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Cover picture: The 1990 IOP 'Beauty of Physics' photographic competition attracted entrants from Eastern Europe, Japan and Australia, as well as from Great Britain. We will reproduce the three winning entries as cover pictures over forthcoming issues. The first by C.A. Pickover, IBM Thomas J. Watson Research Center, New York is entitled 'Simulator Seashells' and is a computer graphics model of a logarithmic spiral, producing a realistic seashell shape. See page 160 for further explanation.
PRESIDENT'S COLUMN

Strategic Meetings

"The Australian Research Council wishes to encourage discipline groups to develop a strategic plan to cover the next 15 years... a steering committee B.J.L. McKellar (University of Melbourne and ARC; J. Collins (CSIRO), D Aitkin (ARC)...) to approach the physics community... Key questions which must be addressed ... etc..." said the letter from my colleague, Professor Bruce McKellar, setting up two meetings, one with the National Committee for Physics, on July 6th, and the other with the AIP Executive and Science Policy Committee, on July 12th.

Both meetings were extremely interesting in that a whole range of important issues was ventilated. It was finally agreed that some form of blueprint was an essential ingredient in getting better funding for physics. The bureaucrats need to be convinced that physics is worthwhile and even essential to the nation's intellectual and economic well-being. But we need to all sing the same song if we are to be listened to.

Devising such a blueprint is a daunting task. It was undertaken by the National Committee for Physics and promptly assigned to a small working group to be led by Bruce McKellar. This move was endorsed by the AIP Executive and elsewhere in this issue may be found some preliminary thoughts on a subject about which we are bound to hear a great deal more in the months to come.

Remembering the story about Oliver Heaviside, who was supposed to have always carried a red rag in case he met a bull, I confess that, for me, one of the most interesting aspects of the meetings was the opportunity to hear the views of and debate with the Chairman of the Australian Research Council, Professor Don Aitkin.

I am pleased to report that he has only one head, no visible horns and the faint whiff of sulphur may be just my imagination. Of course he is very plausible and of course he is very articulate but also he listens well. What a pity that so many of his views, on research, on academics and on Universities are coloured by his own background. In other words, what a pity he is not a physicist.

However, I was glad to discover that his heart appears to be in the right place in that he would like to see a better deal for science in general and for physics in particular, and that, in fact, we have surprisingly large areas of agreement. These would be even greater if the true nature of our kind of enterprise were explained to him in more detail.

I suspect that there are many people like that in Government, hence the need for a strategic plan - we have a lot of explaining to do. (It may also be the case that the humanities educators of the last generation have a lot to answer for.)

On the vital subject of research grants, which are still under his command in 1990, some of the points that he seemed to absorb were that:

* The "clawback", however successful in raising the amount of ARC money available for distribution, has had some genuinely harmful effects in some of the Universities. (I dare say he had heard that before from other sources!)

* One cannot simply fund the top 20% without endangering the base upon which that 20% exists. (I used the analogy of a pyramid to explain the nature of research in the Physical sciences... perhaps an unfortunate image in Victoria that week!)

* Funding only a small number of large projects is just as wrong as giving only a very large number of very small grants. I said that, in my opinion, what is needed is, for example, one $10 million grant; ten $1 million grants; a hundred $100,000 grants and a thousand $10,000 grants. Or that magnitude vs rank order on a log-log scale, should form a straight line with a >

Many people commented on the aptness of the cartoon in the June issue. Here is another one.
Editorial

AINSE – To Be Or Not To Be

Last week I attended the Council Meeting of AINSE. The Australian Institute of Nuclear Science and Engineering. AINSE has been in existence for 32 years, having been formed with the objective of fostering research and training in the areas of nuclear science and engineering. AINSE is funded by a combination of University subscriptions of approximately $300,000 p.a. (each university contributes from $10,000 to $30,000 per year depending on size and success in receipt of AINSE grants in previous years) and a grant (subscription?) from ANSTO of about $800,000 p.a.

AINSE is an organisation under attack and potentially in trouble. The attack is from two directions. Clawback by the Federal Government has caused Universities to look very carefully at their controllable payments, which includes subscriptions. Subscriptions to AINSE are easily targeted, because of the potential to receive funds back by way of project grants, scholarships, fellowships, etc. The immediate reaction is for the University to pass payment of the subscription account to those potentially able to get the return. This is usually Faculties of Science or Engineering. With the inroads of the Federal Government into University infrastructure funding, such subscription funding is difficult to find in cash at the Faculty level.

The second attack is from ANSTO. This is a two-pronged attack or perhaps a choice of ‘either-or’. ANSTO sees an ongoing of $800,000 and wants to know what it gets in return. Better still, ANSTO sees about $1.1 million which, if it had control, could further ANSTO research through extra funding and cheap support from University people anxious to use ANSTO facilities.

What do those outside ANSTO gain? At the moment the most important asset from the point of view of many University researchers is the access to neutron diffraction facilities. Although the Federal Government is considering a proposal to fund Australian access to facilities such as the ILL in Grenoble, nothing overseas will surpass the convenience of a good facility at home. Other researchers value access to the accelerators, to various irradiation facilities, to neutron activation analysis facilities or to the electron microscopes and materials science equipment.

What does ANSTO gain? Access to University research programmes, the support of ANSTO facilities by AINSE, including both personnel and equipment, exposure to students as a potential source of recruits, the stimulus of a constant stream of visitors, the chance to be involved in programmes outside the direct remit of ANSTO.

What does the future hold? At the moment ANSTO, often with AINSE help, is embarking on an expansion of facilities. The Small Angle Neutron Scattering facility is currently being supported by ANSE to the extent of a total funding over three years approaching $0.5 million. The Tandem Accelerator being commissioned now will have about 20% of time available for University work. ANSTO will contribute to staffing of accelerator facilities. The new medical cyclotron with the PET (positron emission tomography) camera will open new fields and opportunities for medical researchers, including those in Universities. AINSE is beginning to discuss the possibility of funding a small animal irradiation facility for that PET. A new isostatic press, the largest in Australia, has potential for University research as well as for materials science use in ANSTO itself. ANSTO has signed a joint venture agreement with Fujitsu to establish a supercomputer facility—collaboration with and access by University researchers is a likely possibility under conditions yet to be finalised.

The partnership of AINSE and ANSTO in the past has been mutually beneficial and rewarding. That partnership must continue in the future. Universities must realise the value of AINSE and accept the responsibility of support. If an accountant’s view is required to show the income versus outgoings to the satisfaction of the Vice-Chancellor, it must take a view over a suitable number of years in the past and forecast results several years in the future. The balance sheet must reflect changes in research emphasis resulting from developments of new facilities. Over the next decade, for example, the emphasis of AINSE support may well change towards the nuclear medicine sciences, reflecting the new facilities.

Equally importantly, ANSTO must remember that it is in partnership with AINSE and not in control. AINSE’s brief must remain the support of nuclear science and engineering across the breadth of those areas and not simply those aspects of interest at any particular time to ANSTO itself. At the same time AINSE must also encourage and facilitate co-operation between ANSTO scientists and their counterparts in Universities.

AINSE itself though is not without its faults. There has been no review of the policies and function of AINSE in the last decade. The Council has decided to initiate such a review and has requested the Executive Committee at least an initial report ready by November. The review is also requested to consider ways in which the funding base of AINSE could be expanded. The role of ANSTO as a national facility and AINSE as the interface to users could well be the basis for approaches to ARC, DITAC, etc.

One more thing is important to the future, both of AINSE and ANSTO. The current source of neutrons for diffraction purposes and for the small angle neutron scattering facility is the HIFAR reactor. This facility is by no means ideal and is old. Australia desperately needs to plan for a new research reactor to be available before the end of the nineties. AINSE, as the voice of Universities in this area, can lead the lobbying and provide much of the detailed argument to win support for this proposal.

