter Released**

Alton Instruments have announced a revolutionary new optical instrument – the Lumiameter LM-30.

The LM-30 is a true optical multi-meter that measures real-time wavelengths, intensities, intensity ratios, FWHM, power, radiance and illuminance of a variety of optical sources at wavelengths between 200nm and 1000nm.

"Part of the problem is that without its own industry, the contribution physics makes to the economy is not recognised".  

*Europhysics News 23, 1992*

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**Australian Designed and Manufactured Laser Scanning Confocal Microscope**

Model SR830 DSP Lock-In Amplifier is manufactured by Stanford Research Systems.

Unlike etalon based spectrum analysers the LM-30 uses a 2048 element photodiode/CCD detector. Thus there are no alignment or input bandwidth restrictions and both coherent and incoherent sources can be analysed. An LCD display provides instantaneous digital readout as well as spectral plots.

A remote fibre optic detector probe allows versatile adaption in laboratory or industrial environments, while the RS-232 interface enables the LM-30 to be integrated into PC based data logging applications.

Alton Instruments is a leading supplier of precision laboratory equipment to the semiconductor, telecommunications and analytical instrumentation industries, as well as to scientists and engineers involved in research into lasers and electro-optics.

For more information please contact the Alton representative for Australia and New Zealand:
Spectra-Physics Pty Ltd
2-4 Jesmon Road
Croydon Vic 3136
Free phone 008 805 696
Tel (03) 723 6600, fax (03) 725 4822.

HBH Technological Industries Pty Ltd,
Dandenong has now made sales of the HBH Fibrescan C900 LSCM in four countries.

The instrument received overseas recognition in the form of the prestigious R&D 100 Award as “One of the 100 most technologically significant technical products of the year,” in the United States. Other winners for the year included, NASA, IBM, the US Atomic Energy Commission, Hitachi, Toshiba, Bell Labs, Kodak, the US Naval Research Labs, Lawrence Livermore and several major US Universities.

Most instruments have been supplied with an air cooled argon ion laser for biomedical research. Currently the optical sectioning capabilities are being used to image immunofluorescently labeled tissue proteins, in vivo responses of microvascular beds; photo activated tumor therapy drugs and the cross sectional structure of individual fibres of paper during drying.

The use of Optical Fibre as the transfer element of the system provides unique versatility to the instrument to non standard components such as bulky lasers, monochromators and detectors and also permits extreme miniaturisation. This is of interest in many areas of physics and current
projects include: Fluorescence time decay imaging using a mode locked pulsed dye laser, Laser Tweezer experiments, Raman Microprobe analysis and a system in which the high intensity of the Scanning laser spot is being used to swamp the self emission and to form images of very hot objects such as welding beds and the interior of furnaces.

The system comes with extensive image analysis software and with a programmable stepper motor to allow the compilation of three dimensional data sets which can then be displayed as rotatable extended depth of field, 3D computer images.

The HBH systems are much less expensive than the imported LSCM's and can be supplied with a variety of lasers or adapted to existing lasers and computer systems.

Systems will be on display at ACOLS (The Australian Conference on Optics, Lasers and Spectroscopy), at the University of Melbourne, December 6-10, 1993.

For further information contact:
Martin Harris
HBH Technological Industries Pty Ltd
Tel (03) 791 7286, fax (03) 706 7974
Mobile 018 547 901
Correspondence to:
PO Box 807, Dandenong, Vic 3175.

**Microstar Laboratories Announces New Data**

Microstar Laboratories, Inc. have announced the DAP 3200e, a data acquisition board that includes its own dedicated 80486 processor. This processing power gives the DAP 3200e unprecedented real-time response: task latency of less than half a millisecond. As well as the 486 processor, the DAP 3200e includes 1 MR or 4 MR of on-board memory, and its own multitasking real-time operating system, DAPL 4.0. The DAP 3200e can therefore handle all the critical real-time aspects of a data acquisition and control system with all its associated analog and digital I/O, while leaving the processor on the PC platform another 486 - say - free to handle the demands of a resource-hungry operating system and user-interface.

A single DAP 3200e with external expansion hardware can acquire up to 512 analog inputs and 128 digital inputs, can process the acquired data, and can update up to 66 analog outputs and 128 digital outputs.

Dual 512-word high-speed FIFO buffers allow the DAP 3200e to bypass DMA hardware and therefore run the PC platform bus at maximum speed. An optimized communications protocol, shared between DAPL and the Microstar Laboratories driver on the PC platform, ensures gap-free data transfer with no errors. This approach also allows up to seven DAPs to share the PC bus without significant hardware restrictions, and with only a single hardware interrupt line. The result is a data acquisition system with massive real-time processing capability synchronized on a single PC platform and with overall mixed analog and digital sampling at over 4 megasamples per second. Analog outputs can be updated at the same rate as analog inputs are sampled, and at the same time. So a DAP 3200e can provide a sophisticated stimulus to an experiment or process, and simultaneously measure the response.

As well as being able to sample inputs at a high rate, an individual DAP 3200e can remarkably update outputs at an even higher rate. An aggregate output rate of 1.6 million updates per second is shared among any or all of up to two analog outputs and up to sixteen digital outputs. Applications include generating aliasing-free high frequency waveforms from memory.

The larger memory model DAP 3200e - allows for plenty of data points for many distinct cycles of a custom waveform to be output before the pattern repeats.

DAP 3200e - the on-board multitasking real-time operating system shipped with every DAP 3200e has over 100 standard commands for on-board processing, including Spectral Analysis. Other DAPL commands configure the DAP, smooth data, condition sensor data, wait for or generate triggers, respond to alarms, and format output.

DAP 3200e Data Acquisition Processors are priced from $5,300, DAPL 4.0 included, and are available now. To control a DAP from Microsoft Windows requires the Microstar Laboratories Windows Toolkit which costs $165.

For more information contact:
Mycos Technology
PO Box 211, Heidelberg VIC 3084
Tel (03) 499 2607, fax (03) 499 4977.

The 486-based Analog Accelerator for Windows, DOS and OS/2 is now available from Mycon Technology.
ARE THERE GENDER DIFFERENCES IN SCHOOL PHYSICS ACHIEVEMENTS?

MARTIN CAON

Data is presented on achievements in the South Australian matriculation (Year 12) physics course for all students from 1986 to 1990. It shows that in three of those year's there was no significant gender difference in achievement while in two years, the girls achieved higher grades than the boys. It is suggested that one of the reasons that there are fewer girls than boys enrolled in Year 12 physics is that a lower proportion of less able girls than less able boys attempt the course.

Introduction

A great deal has been written about the achievements of girls in science when compared with boys. Early studies on gender differences in achievement in science have generally shown that boys outperform girls. Gardner's (1974) review of the literature concluded that boys generally achieve better in science and hold more positive attitudes to science than girls. The International Association for the Evaluation of Educational Achievement, in their first Science survey, found that the mean total science achievement score was higher for boys than for girls (Kelly 1978). Even recent studies report a performance differential in favour of boys. Jones (1991) reports a finding of the 1986 National Science Foundation survey (Washington USA) that seventeen year-old boys outperformed girls in tests of mathematics and science. However, no gender difference in physics knowledge was reported by Klinin, Fensham and West (1989). They tested classes of Year 10, 11 and 12 physics students in Bangkok, Thailand by 30 multiple choice questions and found no significant difference in physics knowledge between boys and girls.