Tony Klein

R.J. MacDonald

Australian Physicist Volume 27, Number 8, August 1990

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A number of recent surveys have emphasised the plight of physics in Australia. The ASTEC report, ‘Profiles in Australian Science’, shows that both the amount of research effort in physics (measured in researcher-years, and including research students in the researcher numbers) and the dollars spent on physics research (in constant dollars) have remained constant over the decade 1975-1984, whereas both the proportion of the world’s physics papers published from Australia, and the impact of those papers in the form of citations, have declined in that period. A Department of Science survey conducted about three years ago, highlighted the large fraction of equipment in University Physics departments which is obsolete or obsolescent. A recent article in Search by John Irvine suggests that academic research in the physical sciences is underfunded relative to a set of West European countries by about $125M and our relative situation has been getting worse in the eighties.

While one can question the methodology of any one of these reports—for example, the world total of physics papers surveyed to produce the data for the ASTEC ‘Profiles’ report is about 30% of the number of physics papers listed in Physics Abstracts—the total picture they paint of our profession in Australia is a cause for concern for physicists. In a situation where physics is of increasing importance as the basic discipline underpinning technology, that picture should be of concern to the community at large.

The Australian Research Council is beginning to suggest to a series of professional bodies that they develop a strategic plan for their discipline. The first of these planning exercises is being undertaken by the Geosciences Council of Australia. The ARC felt that the situation of physics as highlighted in the Profiles report suggested that physics should be the subject of the second of these plans, and appointed a steering committee (Bruce McKellar, Don Atkin, John Collins and David Phillips) to investigate ways in which a strategic plan for physics could be developed. The National Committee for Physics, chaired by Ian McCarthy, has agreed to take responsibility for the development of the plan and will be making a proposal along these lines to the Academy of Sciences. The AIP executive has agreed to support the planning exercise, and the steering committee will be recommending to the ARC that it assist with the funding of the exercise.

It is still rather early to see exactly how the planning will be undertaken, but a broad pattern is developing. The nation committee is proposing the appointment of a working party of three physicists drawn from universities, government laboratories, and commercial laboratories, and has recommended that Bruce McKellar convene the working party. The working party will seek submissions from groups representing the sub-disciplines, and from departments of physics, CSIRO divisions and other interested bodies. After a draft report has been obtained which satisfies the national committee, it will be discussed at a general meeting of physicists before being finalised. This meeting will be in the form of a national conference at a convenient location.

The first question that must be decided is the scope of ‘Physics’ for the purpose of the plan—the two obvious definitions are “those disciplines studied in departments of physics” and “those disciplines relevant to the national committee for physics” —the latter definition containing implied exclusions by the existence of other national committees. The most important aspect of the development of the plan is that it has the support and confidence of the physics community at large, and that it has the support of the client community—the users of the research and the researchers produced by the national research effort. Because of the number of such reports to be produced across a wide range of disciplines, the validity of any goals proposed in the plan for physics and any bids for more resources necessary to achieve those goals will have to be argued very persuasively.

The task ahead is a difficult one, but the consequence of not accepting it is likely to be a continuation of the decline in physics noted in the recent reports, as resources continue to follow students and move away from physics.

The development of the plan is a matter of concern for all physicist, including those working in the fringe areas associated with interdisciplinary studies. The interest and involvement of every physicist is important to the success of the plan. Your views as physicists are important to the committee. If you do not respond and place your views before the committee by submission and by attending the conference to discuss the draft plan, your views cannot be taken into account.

Bruce McKellar

Simulated Seashell by C.A. Pickover
IBM Thomas J. Watson Research Center, New York

The idea that nature and mathematics are inextricably linked is not new—and neither is the application of that idea in computer graphics. What is new is the use of rich software tools and powerful new hardware to visualise mathematical models of nature.

Spiral shapes are one of nature’s most fundamental forms. Spiral patterns often occur spontaneously in matter which is organised through symmetry transformations: change of size (growth) and rotation. The mathematical concept of similarity holds one of the keys to understanding the processes of growth in the natural world. As a member of a species grows to maturity it generally transforms in such a way that its parts maintain approximately the same proportion with respect to each other and this is probably a reason why nature is often constrained to exhibit self-similar spiral growth.

This computer graphic figure is based upon the logarithmic spiral, r = ke\(\theta\), (x,y) = (r\(\cos\theta\), r\(\sin\theta\)) where the r range is \(-12 < r < 6\). Perhaps not intuitively obvious is the fact that negative angles are essential in producing the most interesting and realistic seashell shapes. Readers can check this for themselves. The form also has a helical axis, z, around which the shell grows. Two z functions can be used, z = a0e\(\gamma\theta\) where (\(a > 1\)), or z = be\(\gamma\theta\) (the latter creates more realistic seashells). In all cases the radius of the ‘tube’, R, which makes up the shell is a function of \(\theta\), ie, R = \(rg\), where \(\gamma\) is a constant in the range (0.01 < \(\gamma\) < 3). Computer graphics models of ‘traditional’ and ‘non-traditional’ spiral formulas may help scientists better understand the fundamental roles underlying the apparent spiral repetition of nature since they can now visualise, predict, and define these shapes in precise scientific terms.
Course in Temperature Measurement

The CSIRO Division of Applied Physics is again offering its intensive short course in the theory and practice of temperature measurement this year. The five day course will be given at the Division’s headquarters in Sydney from 15 to 19 October 1990.

The course content has been updated, and a new comprehensive three-volume manual will be provided to participants. More emphasis is to be placed on the philosophy of measurement with the manual giving the fine detail, and a generous allocation of time will be made for consultation and discussion on participants own problems.

The fee for the Sydney course will be $750 and details can be obtained from Mr Robin Bentley at PO Box 218 Lindfield 2070, or on (02) 413 7764.

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THE PERSON: The successful applicant will be a person capable of leading the surface science project team. He/she will have a PhD or equivalent qualification in physics, materials science, or engineering and expertise in the mechanical properties of surfaces, including topics like: Ultramicrohardness, surface ductility, thin-film adhesion and residual surface stress, surface topography, sub-surface damage.

THE CONDITIONS: Appointment would be on an indefinite basis with Australian Government Superannuation benefits. Applicable.

MORE INFORMATION: A selection criteria can be obtained by telephoning Mrs. Gillian Van der Eyk on (02) 413 7452 and further details of the position can be obtained by telephoning Dr. Ken Howman at (02) 413 7388.

APPLICATIONS: Applications should be framed against the selection criteria and consist of personal details, including qualifications and experience. The application, quoting reference No. A593/91 and giving names of two referees, should be addressed to:
The Chief, CSIRO Division of Applied Physics, PO Box 218, Lindfield, NSW 2070.

Closing date for applications: 4 September, 1990.

EQUAL EMPLOYMENT OPPORTUNITY AND A NO-SMOKING WORK ENVIRONMENT ARE CSIRO POLICY.
CONFERENCE REPORT

FOURTH AUSTRALIAN CONFERENCE ON II-VI SEMICONDUCTOR COMPOUNDS

Green Gables Chalet, Warburton, Victoria, 23-25 April 1990

An account by Geoff N. Pain (Telecom Australia Research Laboratories)

When asked to write about this meeting (II-VI Semiconductors 90), my first reaction was "why me?".

On reflection perhaps an organometallic chemist constantly being educated in solid state (or condensed matter) physics is representative of the bulk of the 79 II-VI enthusiasts present at Warburton. Indeed organometallic chemists made up 18% of the full-time researchers present and other breeds of chemist accounted for another 7% (rounding to the nearest whole body or number as appropriate). Without dwelling too long on boring statistics, other groupings included, in decreasing order of whole bodies, university (21) Telecom Australia (17) Australian Industry (15), CSIRO (9), overseas visitors (7), Defence (6) and Government (2).

II-VI Semiconductors 90 followed other successful meetings at Telecom Australia Research Laboratories in August 1984, Monash University in May 1987 and Adelaide University in April 1989. Interest and industry backing has increased almost exponentially over the last seven years to the point where export industries based on II-VI materials are now clearly visible on the horizon for Australia.