In searching for an explanation for the gender difference in performance found by some studies, attention has focussed on the previous science courses taken by boys and girls. If the difference in science achievement between boys and girls is the result of boys having studied more science than girls, then there should be no difference when the amount of science studied is the same. Parker and Offer (1987) analysed data for gender differences in achievement in Year 10 science for the years 1972-85 in Western Australian Schools. Students in their study had followed a similar science curriculum for three years prior to assessment in Year 10. That is, the amount and type of science studied by the boys and girls was the same. The Parker and Offer study found that girls demonstrated slightly higher achievement than boys.

The participation and achievement of girls in senior secondary school physics is seen as the area where there is the greatest differences between the sexes. It would be instructive to determine whether there are gender difference in achievement in school physics courses when achievement is measured by the usual school or education authority grades and when all students have studied the same amount of physics. The purpose of this paper is to report the results of a test of the null hypothesis "that there is no difference in the achievement in Year 12 physics between males and females". The measure of achievement used in this paper is the physics grade awarded by the Senior Secondary Assessment Board of South Australia (SSABSA).

Background

Martin Caon is in the School of Nursing Studies at Flinders University of South Australia, Adelaide SA.

The SSABSA has for many years, awarded a score out of twenty and a grade ranging from A (the highest) to E (the
ARE THERE GENDER DIFFERENCES IN SCHOOL PHYSICS ACHIEVEMENTS?

<table>
<thead>
<tr>
<th>Year</th>
<th>A_1</th>
<th>A_2</th>
<th>B_1</th>
<th>B_2</th>
<th>C_1</th>
<th>C_2</th>
<th>D_1</th>
<th>D_2</th>
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<td>752</td>
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<td>313</td>
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</tbody>
</table>

Data from SSABSA annual reports, 1986-90

lowest) to each of the five subjects that candidates present for assessment by public examination in year 12. The range of scores within each grade is as follows: E for a score of 0 to 7; D for scores of 8 to 10, C for 11 to 13; B for 14 to 16; and A for 17 to 20. Since 1986, the number of candidates scoring each grade and their gender have been published in the Annual Report of the SSABSA. This information allows the analysis of gender differences in achievement in Year 12 physics to be carried out by comparing the relative numbers of each grade awarded to males and females.

Students who choose to study physics at Year 12 in South Australia have generally also studied mathematics and physics in Year 11 and science in Years 8, 9 and 10. While the science courses that were studied in the junior secondary schools will vary considerably between schools, the curricula are established with the aim that they be suitable preparation for someone who will study science in a publicly-examined subject at Year 12.

Hence by the end of Year 12, students have all studied physics for two years, after having studied three years of general science in junior secondary school. It can be said that all Year 12 physics students have had a similar history of school science study: as far as this is possible to achieve within a reasonably diverse secondary educational system.

Table 1 Size of matriculation physics cohort and percentage of females and males 1986-1990.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total number of Year 12 physics students</th>
<th>Males(%)</th>
<th>Females(%)</th>
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<td>3813</td>
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</tr>
<tr>
<td>1990</td>
<td>4004</td>
<td>71</td>
<td>29</td>
</tr>
</tbody>
</table>

Data from SSABSA annual reports 1986-90

Table 2 Numbers of males (m) and females (f) awarded the grades A-E in the South Australian Year 12 physics examinations 1986-1990.

Methods

Population Studied

The population included in this analysis consisted of all the candidates who presented themselves for examination in Year 12 physics in the South Australian syllabus during the years 1986-90, a total of 19,919 students. Students from the Northern Territory (about 200 students per annum) and some of Malaysia's non-government schools (between three and four hundred students each year) also study the South Australian curriculum and are included in the population. The ratio of male: female physics students in the Northern Territory, and in the Malaysian schools, was very similar to that in South Australia (about 2.6: 1) for the years studied.

Statistical Analysis

The five grades awarded by SSABSA are unequal intervals so constitute an ordinal level of measurement, thus a non-parametric test of significance is indicated. The population is divided into two independent samples (males and females) so that the Kolmogorov-Smirnov two-sample test is an appropriate test to use (see Siegel, 1956, p127 for a discussion of this test).

This two-sample test is concerned with the agreement between two cumulative distributions. If the two samples have been drawn from the same population distribution, then the cumulative distributions of both samples can be expected to be fairly close to each other. If the two sample distributions are "too far apart" at any point, that is if males and females differ in the cumulative number of grades A-E awarded, this
ARE THERE GENDER DIFFERENCES IN SCHOOL PHYSICS ACHIEVEMENTS?

<table>
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<th>Year</th>
<th>Kolmogorov-Smirnov D value (highest)</th>
<th>D value required for significance</th>
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<td>.047</td>
</tr>
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* p<.05

Table 3  Results of the Kolmogorov-Smirnov D statistic comparison of Year 12 physics grade distribution of males and females.

suggests that the two samples come from different population distributions. The Kolmogorov-Smirnov two-sample test was applied to each cohort separately.

Results

For the period of this study, the number of students enrolling in Year 12 physics remained fairly static at about 4000 per annum (Table 1). The numbers of males and females who achieved each grade is presented in Table 2. The maximum D values obtained using the Kolmogorov-Smirnov two-sample test are presented in Table 3 along with the D value required for significance at the 0.05 level. In the years 1986, 1987, and 1990 there was no significant difference in achievement between males and females. However, in 1988 and 1989 female achievement was significantly higher than males.

Consequently the hypothesis “that there is no difference in the achievement in Year 12 physics between males and females” is accepted for the 1986, 1987 and 1990 cohorts but rejected for the 1988 and 1989 cohorts.

The data in Table 2 converted to percentages is presented in Table 4. If there is no significant gender difference in achievement then the percentages of males and females awarded the one grade should be similar and show no trends.

Females achieved a higher percentage of “A” grades than males in three of the five years; a higher percentage of “B” grades in all five years; a higher percentage “C” grades in four of the five years. The trend is reversed when the lower grades are considered. Males were awarded a higher percentage of “D” grades in three years (they were equal in 1988); and a higher percentage of “E” grades in each of the five years analysed.

Discussion

It is clear that of the students who choose to do physics in Year 12, males do not outperform females, in fact the gender differences that do exist indicate that the reverse may be the case. Since the amount and type of science studied, by the group of boys was similar to that of the group of girls, prior to measuring achievement, this result is not due to differences in the educational science background of males and females.

There is however, a striking difference in the proportion of male and female Year 12 physics students (in South Australia, males outnumber females in the ratio 2.6:1). This fact raises the question of the relative academic ability of the males and females who choose to study physics at Year 12. It is not clear whether the range of academic abilities among the female Year 12 physics students is the same as that of the males. However this study suggests that it is not. A greater percentage of males were awarded the lower grades “D” or “E” than females. Two possible reasons are that girls apply themselves more diligently than boys - and that lower ability female Year 10 science students are less likely to choose subjects that lead to Year 12 physics than are the lower ability males. It may be that girls need to be more sure of their ability than boys in order to choose Year 12 physics and that this leads to fewer but more able female students in Year 12 physics.

This interpretation is consistent with a study by Gronmo et al. (1991) of Norwegian physics students. They compared the Integrated Science grade of girls who went on to study physics with those of the boys. The female physics students had higher grades than the male students, >

Table 4  Percentage of males (m) and females (f) awarded the grades A-E in the South Australian Year 12 physics examinations 1986-1990.

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It seems likely that as a group, the females that choose physics are more able than the males. If this is true then it is not surprising that females out-perform males in the SSABSA Year 12 physics assessment. The desired situation in a society that aims for equitable outcomes for both sexes is no significant gender difference in physics achievement. Whatever gender inequities there may exist in Year 12 physics, a lower academic achievement by girls is not one of them.

**References**


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**FIX on PHYSICS**

Physicists please help in the promotion of Physics as a subject in Years 11 & 12 by supplying us with illustrated articles for publication in our Education Supplement Fix-on-Physics. Please send articles together with originals of illustrations and/or black & white photographic prints to the Editor (see address on Contents page).

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**ANTARCTICA**

A Natural Reserve Devoted to Peace and Science

![Antarctica Logo](antarctica_logo.png)

**1995 AUSTRALIAN NATIONAL ANTARCTIC RESEARCH EXPEDITIONS**

**PHYSICIST**

(Auroral and Space Physics)

Professional Officer Class 1 or 2

The Antarctic Division invites applications from qualified men and women to participate in the 1995 Australian National Antarctic Research Expeditions (ANARE).

There are several positions available for physicists to carry out research programs and to operate and maintain an extensive range of observatory equipment. The physicists will undertake experimental studies in the fields of, atmospheric sounding, electric field measurement, photometric and interferometer observations of the airglow and aurora, or ionospheric irregularities utilising a digital portable sounder.

Successful applicants will join the Antarctic Division in Tasmania in July 1994, and leave for Antarctica in late 1994 for a period of approximately twelve months. On return to Australia, expeditioners may be required to spend up to twelve months at the Antarctic Division, compiling the results of research undertaken. The total contract term is generally in the order of thirty months.

Applicants must have a degree or diploma in a field of study appropriate to the duties, or equivalent qualifications.

Salary will depend on the applicants level of experience relevant to assigned research projects. Figures quoted are gross per annum as at 10 March 1994.

**Professional Officer Class 1** $28537-$36381 in Australia

$56010-$64532 in Antarctica

**Professional Officer Class 2** $37187-$41561 in Australia

$65336-$69712 in Antarctica

For a full statement of qualifications, further information and official application forms, please contact Recruitment Clerk by telephoning (008) 030 755 or Dr Ray Morris on (002) 323 315.

Applications close on 3 December 1993

The Antarctic Division is an equal opportunity employer and maintains a smoke free working environment.

Department of the Environment, Sport and Territories.
**Student Paper Night**

The annual "Student Paper Night" of the South Australian Branch was held on May 12 this year in the Kerr Grant Lecture Theatre of the University of Adelaide. The meeting commenced with the presentation of the 1993 Silver Bragg Medals to David Pfitzer and Andrew Medlin (in absentia) by the Chairman of the South Australian Branch, Dr Roger Clay. Dr Clay congratulated the recipients on their award, which recognises South Australia's outstanding undergraduate Physics students and expressed the hope that they would continue on with their Physics studies into the somewhat different realm of Physics research. The meeting was then addressed by three postgraduate Physics students, one from each South Australian University.

Margaret Law of Flinders University spoke first on the topic of "Superelastic Scattering from Opticaly Pumped Calcium Atoms", which dealt with the interactions between electrons and free atoms. These interactions are important in many areas, but the equations of motion for even the simplest scattering problem cannot be solved exactly. We must therefore rely on experimental measurements to test the validity of any theoretical approximation. Ms Law commenced with a basic introduction to scattering theory and described the experimental apparatus and techniques that were being applied to superelastic scattering studies at Flinders University. The talk concluded with the presentation of some preliminary results of angular momentum transfer, perpendicular to the scattering plane.

Mike Roberts of the University of Adelaide followed Ms Law and spoke on "Observations of Very-High-Energy Gamma Rays with a new Cherenkov Technique". Cherenkov light radiated from cosmic-ray induced "extensive air showers" is often used to make ground-based searches for extra-terrestrial sources of gamma rays. The technique, which has a threshold of about 1011 eV, is complicated by the need to isolate the gamma-ray initiated air showers from the large background flux of "normal", nuclear-initiated air showers. A new technique, which examines the arrival time distribution of Cherenkov light from cosmic-ray air showers, has been shown to be theoretically capable of discriminating between gamma-ray initiated and nuclear-initiated air showers, especially if the candidate source is at a low zenith angle. The talk described the technique, illustrated the theoretically predicted differences between the arrival-time distribution of gamma-ray and nuclear-initiated air showers and discussed preliminary observations using the technique.

The "Student Paper Night" concluded with a discussion of "Radon Decay in Bone Marrow Fat Cells and the Possible Induction of Leukaemia" by Ms Tammy Uteridge of the University of South Australia. Ms Uteridge's work, which is being performed in conjunction with the Royal Adelaide Hospital, is based on the observed correlation between radon concentration and leukaemia incidence, which has led to speculation of a causal connection between Radon exposure and leukaemia. Modelling studies undertaken at the University of Bristol have suggested that the bloodforming tissues within bone marrow receive a significant dose of alpha radiation from radon decay in bone marrow fat cells. However the epidemiological evidence from several studies that have investigated the relationship between alpha irradiation of bone marrow and the development of leukaemia is varied. Ms Uteridge outlined a program in which she intends to eliminate some of this uncertainty by using morphometry to determine the distribution of stem and fat cells and then using these empirical distributions in Monte Carlo modelling of alpha irradiation of bone marrow.

**SA Science Teachers Association Conference**

**August 1 - 2, 1993**

Members of the South Australian Branch manned an AIP display at the annual South Australian Science Teachers Association Conference held on Sunday August 1st and Monday August 2nd at the Australian Mineral Foundation Building in Coneyham Street, Glenside. Science teachers visiting the display were able to peruse copies of "The Australian and New Zealand Physicist" and help themselves to copies of some of the many "Fix on Physics" articles ("The Physics of Windsurfing" proving most popular) that have appeared in recent editions of the journal. Copies of the article "Who needs a Physicist" by Marek Michalewicz were also in demand. AIP members at the display took the opportunity to point out the benefits of AIP membership, especially associate membership, to interested teachers of Physics and drew their attention to upcoming meetings that were of interest to high-school teachers. Several teachers took the opportunity to register interest in the South Australian Branch's scheme to have working physicists address interested school groups.

Copies of the recent AIP brochure "Physics and your Future" were also available for teachers to take back to their students and career counsellors.

Any South Australian Physics teachers interested in finding out more about the AIP, its activities and membership benefits are asked to contact the Secretary of the South Australian Branch, Dr Tony Lindsay, Communications Division, DSTO, PO Box 1500, Salisbury, SA 5108 Tel (08) 259 6241.