Appropriately the conference opening address by Mr Trevor Robinson of DITAC reminded those gathered that the Australian taxpayer has a large investment in this technology through various generous grant schemes, Defence, Universities and Government owned enterprises. His main theme was the need to focus on the export markets and import replacement using to the full Australia's competitive advantages. These include state of the art technical know-how and large, presently underexploited, mineral resources. The latter and the extractive metallurgy required to achieve various levels of purity were considered in an excellent presentation by Professor David Koch of Monash University Chemical Engineering.

A key feature of this conference was the high calibre of invited speakers and industry representatives from overseas. Professor Shigeo Shionoya of Tokyo Engineering University gave an enlightening overview of II-VI materials, concentrating on the large scale use of ZnS, ZnSe and CdS in a host of practical applications ranging from visible lasers to high definition TV. White light emitting panels are a prime market opportunity being intensively developed at present in Japan and elsewhere.

Dr Robert Triboulet of CNRS, France gave two talks both dealing with the practical difficulties of materials growth. His main research activities are in bulk and MOCVD growth of mercury cadmium telluride (MCT). He also spoke on behalf of RIBER about the present MBE reactor technology and the high quality MCT epilayers presently obtainable. He also focussed his presentations on market driven problems and revealed for example that the estimated usable yield of the four tonnes of bulk CdTe crystal produced annually is about 5%. This might have something to do with the current cost of single crystal MCT which can exceed $16 million per kilogram.

Professor Hiroshi Kukimoto of the Imaging Science and Engineering Laboratory, Tokyo Institute of Technology, discussed MOCVD of wide-gap II-VI compounds and particularly work aimed at control of growth, and carrier concentration. His work is also related to real markets and his preliminary results making blue LED and electroluminescent devices were impressive. Japanese work on MCT is intensive but generally not published at the device stage.

Professor Juozas Vaitkus of Vilnius V. Kapsukas State University, Lithuania, gave an interesting account of ultrafast phenomena in fine particle II-VI composites. Eastern block countries such as the U.S.S.R. and Poland, which has for many years exported II-VI materials (and experts in this area), have pioneered development of new classes of material such as diluted magnetic semiconductors (DMS).

Professor Robert Galazka of the Polish Academy of Sciences reviewed his extensive studies on narrow-gap DMS, including new results on HgTe, PbSnMnTe, 2D structures and HgMnTe as detector material for atmospheric window infrared devices.

Professor Everett Crisman of Brown University addressed the practical problems of surface and interface effects in II-VI and heteroepitaxial systems. Novel plasma oxidation techniques were discussed in terms of effective passivation, as measured by surface recombination velocity, mobility or density of states.

Having briefly tried to cover our international friends' papers, the following is a thumbnail sketch of the remaining 34 talks, posters and other activities in an action-packed 3-day meeting. For sake of brevity, only first named or presenting authors are mentioned in the following.

The first day saw the champagne opening of the large trade display where the sponsor companies offered technical details of materials, bulk, MOCVD and MBE growth equipment, specialty chemicals and gases, vacuum and gas components and optoelectronic characterisation instruments.

Dr Graeme Morris from the University of Queensland presented several papers on various aspects of his group's work on II-VI solar cells made from electrodeposited or evaporated polycrystalline material. Practical, cheap deposition methods are emphasised in his work and it is clear that market research has been well considered in formulating the research program. The problems involved in obtaining reliable methods for surface analysis of the thin films was highlighted.

DSTO and CMTEK Pty Ltd presented papers on heteroepitaxy of CdTe on...
GaAs (Dr Peter Orders et al), ellipsometric monitoring of MBE growth (Mr Doug Carr) and analysis of CdZnTe (Dr Guangfu Shen). The Microelectronics Research Group, University of Western Australia, who collaborated under an IRDB Grant with DSTO, presented papers on deep level transient spectroscopy of MCT (Dr Brett Nener), design of overlap structure MCT detectors and effects of deep levels on photoconductivity of bulk MCT (Mr Vijayan Veerasyam). Also from UWA, Dr Wlodzimierz Zahorowski of Physics described the technique and equipment of soft x-ray spectroscopy for study of partial density of valence states and investigation of solids having symmetry higher than trigonal and lower than cubic.

Professor David Neilson, School of Physics, UNSW, presented results of theoretical modelling of interfaces and surfaces for CdTe and HgTe and considered the technologically vital problem of the interaction of adsorbates with MCT surfaces.

Professor Dan Haneman of UNSW Physics, reviewed solar cells involving II–VI materials and the competing material CuInSe₂. CdTe has reached the commercial production stage and has a theoretical efficiency of 27%. Once again the emphasis is on cheap, scalable processes suitable for mass production. Techniques covered in the talk included spraying, electro-deposition, screen printing and vapour transport. Results from his group on photoelectrochemical cells indicated long term stability was still a research problem.

Dr David Jamieson of the Microanalytical Research Centre, Melbourne University, described their pioneering use of a nuclear microprobe to perform PIXE, RBS and channeling analysis of structures as small as a few microns in size. These techniques, collectively known as 'Nuclear Microscopy' allow standardless mapping of elemental distributions, depth profiles and crystal quality and is particularly suited to analysis of heteroepitaxial layers.

Dr Wojciech Wlodarski of RMIT Department of Communication and Engineering talked about design and performance considerations of II–VI high pressure sensors, a potential export market.

Professor Paul Edwards, Faculty of Information Science and Engineering, University of Canberra, had the affrontery at this II–VI meeting to present (unchecked) a paper on high importance quantum noise reduction in the III–V compound GaAlAs infrared LEDs.

The last, but by no means least, section of presentations to report are the fifteen papers emanating from the team of II–VI devotees at Telecom Austral. Research Laboratories, CSIRO Division of Materials Science and Technology and Applied Physics, Monash University Chemistry Department and RMIT. Most, but not all, of this work is assisted by IRDB Grant 15019, for which the researchers are truly grateful.

Papers from the Telecom team covered SEM investigation of MCT MESFETs (Mr Craig Sandford), application of modified Auger parameters to characterisation of II–VI semiconductors (Dr Martyn Kibed), performance of MCT MSM photodetectors (Mr Novica Pekovic), surface morphology of MCT (Dr Geoff Pain), practical electron microprobe analysis of MCT (Dr Tad Warminski), modelling of SEM of MCT devices (Mr Novica Pekovic) and MSM detector fabrication (Dr Patrick Leech).

Following from IRDB collaboration, papers were presented on x-ray diffraction of MCT on 311, 511 and 711 GaAs (Dr Andrew Stevenson, CSIRO), dopant MOCVD feedstocks for MCT (Assoc. Prof. R.S. Dickson), synthesis of mixed metal tellurium MOCVD feedstocks and pyrolysis to yield MnTe (Dr Kathy McGregor, Monash), RBS and channeling structure analysis of MCT (Dr Leszek Wieclawski, CSIRO), growth of the first Cd₃₅ Mn₆̅₅ Te/Cd₃₅ Mn₆̅₅ Te superlattices by MOCVD (Dr Geoff Pain) and structural analysis and interdiffusion profiles in HgTe/CdTe superlattices and Hg₃₅ Mn₆̅₅ Te (Dr Chris Roesow, CSIRO).

Mr Salvy Russo of RMIT presented, arising from his PhD research program, a paper on RBS and PIXE analysis of MCT epitaxial layers on GaAs. This technique is valuable since thickness and average composition with depth can be determined simultaneously at selected points on the wafer, aiding process development.

Ms Sue Sultes (Telecom) and Mr Dachan Giao (CSIRO) won prizes for the two best posters on the subjects of CdTe pulse electroluminescence from non-annulus solution and the study of Cd₃₅ Mn₆̅₅ Te/Cd₃₅ Mn₆̅₅ Te superlattices respectively.

Thus it should be obvious by now that there was something for everyone! But, of course, there was much more to the conference than just the technical program and trade exhibition. The conference dinner would be a story in itself, best remaining in the memories of the revellers.