**The Great Melbourne Telescope & the Search for Dark Matter**

The annual joint meeting of the Astronomical Society of South Australia and the SA branch of the AIP was held on June 2nd at the Kerr Grant lecture theatre at the University of South Australia in Adelaide. The speaker was Professor Alex Rodgers from the Mount Stromlo and Siding Spring Observatory and his topic was "The Great Melbourne Telescope and the Search for Dark Matter". The talk encompassed both history and physics. The first part of the Professor's talk summarised the history of the Great Melbourne Telescope (GMT). The second part explained its present use at Mt Stromlo in a search for gravitational lensing of light from stars in the large Magellanic Cloud by a postulated cloud of dark matter surrounding the Cloud.

Professor Rodgers began by explaining that the original building and installation of the telescope was due to a happy series of coincidences. After the discovery of gold in the 1850's Victoria was flush with funds and the influential people of Melbourne began
to view it as an emerging Athens of the South. In order to realise this vision, many world-class cultural facilities, a new Botanical Gardens and a new large Astronomical Observatory were planned. As well as performing astronomical observations, the new observatory was to take in hand the business of providing well-ordered standards and be used for geodetic observations which would form the baseline for geographical expeditions. In order to obtain a large telescope worthy to be the centre-piece of this new facility the Victorian government commissioned Howard Grubb of Dublin to provide a 48 inch reflecting telescope at a cost of 4600 pounds sterling. This represented a great leap in technology from the existing 15 inch telescope, and the commissioning was possibly a product of Victorian (in both senses of the word) optimism. In any case, the telescope was required for the above-mentioned purposes. In particular, it was especially suited to complete the survey of nebulae in the Southern skies begun by the astronomer Herschel in South Africa some years previously. The link with Herschel was further strengthened by the choice of maker; Grubb had also constructed many of Herschel's telescopes and specified the choice of material. Like the Herschel telescopes the GMT mirror was constructed not from glass, but from speculum, an intermetallic compound of copper and tin, which had been successfully cast in the quantities required for the manufacture of large mirrors. Because speculum mirrors deteriorate when exposed to air two mirrors had to be cast, in order that one could be used while the other was being refurbished. The refurbishing was performed by a polishing machine designed especially for the purpose which is now in the Technological Museum in Melbourne.

When the telescope was shipped to Melbourne it was fitted with an equatorial mounting in order to allow increased tracking ability. It was then housed not in a dome, which would have been too difficult to build, but in a large sheltered, with a retractable roof. As all Australians other than Victorians know, Melbourne is not the best place for a world-class observatory. Visibility there is classed as fair only 40% of the time and good for 17%, so this retractable roof was shut for much of the time. This would seem to indicate that the GMT was from the start, a slightly ill-conceived venture. This appeared to be borne out when, in 1870, shortly after the installation of the telescope there were public protests from amateurs who claimed to obtain better performance with their 10 inch and 6 inch telescopes. These claims were not unfounded as the sheer size of the GMT meant that atmospheric turbulence played a role in distorting the received image, a phenomenon that does not occur for telescopes smaller than 10 inch and 6 inch devices. Unfortunately this was not widely understood, and the inexperience of the staff in dealing with such big telescopes told against its success. To make matters worse, the one member of staff who had been involved with the project since the beginning, Mr Le Sueur, left after a year with the telescope. This was not before he had created somewhat of a furor by publishing drawings of η Carinae which appeared to contradict those obtained by Herschel some years previously. Le Sueur had, in fact, discovered a nova which exploded between the two observations, but novae were not understood at the time and the apparent contradiction resulted in a dispute which was eventually referred to the British Association for the Advancement of Science and the Royal Astronomical Society. The apparent contradiction and poor performance of the telescope led to the professional bodies deciding that incompetence was to blame. Those damned colonials had obviously not taken proper care of what was, when it left Britain, a perfectly good telescope. Still, what could you expect from a country populated by emigrants and the descendants of convicts?

The problem was that such a large telescope was not only surprising at its time, and, like all great ideas which are ahead of their time, was scorned by the experts of the day. Consequently it lay relatively dormant, as far as research was concerned, until 1893. In 1893 the great recession of the 1890's hit Victoria and the telescope fell into disuse, through lack of funds and consequent government cutbacks, presaging another recession some 100 years later. By 1920 the telescope was in a state of disrepair and was taken over by the Commonwealth Government, and in 1946 Mount Stromlo bought it from the Government for a paltry 300 pounds. The telescope was refurbished and fitted with a new 50 inch glass mirror. One of the old speculum reflectors was retained as a souvenir and now resides in the Technological Museum in Melbourne. The other was dropped and broke! The refurbished GMT was to be used for photometric research in the infrared, but that project never eventuated. It did, however, become involved in the delineation of the two stellar populations in the Magellanic Cloud, a project which lasted from 1960-80. The telescope has recently been refitted again, this time becoming once more, a telescope for the visible region. In its latest guise it has a new casing and computer-controlled tracking device, thus making it a bit like the proverbial grandfather's axe; still the same axe it was 50 years ago, only it has a new handle and a new head. However, the GMT at least still has the Grubb name plate sitting proudly on the rebuilt telescope!

Having brought us up to the present day Professor Rodgers explained the search for dark matter currently underway using the GMT. There are strong arguments, connected with the inflationary scenario, that immediately after the Big Bang the universe was flat, with zero space-time curvature. However, if the astronomically visible matter constitutes all the matter in the universe then the matter density of the universe is only about 10% of that required for the universe to be flat, thus suggesting that there is some form of missing, astronomically invisible matter, which is known as dark matter. This dark matter may well also explain the currently mystifying formation of the galaxies in the early universe, by supplying the extra mass necessary for the galaxies to condense out of the relatively formless early universe. Thus the discovery of large quantities of dark matter would kill two cosmological birds with one stone.

Further evidence for the possible existence of dark matter comes from observations of galactic rotation curves in spiral galaxies. If the rotational velocity of visible galactic components is plotted as a function of radius from the galactic centre, one obtains a curve which is reasonably flat all the way out to the edge of the visible galaxy. If the galaxy was in equilibrium we would expect the stars in the outer reaches of the galaxy to have rotational velocities governed by the Kepler law:

\[ T^2 \propto R^3 \]

where \( T \) is the orbital period and \( R \) is the distance from the galactic centre. If we rewrite this for the rotational velocity:

\[ \omega = \frac{2\pi}{T} \]

we obtain:

\[ \omega \propto \frac{1}{R^{1/2}} \]

The observed departure from this law could be explained by a dark ring of non-luminous material extending from the edge of the luminous region and changing the galactic dynamics in such a way as to produce a flat rotation curve. 

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*Australian & New Zealand Physicist Volume 30, Number 11, November 1993*
The dark matter which solves these three difficulties is thought to be of one (or both) of two possible types:

**WIMPs**

Weakly Interacting Massive Particles, a multiplicity of particles left over from the Big Bang which do not have much effect on ordinary particle interactions but do supply the missing mass. These particles could be massive neutrinos, axions, gravitinos or any other of a number of postulated particles whose existence is yet to be confirmed.