Special thanks are due to the organising committee, the sponsors, the proprietors of Green Gables Chalet and two individuals who each made outstanding efforts in organising the event. I refer to the 'godfather' of II–VI materials in Australia, Dr Mark Kwietsiak and Dr Andrew Stevenson (Conference Secretary).

All that remains to be said to readers who have made it to the end is that in 1991 it is planned to hold a 'Compound Semiconductor Conference' which will doubtless be larger and perhaps as successful as II–VI Semiconductors 90.
The multiple monochromator and atomic absorption spectrometer

by Sir Alan Walsh
former Assistant Chief, CSIRO Division of Chemical Physics

Since my retirement in 1976 from full-time duties with the CSIRO Division of Chemical Physics, I have been an admiring spectator of the remarkable growth of the Australian scientific instrument industry. An indication of the increasing importance of the industry is that this meeting is to be devoted entirely to a discussion of its history, present status and future prospects.

I have been asked to indulge in some personal reminiscences of the development in CSIRO, in the early 1950s, of the multiple monochromator and the atomic absorption spectrometer. I accepted this kind invitation, not merely to wallow in nostalgia, but also because I hope that the story of these two projects may serve as a reminder that new types of scientific instruments are often the unplanned and unexpected by-products of free-ranging scientific research.

The background to the invention of the multiple monochromator is as follows. In 1946 I became the first member of the spectroscopy group in the Chemical Physics Section of the CSIR division of Industrial Chemistry. The Section leader, Dr. A.L.G. Rees, first asked me to undertake, under his guidance, research in the then relatively new field of infra-red spectroscopy, which was proving of great value in investigations relating to the composition and structure of many organic substances. By the time I arrived, Lloyd had already purchased a Perkin-Elmer infra-red spectrometer. This was a conventional single-beam instrument using a thermocouple detector whose output was amplified by a D.C. amplifier. Recording was slow and tedious because slight changes in room temperature gave larger changes in the output signal of the thermocouple than the radiation signals to be measured. Good spectra could only be obtained during the stable temperature conditions prevailing in the early hours of the morning. A most important and welcome advance was the development overseas in the late 1940s of thermocouples having a much improved response time. This made it possible to modulate radiation from the light source before it entered the monochromator and to measure the modulated output of the thermocouple by a synchronously tuned A.C. detection system. Recording of spectra was transformed and it also became possible to record infra-red spectra of samples at high or low temperature. My quality of life was greatly improved!

In the meantime my colleagues in the luminescence group had purchased a double monochromator consisting of two monochromators in series. They were experiencing immense difficulties in getting the two coupled monochromators to be simultaneously in accurate alignment at each and every wavelength. I was unable to help and as far as I can recall the problem was never solved. Some time later I became involved in the design of multiple-traversal absorption cells to provide better absorption sensitivity. In another project I was experiencing a need for a spectrometer of better optical resolution than my instrument. In 1949 my experience with the modulated source/synchronous detection system, the double monochromator, the multiple-reflections cell, and the need for better resolution began to interact and led to my development of a multiple-pass spectrometer in which radiation passes more than once through the optical system of a monochromator.

The multiple monochromator is best understood in terms of the conversion of a conventional monochromator (Figure 1a), to a double-pass monochromator (Figure 1b). In the conventional arrangement, radiation from the source is modulated before passing through the entrance slit S1, through the optical system of the monochromator and emerging at the exit slit S2. Conversion to a double-pass monochromator required the addition of the mutually perpendicular mirrors M3/M4 whose line of intersection is on the focal curve of the monochromator. For any one setting of the plane mirror M2 we now have single-pass radiation and double-pass radiation of a different...
wavelength simultaneously passing through the exit slit. By modulating the radiation at M3/M4, instead of at a conventional position before the entrance slit, the A.C. detection system only gives output signals for double-pass radiation. This simple system proved very effective: optical resolution was almost doubled; and signals due to scattered radiation which were a problem in previous infra-red spectrometers, were virtually eliminated.

Immediately after the publication in 1951 of our first paper describing the double-pass monochromator, Perkin-Elmer applied to CSIRO for a licence to manufacture. This was promptly and willingly granted. We had previously discussed at length the possibility of manufacturing our spectrometer, completely or in part, in Australia. We had reluctantly concluded, I believe with every justification, that it was not possible. Within two years of the publication of our first paper, Perkin-Elmer began commercial production, which continued throughout the life of the patent. I recall vividly the receipt of our first royalty payment. I was elated but Lloyd Rees quickly brought me back to earth. He forcibly pointed out that the royalty payments alone were a totally inadequate reward. He insisted that CSIRO should make every effort to ensure that novel scientific instruments produced in its laboratories were commercially produced in Australia and sold world-wide. From that time on Lloyd campaigned relentlessly in support of the desirability and feasibility of Australia creating an indigenous scientific instrument industry which would make a major contribution in the Nation’s economy. His remarkable vision, energy and faith have indeed played a major role in the birth of the industry.

The initiation of my interest in atomic absorption spectroscopy was due to interaction of experiences in two different fields of spectroscopy. From 1939 to 1946 I worked exclusively on the development of methods of elemental analysis based on the measurement of atomic emission spectra. After joining CSIRO in 1946, my work was initially concerned mainly with various aspects of molecular spectroscopy. Early in 1952 I began to wonder why, as in my experience we usually studied emission spectra of atoms but not absorption spectra of molecules. I was led to the surprising conclusion that atomic absorption methods of elemental analysis could have vital and previously unsuspected advantages over some of the widely used methods based on the measurement of emission spectra. The background to this thought is given below.

In 1859 two great German scientists, Bunsen (who is most widely known for his invention of the Bunsen burner) and Kirchhoff, laid the foundations of a totally new method for carrying out elemental analysis. They showed that when a sample is converted into a hot atomic vapour by, for example, introduction in a flame, the colour of the radiation emitted provides a powerful means of determining which elements are present in the sample. This was made possible by their discovery that each element only radiated light of specific colours (which the scientist usually expresses in terms of wavelength) which are highly specific for each element. The best known example is sodium, which emits yellow light. This can easily be seen by looking at a sodium street lamp or sprinkling a little salt, which consists mainly of sodium chloride, into a gas burner on a domestic stove. Bunsen and Kirchhoff also discovered that the atomic vapour of an element could also absorb radiation of these specific wavelengths. Thus elements could be identified from the wavelengths of the radiation they emitted or absorbed. For almost a hundred years after Bunsen and Kirchhoff’s great discovery, the development of spectrochemical methods of elemental analysis was restricted almost entirely to atomic emission methods. The possibilities of developing atomic absorption methods were almost completely ignored. There appeared to be two reasons for this. In the first place, it was generally much more difficult to make atomic absorption measurements. Secondly, it was generally assumed that emission and absorption methods would have the same performance. This was largely the result of most text books and teachers having, for almost a century, given misleading interpretations of Kirchhoff’s Law defining the relationship between absorption and emission of radiation.

The different characteristics and capabilities of atomic emission and atomic absorption methods of elemental analysis are determined mainly by one simple fact: atomic emission originates only in excited atoms, while atomic absorption originates predominantly in ground state (i.e. unexcited) atoms. In the case of flame methods, for example, the only elements which are sufficiently excited to give appreciable emission when sprayed in an air-cooled or air-acetylene flame are the alkali metals, which have a low excitation-potential. By contrast, such flames show strong absorption for a wide range of elements because of the presence of ground-state atoms. This was one of the main reasons for my decision to explore the possibilities of atomic absorption methods.

My first experiment was extremely simple. I measured the absorption of light from a modulated sodium lamp when it passed through a flame in which a salt solution was sprayed. The light passed through a simple monochromator to a photocell, the output from which was fed to a cathode-ray oscillograph which provided an A.C. amplifier, the output being shown on the CRT screen. Any emission from the flame was not modulated and thus gave no output signal. The results were extremely encouraging.
THE MULTIPLE MONOCHROMATOR AND ATOMIC ABSORPTION SPECTROMETER

When I tried to extend my measurements to elements such as zinc, cadmium, iron, nickel and copper, whose sensitive lines were in the ultra-violet, I used as a light source a hydrogen lamp, which emits a continuum in the ultra-violet. The results were very disappointing. It became apparent that the problem originated in the extremely narrow widths of the atomic absorption lines. They were, in fact, very much narrower than the spectral slit-width of the best monochromator available. It was therefore impossible to measure an accurate profile of the absorption lines. Early in 1953 I decided that the best solution was to use as light source an atomic spectral lamp which emitted a spectrum of the element to be determined. Furthermore, the lamp was to be so designed and operated that it gave line-widths which were much smaller than those of the absorption lines to be measured. The experimental arrangement is shown schematically in Figure 2. An atomic spectral lamp emits a sharp-line spectrum of the element to be determined. Radiation emitted by this lamp is modulated before it passes through the atomic vapour of the sample, which is atomized by spraying into a flame. The transmitted radiation, together with any radiation emitted by the flame, then passes to a monochromator which selects the appropriate spectral line which passes through the exit slit to a photo-electric detector. The output of the latter consists of an A.C. signal originating from the atomic spectral lamp and a D.C. signal originating from flame emission. The A.C. detection system rejects any D.C. signals so that the output signal is due only to radiation emitted by the spectral lamp.

The use of a sharp-line source, as illustrated in Figure 3, greatly simplifies atomic absorption measurement. The monochromator is only required to isolate the emission line of the same wavelength as that of the absorption line to be measured from other emission lines emitted by the source. This is usually a simple matter. By putting the resolutions of the system in the source instead of in the monochromator, the required line for measurement can be isolated with great ease and certainly; it is indeed a very attractive feature of the atomic absorption method.

In 1953 we lodged our patent application and in March 1954, we exhibited a working model of our atomic absorption spectrometer at the Institute of Physics Exhibition of Scientific Instruments held in the Physics Department of Melbourne University. By this time we were already trying, with no success whatsoever, to interest Australian manufacturers in the commercial production of our spectrometer. My first publication in 1955 describing the instrument aroused virtually no interest by analysts or manufacturers of spectrophotometric instruments.

The only instrument firm to show enthusiasm for our work was the British firm of Hilger and Watts Ltd, one of the world’s most prestigious manufacturers of spectrophotometric equipment. Their Research Director, Dr A.C. Menzies, was greatly impressed when he visited our laboratory in 1954 to assess the potentialities of our spectrometer. As a result Hilger and Watts applied for, and were granted, a licence to manufacture. Their instrument appeared on the market in 1957 and we were astonished to find that it did not incorporate our modulated source and A.C. detection systems. Use of such instruments could not duplicate the results we had obtained and, as a result, they were regarded with increasing scepticism.

It was at that stage, early in 1958, that we decided to arrange for three small Melbourne firms to make the various components of a very simple atomic absorption spectrometer we had designed. One firm made the spray-chamber burner assembly, another the special atomic spectral lamps we have developed, and the third made various electrical and electronic components. The monochromators were imported. Some thirty of these do-it-yourself ‘working man’s atomic absorption spectrometers’ were installed in Australian laboratories and generated tremendous enthusiasm for the atomic absorption technique. In 1962 the firm of Techtron Pty Ltd, which had been manufacturing the electronic items, decided to market a complete AA spectrometer. Initially the monochromators were imported, but later they were manufactured in Australia and incorporated diffraction gratings ruled on the grating engine designed in the Division of Chemical Physics.

I think the production of complete atomic absorption spectrometers can be considered the birth of the Australian spectroscopic instrument industry. This continues to flourish and now employs directly some seven hundred people, a similar number being employed in providing the manufacturers with goods and services. I trust that this brief account of the multiple monochromator and the atomic absorption spectrometer illustrates the manner in which free-ranging research can lead to the birth of new scientific instruments. Hopefully, Australian research will continue to yield many further examples in the years ahead, not merely of the birth of new instruments but of new industries. I trust that those responsible for guiding and governing Australia’s future science program will never forget one of the great lessons of the whole history of science: that many of the most valuable contributions to national prosperity and well-being have resulted from the unexpected advances resulting from uncommitted research. If Australia ignores this, then there is no Australian industry that will suffer more than the healthy scientific industry whose future we are to discuss at this meeting.

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by J.D. Cashion
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This article is the first of what I hope will be a series of articles for the Education Section of the Australian Physicist around the topic of the physics of various sports and games. They arose out of my interest in improving my own performance at several sports which I look up after the youthful, experimental phase and well into the adult, analytical phase. However they provide excellent examples for illustrating physical principles in a context in which most young people have at least an interest, and in many cases a real passion.

I hope that they will provide a sympathetic basis for discussing and teaching physics and maybe help some others iron out their faulty techniques. I would also be delighted to receive comments or more information from others interested in the topics—I don’t claim to be expert in either physics or execution of any of them.

The design and construction of squash raquets has undergone several changes over recent years from the round-headed wooden raquet with either a wooden or steel shaft to the oversized head, often of non-circular shape and made from aluminium alloy or composites containing glass, carbon, boron or kevlar fibre. The differing dynamic responses of these materials now gives the user much more scope in choosing a raquet which suits, or sometimes does not suit, their game. We can use some simple physics to help define the criteria for designing and choosing such raquets. The same principles also apply to tennis and badminton raquets, but because the deformations are larger with squash raquets then the choice is more important.

Most of the readers of the Australian Physicist will be familiar with the concept of the centre of percussion or “sweet spot” on a bat or raquet. You can easily find the centre of percussion of your favourite cudgel by holding it between thumb and forefinger at the position where you would normally grip it and measure the period of oscillation. Using this period in the formula for a simple pendulum, \( T = 2\pi\sqrt{\frac{l}{g}} \), and solving for \( l \) gives the distance from the position being held to the centre of percussion. For my raquet I obtained 49cm, which put the sweet spot right in the middle of the head area.

The significance of this point is that if we consider (for ease of discussion) a ball striking a stationary raquet at the centre of percussion, then the combination of the translation of the centre of mass backwards and rotation of the raquet about the centre of mass produces one point on the raquet which doesn’t move - the point where you are holding it. Hence there is no reaction on the user’s arm.

However, this consideration makes it clear that the centre of percussion and the hand position are conjugate points - so if you don’t hit the ball in the sweet spot then the point of zero reaction will be somewhat different from where you are holding it. Then it jars! For the raquet designer this produces a problem because a significant number of players, including world champions such as Hashim Khan, hold the raquet where the grip joins the shaft (although as a converted tennis player I find this most uncomfortable). Why do they do this? The answer is that the raquet is not a rigid body but can flex roughly about the midpoint of the shaft. Since it is not tied at the ends like a guitar string then the nodes of the fundamental mode of vibration are moved in from the ends with one being at the top of the handle.

Thus, gripping the raquet at this point reduces the effect on the user’s arm of the oscillation of the raquet.

This gives two possible causes for sore arms from raquet sports - one due to impact (jarring) and the other to oscillation, which will be worse if the oscillation happens to strike a sympathetic resonance in part of your arm structure. The vibrational frequencies of squash raquets can vary from about 100 - 200 Hz so a raquet which may suit you may be painful for a friend with a different build. The designer can make the amplitude smaller by making the frame stiffer - but this increases the impact shock. The compromise design will also include good damping so that the oscillations die away quickly. Typically the injection moulded composites have the best damping and aluminium the worst while the compression moulded composites have the highest frequencies.

There is another centre which is important - the centre of power derived from the deformation of the strings. For a stiff circular raquet head the centre of power is clearly at the geometrical centre, but increasing the mass around the edge of a flexible raquet will move the centre of power towards that point. For most players, a lower string tension will result in a higher ball speed because there is less deformation of the ball (contrast with tennis) but the resulting “double hit” effect as the ball touches and leaves the raquet produces a loss of accuracy which overrides the advantage of the gain in ball speed.