**MACHOs**

Massive Compact Halo Objects, brown-dwarf type "stars" which form halos surrounding existing galaxies. That is, it is postulated that all galaxies have an encircling halo of "stars", of roughly the size of Jupiter, which never quite ignite. Quite a considerable amount of astronomically-invisible mass could be concentrated in such MACHOs.

The problem is how to detect MACHOs if they are astronomically invisible? In practice it is hoped they may be detected by the effect they have on the light from other stars, as quasars and neutron stars are detected at present. Large compact masses lead to local variations in the gravitational field curvature and the corresponding bending of light rays which pass near the object. The MACHOs then form gravitational lenses which produce concentric ring images of sources which are in a direct line between the observer and the MACHO. Consequently, the alignment of the observer, MACHO and source leads to image brightening on a time scale:

\[ \Delta t = (2 \text{ days}) \times \sqrt{\frac{M}{M_j}} \]

where M is the mass of the MACHO and \( M_j \) is the mass of Jupiter.

Furthermore, the characteristic of this image brightening is that it is completely independent of wavelength, and so can be distinguished from increased emission from the star under consideration, which will tend to have some non-uniform distribution over the electromagnetic spectrum.

The GMT is currently involved in making photometric sweeps of the large Magellanic Cloud (LMC). It is recording time sequences of intensity for a huge number of stars in the LMC at two different wavelengths. (Data has been collected on 10,873 variable stars alone.) If MACHOs exist in the numbers required theoretically then in the next five years the experiment should produce 40 time sequences which show the characteristics of a MACHO-induced brightening of the source. As yet no gold-plated MACHO events have appeared, but over 90% of the data is yet to be collected and/or processed. Even if the experiment finds no MACHOs such a vast mass of data will provide a fertile field for Ph.D studies for many years to come. In about five years all the data should have been collected and processed and it will be known if MACHOs can resolve the above theoretical difficulties or whether it is necessary to start looking for some new source of dark matter.

Professor Rodgers said, was a far more definite aim than the vague “study of nebulae” for which the GMT was originally constructed. It represented a specific scientific project with a “yea or nay” answer and, as such, was a worthy occupation for this venerable telescope.

By way of a Stop Press Professor Rodgers concluded his lecture by reporting on the progress of the new large Australian telescope proposed for siting at Freehill Heights in the Flinders Ranges, the best seeing region in Australia. Theoretically the site has a similar cloud cover as the Andean region of Chile. But, of course, the altitude is less, so the seeing may prove to be not quite as good. Even so, the plan to build a telescope in Australia looks on the scale of the new KEK telescope in Hawaii is extremely exciting, not just for astronomers, but for the whole scientific community. A team is soon to go up to the site in order to examine the feasibility and logistics of the project and official announcements are expected shortly. How probable funding for the project is in this economic climate is another matter. Unlike Victoria in the 1850s Australia is, at present, in the middle of a boom, but a recession. The chances of funding for such a big project are consequently smaller.

The joint meeting concluded with questions and supper. Over supper one of us mused that Professor Rodgers talk was reminiscent of Milton. In Milton’s great poem “Paradise Lost” he wrote: “Hereafter, how they came to model heaven and calculate the stars; How they would wield the mighty frame; How build, unfold, contrive, to save appearances.”

This quotation, quoted by A.S. Eddington in his book, “Space, Time and Gravitation”, is particularly apt for the history of the Great Melbourne Telescope. While Australian astronomers have been modelling heaven and calculating the stars over the past 120 years they have “built and unbuild” the GMT’s mighty frame more than once. Now, once more, the GMT is being used to “calculate the stars” as it searches for evidence of the missing dark matter whose discovery will resolve many astronomical and cosmological puzzles and so “save appearances”!

Bill Boundy
Daniel Phillips

Editor’s Note: The discovery of the first MACHO using the GMT has now been published in Nature 365 (1993) 621, “Possible Gravitational Microlensing of a Star in the Large Magellanic Cloud” by Alcock et al.

18TH CONDENSED MATTER PHYSICS MEETING

Charles Sturt University
Wagga Wagga
9 - 11 February 1994

This conference will be held at the Convention Centre at Charles Sturt University. Accommodation will be available on the University Campus near the Convention Centre. A Workshop on Rare-Earth Magnets and Applications will run prior to the Wagga '94 meeting at the same venue and joint registration for both will be possible.

The CMP meeting is an opportunity for physicists in all areas of condensed matter to meet in an informal atmosphere to discuss research and other matters of importance in the field. The usual Wagga format will apply with emphasis on contributed poster papers plus a number of invited keynote oral papers. There will be no parallel sessions. Abstracts are requested in all areas of condensed matter physics.

There will be some emphasis by way of keynote papers in the areas of rare-earth and transition metal magnetism and high Tc superconductors. Invited speakers include: E.W. Collings (Battelle USA), G. Eska (Bayreuth, Germany), D.K. Finnemore (Iowa State USA), D. Riepe (Hahn-Meitner, Germany), L. Schultz (ISW Dresden, Germany), L. Shakhmuratov (Kazan, Russia), R. Street (UWA), J.W. White (ANU), Z. Zhao (Chinese Academy of Sciences).

Some contributed papers will also be selected for oral presentation.

Further Information from:
Assoc Prof Don Chaplin
tel (06) 268 8803 or
Dr Wayne Hutchinson, tel (06) 268 8804.

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Australian Defence Force Academy
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Since 1985, the Australian Science Archives Project (ASAP) has been working to ensure that Australia’s scientific heritage is preserved and made accessible. Recently, ASAP opened a Canberra office in the Australian Academy of Science’s Becker Building to enable it to pursue these national responsibilities more effectively. ASAP hopes to work closely with the Australian Foundation for Science on a series of projects related to the history of Australian science. In addition, ASAP’s range of information and archival services are now being made available to supporters of the Foundation.

INFORMATION
ASAP acts as a national information centre on the history of Australian science. Its major resource is the Register of the Archives of Science in Australia (RASA), a database containing information on the archival records of close to 2,000 Australian scientists. RASA is constantly being expanded, and a major effort is underway to incorporate information about scientific societies and organizations. Some of the information contained in RASA is already available in published form as the Guide to the Archives of Science in Australia, and on-line through the National Library of Australia’s OZLINE facility. In cooperation with the Foundation, ASAP is planning to incorporate RASA in a multimedia educational resource.

The History of Australian Science Newsletter is published for the Australian Academy of Science by ASAP three times a year. This newsletter contains news, reports, reviews, articles and notices relating to the history of Australian science, and acts as a contact point for a widely-dispersed community of scientists, historians, archivists, teachers and museum workers. HASH is available free-of-charge to all those with an interest in the area, and is currently mailed to over 1100 people in Australia and overseas. If you would like to be added to the mailing list please contact the Canberra Office. ASAP is always keen to receive items for the newsletter as well as further historical data for its files, so if you have information on any aspect of the history of Australian science that you think might be of interest to us - please let us know!

ARCHIVES - ADVICE AND PROCESSING
ASAP does not collect archives, rather it works with the creators of records, or their families, to ensure that archival collections are properly preserved. Contact ASAP for advice on storage and organization of your archival records, or for suggestions of suitable repositories. ASAP also undertakes a wide variety of archival processing tasks, from on-site surveys to detailed listings, using its own highly effective processing system. Not only can ASAP ensure that an archival collection is preserved, it can produce a detailed guide to the collection that will enable ready access by future researchers.

ASAP is entirely self-funded, and is dependent upon funds raised through grants, donations and consultancies for its continued existence. Archival processing can be funded by the creators of the records or, where appropriate, ASAP will work with record creators to identify outside sources of funding.

FOR FURTHER INFORMATION
If you have any questions about ASAP or any of the services described above do not hesitate to contact either the Melbourne or Canberra Office, details listed below.

Gavan McCarthy
ASAP Melbourne Office
Department of History & Philosophy of Science
University of Melbourne
Parkville VIC 3052

Tim Sherratt
ASAP Canberra Office
GPO Box 783
Canberra ACT 2601
Tel (06) 257 7985, fax (06) 257 7986
Some AIP members may not be aware of certain privileges that AIP membership entitles them to. For your information we have reprinted below extracts from a recent letter to the AIP president, Bob Crompton, from Amy Halsted, Administrator APS, Department of International Scientific Affairs.

"...Several societies with whom the American Physical Society has established reciprocal agreements have asked for clarification on the provisions of those agreements and how to invoke them. I am writing to explain these benefits, and to ask you to encourage your members to take advantage of them.

The first provision states that AIP members may submit papers to APS meetings with the same privileges and limitations as APS members. Abstracts for these papers must be submitted by the appropriate deadline date and in the proper format, in accordance with the guideline that appear regularly in APS News.

The second provision states that AIP members may register at APS meetings at member rates. Your members need only state that they are AIP members when registering at an APS meeting, and they will receive the APS member rate. Their AIP membership will be accepted on faith. In addition, registration forms for future APS meetings will include a listing of existing reciprocal membership agreements, so that an AIP member who was unaware of the benefit will be cued to take advantage of it.

The third provision states that members of the AIP may subscribe to APS journals at the same rates offered to members of societies that belong to the American Institute of Physics (USAIP here to avoid confusion). The USAIP is a service organization with some twelve member societies, including the APS. Many physicists belong to two or more USAIP member societies. Inexpensive journal subscriptions is one of the most attractive benefits of APS membership. If we offered journal subscriptions at member rates to the members of other USAIP member societies, these individuals would be less likely to join APS. APS depends on member dues to help pay for our outreach activities, including international affairs. The best solution was to offer an “USAIP member society rate” which consists of the regular APS member subscription rate PLUS whatever the current APS dues are PLUS $10. An individual is usually better off joining the APS, getting full benefits, Physics Today, APS News, member rates on journals, and saving the extra $10.

The same holds true for members of the societies with whom we establish reciprocal membership agreements. If we offered APS member rates for journals to members of the KPS, for example, we would lose a number of the approximately 200 APS members residing in Australia. To avoid this, we offer the USAIP member society rate through the reciprocal membership agreement. I wish it were possible to be more generous...."

**AGREEMENT FOR RECIPROCAL MEMBERSHIP PRIVILEGES BETWEEN THE AMERICAN PHYSICAL SOCIETY AND THE AUSTRALIAN INSTITUTE OF PHYSICS**

The American Physical Society (hereafter, APS) agrees to extend reciprocal membership privileges as defined below to individual members of the Australian Institute of Physics (hereafter, AIP), and the AIP agrees to extend membership privileges as defined below to individual members of the APS.

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2. AIP members may register at APS meetings at member rates; and
3. AIP members may subscribe to APS journals at the same rates as members of the other member societies of the American Institute of Physics.

Conversely

1. Members of the APS may submit papers to AIP meetings with the same privileges and limitations as AIP members;
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This agreement shall remain in effect for a minimum of two years following the date below, after which time, the terms of the agreement may be reviewed, renegotiated, renewed or terminated if either AIP or APS so desires.

Signed, for the AIP

Anthony W. Thomas
President
Australian Institute of Physics

Date: July 3rd, 1992

Signed, for the APS

N. Richard Werthamer
Executive Secretary
American Physical Society

Date: May 20, 1992
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Chernobyl Revisited - Once Again

Indonesia’s decision to build twelve nuclear power reactors is in the news, along with the continuing battle by the residents of Sutherland Shire to prevent replacement of the HIFAR reactor at Lucas Heights. Obviously the Indonesians feel that they can avoid creating a Chernobyl in their backyard, while the Sutherlandians feel differently. People have to make up their own minds about the dangers, but there is no substitute for reliable information when forming an opinion on any subject, most of all if the subject is nuclear power.

In our March issue last year, I reviewed Vladimir Chernousenko’s account of the Chernobyl disaster in which he set out to demolish some of the myths surrounding it. To some extent he succeeded, even though he freely confessed that his treatment of the subject was somewhat emotional. Hardly surprising, given that the Ukrainian authorities threw him in charge of the horrifying clean-up operation. Chernousenko’s book, Chernobyl: Insight from the Inside, contains plenty of facts, figures and views, culminating in his reaffirmation of belief in the need for nuclear power in his country.

Presenting a very different account of the Chernobyl disaster, is Piers Paul Read’s sensationally titled volume Ablaze: the Story of Chernobyl. It turns out that the title is the most sensational feature of a very level-headed treatment. In contrast to Ukrainian Academician Chernousenko, who was put in the hot seat (pardon the pun) at an early stage, Read was an outsider who had to go to great lengths to secure interviews with the key players in the Chernobyl drama.

Chernousenko was trained as a theoretical physicist, while Read is a bestselling novelist. Yet Read manages to deliver a sense of immediacy mostly lacking in Chernousenko’s first-hand report. This is where Read’s skill as a writer shines through: his careful research, access to hitherto secret reports, extensive visits to ministries, institutes and centres formerly closed to foreigners, gave Read the material to weave into a coherent story that carries the reader along like a good novel.

The picture Read portrays of the Soviet scientific and engineering establishment and its leaders is an eye-opener to anyone who has never had much contact with them. After Valeri Legasov, deputy director of the Kurchatov Nuclear Institute, was denied recognition and decoration for his heroic deeds in the aftermath of the Chernobyl disaster, he hanged himself. His all-powerful boss, Academician Anatoli Alexandrov broke down and sobbed “Why did he abandon me?”. It simply did not occur to the mighty Alexandrov that he had received more loyalty from Legasov than he bestowed in return.

Part of the problem facing the unfortunate reactor operators was their total lack of knowledge of other reactor mishaps in the Soviet Union, let alone reliable facts about reactor accidents in the West. Then they had the problem of inadequate instrumentation: dosimeters unable to cope with the extreme levels of radiation denied those at the scene full knowledge of their peril. Next day a wedding party just across the river from the erupting reactor carried on celebrating: the sun was shining brightly - what could be wrong?