The mechanics of all these considerations and the ability to tailor new materials has provided quite a challenge to squash...
A SIMPLE SOLAR-SIMULATOR

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Many students are fascinated by solar experiments, but many have great difficulty understanding the somewhat complex variation of solar irradiance both during a single day and throughout a year. Whereas a systematic program of actual observations of these variations requires great patience and dedication of time and effort, we have found that a simulation experiment rewards students with fast and effective learning.

The cheap and simple apparatus is shown in figure 1. It mainly consists of 4 strips of metal bent to circular shape to simulate the meridian circle (graduated in degrees) and the sun paths for midwinter, midsummer and the equinoxes (time graduated in hours). A step-down transformer driving a small bulb (the sun) attached by a magnet to the sun paths, a solar cell driving a milliammeter (a solarimeter), and a model solar wooden solar house with adjustable eaves complete the equipment.

The simulation represents of the sky sphere.

Figure 1 Photograph of the solar simulator apparatus

Figure 2a View of the sun’s paths on the sky sphere
course the position of the sun and its path across the sky for various times of the year, figure 2a. The geometry is well known to solar energy scientists, (Charters and Prior, 1981, p21), who usually summarize the effects using a sun path diagram, figure 2b, which is a projection of the solar simulator onto the horizontal plane.

A large number of experiments are possible using the simulator including...

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4) The diurnal interaction of solar radiation with a solar collector or with the model home. The overhang of the eaves and the placement of windows and shade trees can be varied for the model home. Students enjoy learning with the simulator. Interested readers may obtain further technical details and a full experimental script from the authors on request.

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THE PHYSICS OF SPORT - SQUASH continued

racket designers. Clearly one aim is to locate all the three centres at the same point of the racket, but the rest is a compromise between string strength, lightness, head size, power and price, while catering for the differences in build, style, skill and purse of the clientele.

The ball provides another interesting part of the mechanics of squash because there are three grades of ball with different bounciness to enable players of less ability to keep the ball in play long enough to have a reasonable rally. The coefficient of restitution of the ball is highly temperature dependent (squash in the tropics isn't just exhausting because it is hot!) and I believe that the differences in the bounciness of the grades of ball is achieved at least partly through the different equilibrium playing temperatures attained by the different compositions. Does any reader have any more information on this?

Let me close with another question. Sometimes a shot which is hit hard into the front wall "dies" before the service line, much more quickly than might be expected from similar strength shots which may reach the back wall. What is the optimum way of hitting this shot and what is the mechanism of the energy loss? My observation to date indicates that a small amount of either topspin or underspin will work. Any contributions will be gratefully received.

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**Reference**


Figure 3a Variation throughout the day of solar power falling on 1 m² of horizontal surface, at various times of the year.

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Figure 3b Variation throughout the year of solar energy collected on 1 m² tilted at various angles.
When the first AUSSAT B satellite is launched on a Chinese Long March rocket in the early 1990s, the Onora Valley Range facility south-east of Canberra will monitor its orbital height of 36,000 kilometres by bouncing a laser beam off a precision optical array on its surface. Even at the speed of light, the beam will take about a quarter of a second to make the 72,000 kilometre round trip. It is no mean technical feat to detect its return; the beam will be vastly weakened in intensity after passing twice through the Earth's atmosphere.

Moving Target

The great distance causes a second problem. Even though the AUSSAT B satellite will be in geostationary orbit, the return beam must be displaced slightly in the direction of the Earth's rotation, just as a hunter tracking a moving target with his rifle, must shoot slightly ahead to compensate for the time the bullet is in transit.

A small company in suburban Hawthorn, James Optics Pty Ltd., is making three sets of optical arrays for the AUSSAT B satellite for British Aerospace Australia, which has an offset contract with the primary manufacturer, Hughes Aircraft Corporation of the United States.

James Optics was established in 1968 by British-born William James, who entered the field of precision optics as an amateur astronomer making his own telescopes in Melbourne during the 1960s. In 1960, he decided to make optics his career and gained more formal experience with the British astronomical optics manufacturer C. C. Hargreaves and Thompson and Imperial College in London. Returning to Australia in 1965 to join the optics group in the University of Tasmania's Department of Physics, he designed an 0.4 metre telescope for the University's new observatory, and made all the mirrors and lenses for it.

William set up a business in Melbourne three years later to meet a need in Australia for the manufacture of precision astronomical optics and prototype optics for research, industry and defence. His reputation has grown since then - he specialises in making large reflectors for professionally-used telescopes and for the occasional dedicated amateur astronomer.

The AUSSAT B project is an unusual but not atypical job for James Optics. It demands an array of 14 precisely shaped cube corner prisms, an optical device familiar to surveyors and, whether they know it or not, to motorists. A cube corner prism, with its three internal faces set at 90 degrees to each other, has the remarkable property of reflecting any light beam entering it directly towards its source. Laser-based surveying instruments employ cube-corner prisms as targets, and tiny arrays of cube-corner prisms are used as reflectors in car tail-lights, as well as in reflective road signs.

Each of the 14 prisms on AUSSAT B will be mounted on the satellite's Earthward-pointing surface. The multiple prisms offer a larger target for the diffracted laser beam, but also are arranged in such a way that they produce a doughnut-shaped return beam of light that is several hundred metres across when it reaches the ground, making it more readily detectable.

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Slight Offset

Each cube corner is cut from a master cube of high-purity optical glass; even slight inhomogeneities in the bulk material can bend or scatter the light as it enters and leaves the prism. Instead of the three faces of the prism intersecting at perfect right angles, they are offset by a minuscule angle-about 0.8 arc seconds, to produce the necessary offset to compensate for the Earth's motion.

A diamond saw is used in cutting the master cube and then a single prism is sliced from one corner, a procedure taking about a week. The window face of the prism—the one through which the laser beam enters—must be ground extremely flat. The three internal faces are not coated, because the prism works on the principle of total internal reflection; the beam bounces off each face at an angle that prevents any light escaping from the prism's confines.

Each prism is coated with a thin layer of a transparent, electrically conductive material called indium tin oxide, which effectively grounds it through the satellite's metal body, preventing arcing of static electricity resulting from charged solar particles. Arcing generates a radio signal that can distort the data being transmitted through the satellite.

Outstanding Work

Although William does not possess even the basic academic qualification of a degree, he was made a Fellow of the Australian Institute of Physics for his outstanding work in optics, and was appointed a Member of the Order of Australia for services to Applied Optics. Reprinted from Vol. 7 No. 5, June 1989.
GREENHOUSE STUDIES

assessing uncertainties versus debunking hype

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In his President’s column in the October 1989 number of the Australian Physicist, Professor Klein makes a number of rather provocative statements about the discussion of the greenhouse effect. Some of these are valid comments on current scientific uncertainties, but many of them are quite misleading. In trying to separate the state of knowledge from the hype about the greenhouse effect, it is worth identifying 6 stages in the analysis:

1. Detection of increases in concentration of radiatively active constituents of the atmosphere;
2. Determining the causes of these increases so that we can start to make predictions about future changes;
3. Assessing the radiative effects of these gases;
4. Calculating the climatic effects of these changes in the earth’s radiation budget (and at some point detecting such effects);
5. Assessing the impacts of climatic changes;
6. Developing strategies to deal with the problems.

This summary makes it obvious that a very wide range of disciplines are involved; this leads to a very great difficulty in obtaining expert opinion. Even scientists who are experts in particular aspects of one (or part of one) of the areas listed above find themselves called on to comment on wider matters; this article is no exception to that rule. With regard to the role of experts, I came across a particularly pertinent article in the proceedings of this year’s Simulation Society Conference. The conclusion was that bushfire modelling is not a science in the legal sense that no bushfire modeller can satisfy the criteria required of expert scientific witnesses. After legal argument (which incidentally cost more than the value of the disputed claims) this point of view was accepted in a judgement in the South Australian Supreme Court on matters arising from Ash Wednesday bushfires (Purton, 1989). The difficulty seemed to be mainly with the range of different disciplines involved in bushfire studies. These cases may provide a useful warning to those of us involved in greenhouse studies where the range of disciplines is much wider.