Read’s well-written story of Chernobyl is required reading for anyone with an interest in the human side of the disaster. Read makes no judgements and in this regard his book is exemplary. Taken together, Chernousenko’s statistic-filled chronicle and Read’s painstaking post-mortem are the best overview of Chernobyl we have. The definitive account of the disaster, however, is yet to be written.

Piers Paul Read’s Ablaze: the Story of Chernobyl, 478 pages in hardcovers, was published by Seeker and Warburg and retailed in Australia for $45.

Colin Key
Reviews Editor

Greek eclipses waited a thousand years for Kepler. Tensor calculus waited 40 years for Einstein.
Due to their electronic structure the narrow gap semiconductors are suitable as infrared detectors. Traditionally InSb and CdHgTe (with more than 80% of HgTe) compounds were exploited for such a purpose. However, the new opportunities were created when it became clear that the incorporation of magnetic impurities like Mn or Fe into II-VI narrow gap materials could add special magnetic and magneto-optical properties. Looking through the papers one can come to the conclusion that no entirely new phenomena were reported. What is encouraging is a high proportion of technology-oriented contributions. At present the III-V MBE technology has reached very high perfection, while II-VI MBE grown superlattices and quantum well structures still need to be improved.

I was involved for years in defect structure analysis of the narrow gap semiconductors, so it was interesting for me to find out that the problem of defects has not yet been solved. The demand for the study of defects is even more urgent than future technical possibilities because there is a lack of the appropriate methods giving microscopic information on impurities and defect complexes.

The overall impression from this book is that the subject of narrow gap semiconductors has significantly changed in recent years. I must say I agree with the statement of Professor McGill, given in his opening address, that infrared devices based on narrow-gap semiconductors, especially type-II superlattices based on the III-V system InAs/GaSb, have a bright future.

The book is meticulously prepared for publication and should be found on the shelves of every serious library which supports research on semiconductors. Research students in semiconductor science and technology, as well as industrial and academic researchers in this field should be encouraged to reach for it.

T. Warinski
Telecom Australia Research Laboratories

Dye Laser Principles

This book covers a number of topics relevant to dye laser research and development. It is a collection of short topical articles, each written by an expert in the field. This mode of presentation is both an advantage and a drawback to the volume. On the one hand, the technique allows a wide variety of topics to be treated by the people best able to do so. On the other hand, the book tends to be uneven in quality, and suffers from repetition. For example, the two-level Maxwell-Blanch equations in chapter two are repeated in chapter three, with essentially no changes.

A further drawback of the book is the relative lack of sophistication of the theory presented. Thus, there is no recognition that the two-level, planar Maxwell-Blanch equations are a very crude approximation to the realities of laser operation, which invariably involve more than two levels, and modes which are Gaussian rather than planar. Similarly, problems of noise and fluctuations are ignored in the theory presented here. Instead, the reader is (correctly) told that dye laser amplitude noise is far from being explained by the usual textbook model of a van-der Pol oscillator with Schawlow-Townes phase noise due to spontaneous emission. No mention is made of more relevant models that are now available.

To compensate for the oversimplified theory presented, which is largely inadequate, there is a wealth of experimental detail and a large number of modern references. The list of references is especially comprehensive, covering topics ranging from the earliest dye lasers in the 1960's, to recent work on ultra-fast dye lasers. In fact, the book's topical style has enabled the editors to cover a range of applications. Chapters include femtosecond dye lasers (one of the best chapters), narrow-linewidth pulsed dye lasers, cw dye lasers, photochemistry of organic dyes, laser dyes, industrial applications, isotope separation, and medical uses. A useful appendix on laser dyes gives a comprehensive survey of a number of common dyes. Although the information given is really too brief to be useful as it is, it certainly gives the reader an idea of the range and wavelength coverage that are currently available.

In summary, the book is somewhat of a mixed bag, which reflects the specialised interests of a number of researchers - rather than a coherent text of the type the title suggests. The field still seems to be wide-open for a book that genuinely treats the principles of dye laser operation. In view of the lack of alternative texts with the coverage of this volume, I would recommend it as an addition to a library of modern quantum electronics; but with strong reservations about the theory included here.

Peter Drummond
Department of Physics
University of Queensland

Integrated Optoelectronics
Waveguide Optics, Photonics, Semiconductors
K.J. Ebeling
Springer-Verlag, Berlin 1993 ix + 537pp., DM98 (hard cover)

In a field that is generating new books at about as fast a rate as the subject itself is ballooning this book promises to stand out from the crowd as a text and reference, especially for the...
Reviews

Applied Physics community and for Device Engineers. However I would strongly recommend it to the Physics community at large for an insight into one major area into what good Applied Physics is really all about, namely the application and development of a lot of basic Physics. This is unquestionably a Physics book and it would be a pity if its potential readership was diminished by the specialised engineering sounding title. It is amazingly comprehensive and self-contained. Little if any cross reference to any other texts is necessary for understanding. All of the underlying electromagnetic and optics theory, quantum mechanics, solid state physics, physics of noise and of course semiconductor device physics and waveguide theory is given a sound and reasonably mathematically detailed treatment. Of necessity some basic aspects such as diffraction and scattering and some mathematics are a little shallow relative to other basics but they are adequate for the purposes.

The major difference to broader sounding text books is that the applications of all these basics are to materials, structures and devices used in optoelectronics. For instance most of the solids concepts are applied to GaAs, InP and their alloys. The topics are up to date. Examples include the more than a dozen different laser diode structures which are analysed and a detailed discussion of quantum wells, wires and boxes, and how they absorb, amplify and are put to use in laser diodes and optical modulators. As expected there are numerous plots and curves to demonstrate theories and performance of devices but a key feature is the vast number of intricate device structures that are clearly portrayed in either or both of plan or sectional views. Such drawings are an essential aid to understanding the physics and the operation, yet this is often a weakness in many books in the photonics field which relies so heavily on clever and precise microstructural engineering.

The subject of the main title (which should have been abbreviated by leaving out the word integrated) is finally reached in the last chapter after all components and individual devices, except the FET's used in integration, have had their own go on the previous 487 pages. It is a brief chapter because the integration of lasers and transistors or detectors and transistors onto a single substrate involves formidable challenges for the future as individual components conflict in their optimization requirements. Thus at this time integrated source or detector systems cannot match hybrid device performance.

Ebeling's book is based on a whole year course to final year physics and electrical engineering students in Germany. Its presentation is business-like in the German-Springer tradition rather than the more glamorous, spacious and costly composition in some of its American based competitors. It should be seriously considered as a text by those teaching Senior undergraduate, Honours or Postgraduate courses in the area of optoelectronics or even just applied optics solid state or device physics. Sections would be quite suitable for some senior undergraduate courses not only in optoelectronics but more generally. In this age of relevance some transparent real world applications of for instance basic quantum mechanics and optics are succinctly demonstrated. It will find its way onto the shelves of many physicists and engineers and is a must for libraries.

G.B. Smith
Department of Applied Physics
University of Technology, Sydney

Radiology After Chernobyl; Biogeochemical Pathways of Artificial Radionuclides (SCOPE 50)

Sir Frederick Warner & Roy Harrison (eds)
John Wiley & Sons, Chichester
UK 1993
xx + 367pp., A$225.00 (hard cover)

SCOPE (Scientific Committee on Problems of the Environment) is one of the committees of ICSU, established in 1969 as a multidisciplinary task force "to assemble, review and assess the information available on man-made environmental changes and the effects of these changes on man...."

The explosion of Reactor No. 4 at Chernobyl on 26 April 1986 profoundly affected the whole world. This book brings together the results of an international study on the ways in which radioactive materials released by human activities spread in the environment, but it stops short of considering health effects, which it says are the concern of other bodies. Cases reviewed also include: Sellafeld, Cap de la Hague, Kyshtym, Windscale, Three Mile Island, Hanford and the break-up of nuclear powered satellites.

It is, in other words, a resource book; not very exciting but nevertheless important for relevant libraries - which no doubt helps to explain its incredible price!

Readers can perhaps imagine the complex and convoluted pathways by which radionuclides move in the environment, accumulate in the food chain and become available for human consumption - radioactive gases, aerosols and particles in various physical and chemical forms travelling through atmospheric, terrestrial, aquatic and urban spaces. Modelling such situations is extremely difficult and data is not abundant, whence one helpful outcome of the tragic Chernobyl accident.

I smiled once while reading this book; it was pleasing to know that the "predicted dose reductions achievable in the urban environment through the application of various decontamination techniques reveal that digging gardens and defoliating trees should be of..."
highest priority...". But then I thought, why am I smiling?

John Jenkins
History Department
La Trobe University

Book Notices

Handbook of Infra-red Standards II
G. Guelachvili & K.N. Rao
Academic Press, Boston 1993
ix + 715pp., US$149.00 (hardcover)

This reference text supplements the 1986 calibration tables by the same authors. It offers spectral maps and wavenumber tables to 8-figure precision in the 1.4-4.4 μm waveband for several convenient gaseous molecules, and at 6.2-7.7 μm for CH3Cl. There is also a compilation of recently-published heterodyne frequency measurements for an assortment of gases, and 11-figure accuracy frequencies for OsO4 transitions near 10.4 μm. The spectral maps make the tables easy to use, and the book should be a valuable reference for any seeking high-precision wavelength calibrations in these spectral wavebands.

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More details on page 269 of this issue.

New Books

Carbon - Element of Energy and Life
L.E. Cran & D.A. Varvel (eds)
Science Foundation for Physics, University of Sydney NSW 1993
xii + 240pp., A$20.00 + p&p (paperback)

The World Treasury of Physics, Astronomy and Mathematics
T. Ferris (ed)
xv + 859pp., A$27.95 (paperback)

Solid State Dosimetry
Radiation Protection Dosimetry Series
E.P. Goldfinch, S.W.S. McKeever and A. Schramm (eds)
Nuclear Technology Publishing, Ashford, Kent 1993
xvii + 710pp., UK£125.00 (hardcover)

Quantum Processes in Semiconductors 3rd edition
B.K. Ridley
xv + 378pp., A$110.00 (hardcover)

Radiation Exposure of Civil Aircrew
Radiation Protection Dosimetry Series
G. Reitz, K. Schnauer & K. Shaw (eds)
Nuclear Technology Publishing, Ashford, Kent 1993
ii + 143 pp., UK£30.00 (hardcover)

Stopping Powers and Ranges for Protons and Alpha Particles
Report 49
International Commission on Radiation Units and Measurements
Bethesda MD 1993
x + 286pp., No price given (paperback)

Australian Journal of Physics

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December 6 - 8  COMAD, Australian Compound Optoelectronic Materials and Devices Conference at the Huxley Theatre, Australian National University, Canberra ACT
Contact: Dr C. Jagadish or Dr R.J. Egan, Dept Electronic Materials Engineering, RSPPhysSE, ANU, Canberra ACT 0200. Tel 06-249-3920, fax 06-249-0511

December 6 - 10  ACOALS 93: Australian Conference on Optics, Lasers and Spectroscopy at the University of Melbourne, Parkville VIC 3052. Incorporates the 9th Conference of the Australian Optical Society, the 8th Australian Laser Conference, and the 18th Australian Spectroscopy Conference
Contact: Helen Frangos, Conference Manager on tel and fax 03-344-6122

December 9 - 14  Asian Region Seminar on Crystallography in Molecular Biology, University of Madras, India
Contact: Prof S. Parthasarathy (Convener ARSCMB)
Department of Crystallography and Biophysics, University of Madras, Guindy Campus, Madras - 600 025 India. Tel 41-6376 UNOM IN, fax 91-44-415856

December 10 - 12  ASB-93, XVIth Annual Conference for the Australian Society for Biophysics
Contact: Dr Ron Pace, Dept of Chemistry, Faculty of Science, Australian National University, GPO Box 4, Canberra ACT 2601. Fax 06-249-0769

December 13 - 17  PPC-3, Third Pacific Polymer Conference at the Gold Coast in Queensland
Contact: PPC-3 Secretariat, Chemistry Dept, University of Queensland, Brisbane QLD 4072 Australia. Fax 07-365-3628, email: odonnell@chem.chemistry.uq.oz.au

1994

January 17 - 19  International Conference on “Physics & Industrial Development: Bridging the Gap” at the Taj Palace Intercontinental Hotel, New Delhi, India
Contact: Prof S. Chandrasekhar, Centre for Liquid Crystal Research, PB No 1329, Jadavpuri, Ahmedabad - 380 013 India. Tel +91-80-340124 (ext 226), fax +91-80 340492

January 10 - 28  7th Physics Summer School: Statistical Mechanics and Field Theory, Canberra
Contact: V.V. Bazhanov, Dept of Theoretical Physics, RSPPhysSE, ANU, Canberra ACT 0200. Tel 06-249-2943, fax 06-249-4676

January 24 - 28  The 6th International Symposium on Quantum Optics, Rotorua, New Zealand
Contact: D.F. Walls or J.D. Harvey, Department of Physics, University of Auckland, Auckland, New Zealand. Tel 06-9-373-7999/8843, fax 06-9-373-7445

February 6 - 8  Workshop on Rare-earth Magnets and Applications at Charles Sturt University, Wagga Wagga NSW
Contact: Dr S.J. Collocott, CSIRO Division of Applied Physics, PO Box 218, Lindfield NSW. Tel 02-413-7130, fax 02-413-7383, email steve@dad.csiro.au

February 9 - 11  18th Condensed Matter Physics Meeting at Charles Sturt University, Wagga Wagga NSW
Contact: Conference Secretariat, Department of Physics, University College UNSW, Australian Defence Force Academy, Canberra ACT 2600. Tel 06-268-8804, fax 06-268-8786, email wagga@phadfa.ph.adfa.au

February 21 - 24  NCAR Graphics Tutorial and Conference, University of Technology, Sydney
Contact: Dr K McGuffie, Department of Applied Physics, University of Technology, Sydney, PO Box 123, Broadway NSW 2007. Tel +61-2-330-2219, fax +61-2-330-2204, email kendal@phys.uts.edu.au

Contact: Conference Secretariat, 7th ARSC, PO Box 29, Parkville VIC 3052. Tel 03-387-9955, fax 03-387-3120, email 7arsc@dare.csiro.au

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