Beyond the difficulties of ‘over-extended experts’, now that discussions of the greenhouse effect has moved outside of laboratories and into the political arena, there is the problem that many people’s involvement stems from vested interests or pre-existing political beliefs. The message on my car radio as I came to work today was ‘buy brand X compost bin to help fight the greenhouse effect!’ More seriously there have been many attempts to claim that concern over the greenhouse effect comes solely from the nuclear power industry. Thus discussion about the greenhouse effect is vulnerable to the sort of distortion of science by hype against which Professor Klein warned us. Of course, as physicists, we will be aware from the ‘cold fusion’ affair that hype can distort science under conditions of far less complexity than those pertaining to the greenhouse debate.

Trace gas increases

Professor Klein commented that he had seen no evidence of increases of greenhouse gases other than CO₂. There is, however, a very extensive literature documenting observations of the increases and the figure shows some of the latest data from our own laboratory (Fraser and Derek, 1990). In considering changes in greenhouse gases there are three different time-scales that are important. The first is the period of (reliable) direct measurements. This spans the last 1 to 3 decades depending on the gas concerned. The second is the industrial period since about 1800. Looking at this period assures us that we do have a long term increase, thus ruling out the possibility (which always seemed rather unlikely) that our direct observations represent a decadal-scale fluctuation. Data for the longer period are obtained by measuring the composition of air trapped in bubbles in polar ice (Neftel et al 1985; Pearman et al 1987). The third, longer-scale, records are also from bubbles in polar ice covering one or more glacial periods (Barnola et al 1987; Chappellaz et al 1990). These records show depletions of CO₂ and CH₄ during glacial periods and are telling us something (and we still don’t know precisely what) about feedback paths connecting atmospheric composition and climate.

The figure shows some of the evidence for increases in the minor greenhouse gases. The data are from the Cape Grim Baseline Atmospheric Pollution Station in Tasmania. The figures are from the annual report of the Station for the year 1988. Methane data from the US GMCC Global sampling network are given by (Steele et al., 1987). Chlorofluorocarbon data from international ALE/GAGE programs are given byCumold et al (1986). American CO₂ data are given by Conway et al (1986) and Australian CO₂ data by Beardsmore and Pearman (1987); this reference is in a conference issue (volume 39B, No 1-2) of Tellus which reports results from many other
CO₂ monitoring programs. Updates of some of these data sets can be found in the annual reports of various national monitoring programs (e.g. Forgan and Ayers, 1989; Elkins and Rosson, 1989).

Causes of changes

The reasons for the increases in the various greenhouse gases are varied. The simplest to describe are the chlorofluorocarbons (CFC's). These are purely anthropogenic, are released at the earth's surface and are destroyed photochemically in the stratosphere. The slow destruction means that they will persist with average lifetimes of the order of a century. The actual mode of destruction apparently leads to catalytic destruction of ozone. This occurs on a global scale through gas-phase reactions. So far the effect seems to be just within the limits of detection. More dramatically, what are apparently surface reactions on polar stratospheric clouds lead to the massive local depletion over the Antarctic in spring known as the ozone hole.

For methane the situation is less certain. There is a large natural source onto which anthropogenic perturbations are superimposed. Possible changes in sources include: methane released from fossil fuel, increases in biomass burning, increases in rice paddies, increasing numbers of cows and release of methane from thawing permafrost. Another possible contribution to the observed increase could be a weakening of the natural methane sink which is due to interactions with the hydroxyl radical (OH). If increases in other pollutants have led to a decline in atmospheric OH then part of the increase in methane concentrations would be explained by having a reduction in sink strength.

For CO₂ the main cause of the increase is fossil fuel use which releases 5 Pg (i.e. 5 x 10⁹ kg) of carbon as CO₂ into the atmosphere each year. An additional contribution from deforestation is poorly known. The observed increase in atmospheric CO₂ corresponds to 3 Pg per year, the difference being taken up, presumably by the oceans and, to an extent which is the subject of current controversy (Tans et al 1990), by the terrestrial biota.

Radiative effects

The various greenhouse gases exert their effect on climate by altering the earth’s radiation budget. In broad terms they pass incoming short-wavelength radiation (and stop some of the outgoing long-wavelength radiation). The quantitative details depend on such things as the strength of the absorption (the extent to which the bands are saturated and the degree of overlap between absorption by different species). It is at this level that we can start to make comparisons between the relative importance of the various greenhouse gases.

On a molecule for molecule basis, the warming effects of CO₂, CH₄, N₂O and CCl₃F are in the ratios 1 : 21.2 : 206 : 12,400. The importance of the gases needs to be weighted by the extent to which a molecule persists in the atmosphere. The relative scaling factors will vary depending on how the period in which we are interested compares to the mean lifetimes of the gases in the atmosphere. The relative warming effects of the 4 gases, averaged over a 100 year period after release, is in the ratio of 1 : 7.6 : 290 : 1,100 per molecule. In describing the relative importance of current releases, we need to multiply by the current anthropogenic source strengths. This gives relative warming effects (again averaged over 100 years after the release) in the ratios 1 : 0.025 : 0.066 : 0.032. All the sets of ratios given above are relative to current concentrations. Because the CO₂ absorption bands are more highly saturated than other greenhouse gases, the relative importance of CO₂ in any of the above comparisons will decline slowly with time.

Climatic changes

The climatic consequences of these radiative changes are assessed using atmospheric models of varying degrees of sophistication. Our confidence in these models comes from their ability to produce many aspects of the current climate from a combination of physical laws and parameterisation of such laws. The generally agreed conclusion is that there will be a global warming which, for a doubling of CO₂, will be in the range 1.5K to 4 K on average with greater changes at high latitudes and smaller changes in the tropics. However, the models do not give consistent predictions of rainfall changes.

In spite of these limitations, these model results are the basis for the confidence on the predictions of greenhouse warming, because we believe that they contain the basic physical mechanisms governing the climate system, at least in the atmosphere. The physics of the climate response is massively complicated, involving radiative transfer, thermodynamics of air/water mixtures and turbulent fluid dynamics all on a global scale. Nevertheless, most of what is in climate models represents universal physical laws and the widespread institutional separation of meteorology and physics should not prevent us as physicists from taking an interest in how such modelling is done. (The unacceptably large spread of estimates of temperature changes and the lack of consistent predictions of rainfall, together with continuing minority criticism of the whole modelling approach mean that informed involvement by knowledgeable groups such as the physics community will be an important part of the on-going debate.)

One consequence of a global warming will be a rise in sea-level. In the initial stages, the main mechanism will be thermal expansion of the upper layers of the oceans rather than changes in ice sheets.

Serious uncertainties arise when we start to consider feedbacks less direct than those mentioned above. We enter realms in which we have little quantitative knowledge about events that may be extremely serious, albeit relatively unlikely. One example concerns the stability of the West Antarctic ice sheet with respect to changes in temperature and sea-level (which is important because some of the base of the ice-sheet is below sea-level). The current consensus is that the ice-sheet is stable at least for the next few centuries. Of current concern is the role of ocean circulation in closing a 'feedback loop' connecting CO₂ and climate (Broecker, 1978). The various long-term ice-core records seem to indicate that climatic changes will lower atmospheric CO₂ concentrations during glacial periods. Suggested mechanisms must still be regarded as speculative. If such a positive feedback also occurs in response to greenhouse warming then the current climate model predictions would most likely be underestimates.

Detecting climatic changes

The ultimate test of climatic predictions is in comparing them to real-world changes. Because of the major impacts that such changes would have, it would be desirable to have the model predictions confirmed (most probably with some need for adjustments) as soon as possible. Thus the problem of 'early-detection' of greenhouse changes is of considerable importance. The present status can be summarised by saying that significant changes (in the predicted direction) in temperature and sea-
level rise are well-documented but that these cannot be unambiguously attributed to the greenhouse effect.

The global average temperature record shows an overall increase of 0.5–0.7 K over the last century with a number of fluctuations including a slight cooling from about 1940 to about 1965. Disaggregation of the data shows this cooling to have occurred mainly in the northern hemisphere. The other notable feature is that the 1980’s were the warmest decade on record. If one analyses the data as a potential CO₂ warming signal plus natural climatic noise then the record must be regarded as too noisy for the signal to be detectable at present. While satellite data has the potential for removing errors due to limited sampling and varying observational techniques, it will not reduce the effect of natural climatic variation. Therefore the recent failure (Spencer and Christy, 1990) to detect a significant trend in 10 years of satellite-derived temperature data is entirely to be expected. Indeed, as pointed out by Jones and Wigley (1990), the good correlation between the satellite data and the land-based temperature record is an important validation of the adequacy of the spatial coverage of the land-based data. If some of the variability could be identified as due to known forcings then the residual climatic noise would be smaller and a CO₂ signal could be detected more readily. Various attempts have been made, attributing temperature variations to such things as the effects of solar variability, aerosols from volcanic eruptions, anthropogenic aerosols and NOₓ from nuclear testing (Kondratyev, 1988). These last two explanations have the attraction that they can explain why the cooling was a northern hemisphere phenomenon. However the multiplicity of possible influences prevents the reliable identification of any of them by statistical approaches and so the statistical detection of a CO₂ warming must await longer records. While the temperature trends can not be attributed to the greenhouse warming on purely statistical grounds, with the 90% confidence level that is usual in statistical studies, many scientists, including myself, would assign a confidence level of over 50%, i.e. we believe that, more likely than not, the observed changes, particularly those of the last decade, are due to the greenhouse warming. However, as noted above, the main reason for our confidence in the reality of the greenhouse effect is direct observations of changes in atmospheric composition and the belief that we know the basic physics of the climate forcing mechanism.

Climatic impacts

Any attempt on my part to discuss the impacts of climatic changes would have me straying far too far from my field of expertise as a mathematical physicist turned biogeochemical modeller. In Australia we are fortunate in having available the reports for the ‘Greenhouse 87’ conference dealing with a range of studies of impacts of climatic change on Australia (Pearman, 1988). The introductory articles in that volume are also a useful source of information about the atmospheric science aspects of the greenhouse problem (covering topics such as trace gas budgets and modelling and detection of climatic change).

There are, however, several obvious comments on Professor Klein’s claim that ‘compared to well-documented fluctuations in global climate on time-scales of millennia, let alone millions of years, the worst possible effects seem to pale into insignificance’. He seems to miss several important points.
Greenhouse Studies

Firstly, the predicted greenhouse changes are not insignificant compared to changes over recent millennia. While paleoclimatic data are subject to much uncertainty, reasonable estimates for the previous warm periods 10000BP, 60000BP and 125000BP (the last interglacial) suggest that these were about 1K, 1.5K and 3K warmer than at present (see for example Back, 1988). Even the Pliocene (5000000 BP - 3000000 BP) experienced temperatures close to the top of the range of predictions for warming from CO₂-doubling. Thus it seems highly probable that a doubling of CO₂ would cause temperature changes larger than any climatic level experienced in the whole of recorded history. (An interesting starting point for reading about how much climatic changes may have affected human history is Lamb, 1982). Secondly, the CO₂ doubling, for which the predicted warming is 1.5 to 4 K, will not be an end-point for climatic change unless very severe actions are taken to reduce greenhouse emissions. The CO₂-doubling (or its equivalent, taking into account the role of other gases) is much nearer to being a ‘best-achievable’ case rather than a ‘worst-possible’ case - the complete utilisation of fossil fuel reserves at current consumption rates would see CO₂ rise to 6 to 8 times the pre-industrial level. Finally, and perhaps more importantly, the ‘greenhouse’ changes, however large they are, will happen on time scales much less than millennia. This rapid rate of change will severely strain the adaptive capability of human and natural systems.

Strategies for actions

Any decisions for actions about the greenhouse problem need to be made in terms of comparing the costs of action against the consequences of inaction, assessing them in the light of existing uncertainties. Further discussion is given by Tucker (1990). Obviously, the easiest choices are for those actions that have additional benefits. In this category, addressing environmental problems such as desertification and other forms of land degradation will be beneficial under any climatic regime and will have our agricultural systems in better condition for adapting to climatic changes.

It is necessary to prepare for both reduction of emissions, otherwise we will go far beyond a CO₂ doubling, and for adaptation because past releases and current practices are almost certainly committing us to a significant warming. To quote Pickett (1989) “We know enough about the greenhouse effect to know that we must urgently seek to limit its rate of warming and eventual extent if disaster is to be avoided. We also know that some adjustments to climatic and other changes which are unavoidable must be made... some uncertainty may be inevitable for a long time, we should plan for adaptability and resilience…”.

Discussing apocalypses

So where are we left with this mixture of knowns, unknowns and hype? Clearly more research into all the aspects of climatic change is needed. In Australia, existing greenhouse research in the Division of Atmospheric Research of CSIRO has been strengthened by recent government funding. The Bureau of Meteorology Research Centre has been similarly funded. The greenhouse research grants scheme that is just beginning should further broaden this research base. The next level of action is for planners to realise that planning on the basis of a stable climate is now even less sound than it would be with only natural climatic variability. In terms of actions we must adopt strategies for both reducing greenhouse emissions and for adapting to greenhouse changes.

In a democratic society, major actions must ultimately rest on a public acceptance of the need for such action. This implies a need for public communication. Roan (1989) has given an account of the history of debate over the role of chlorofluorocarbons in depleting the ozone layer. She includes a particularly pertinent quote from Sherry Rowland (cosignator of the theory of ozone depletion by CFCs) “What’s the use of having developed a science well enough to make predictions if, in the end, all we are willing to do is stand around and wait for them to come true?”

References


Welch Foundation Scholarship 1992

Announcement

A scholarship is offered to a promising scholar who wishes to contribute to the study of vacuum science techniques or their application in any field.

Conditions of the scholarship

This scholarship is offered for a one-year period starting 1 September 1991. If for some reason, the candidate cannot begin their work as scheduled, they can begin within three months after 1 September 1991. In the case of a delay of more than three months, another candidate will be chosen. The laboratory where the candidate wishes to work must approve any delay in the commencement of work.

The scholarship holder is encouraged to seek funds in addition to the scholarship but should obtain the authorisation of the Chairman of the Welch Committee of the IUVSTA before accepting any additional funds. Traditionally, this authorisation has been granted.

The amount of the Scholarship will be approximately US$12,500.

The scholarship money is paid in three installments—one of $5,000 at the beginning, another of $5,000 six months after, and a third of $500 upon delivery of a final report after completion of work. A brief mid-term report is required before payment of the second installment.

Applications are invited to make arrangements for the proposed research program with a laboratory of their choice. Because of the international nature of the scholarship, strong preference will be given to applicants who propose to study in a foreign laboratory in which they have not yet studied. A form outlining the research program and signed by the supervisor in the laboratory where the research is to be carried out must be submitted with the application to indicate the agreement of the laboratory and the proposed supervisor to your studies.

Candidates for the scholarship should have at least a Bachelor’s degree; a Doctor’s degree is preferred.

Application procedure

Candidates can obtain the necessary forms for the scholarship from the IUVSTA Welch Foundation Administrative Office:

Dr W.D. Westwood
Advanced Technology Laboratory
BNR
Box 3511, Station C
Ottawa, Canada K1Y 4H7

Candidates for the Welch Scholarship are invited to send their applications to the above-noted address before 15 April 1991.

Each candidate’s application should include the following:

- A curriculum vitae
- A photocopy of, or attestation of, all diplomas
- Name and address of laboratory chosen; a 200-word abstract describing the research he/she proposes to perform; and a letter indicating that the facilities of the host laboratory will be available.
- A declaration that the candidate will not violate any laws of his/her own country during his/her tenure of scholarship.
- A declaration that the candidate will not violate any laws or engage in any political activity in the country where he/she intends working.
- Two recommendations from present or past professors, or research directors.

Candidates will be informed of the results of their applications as soon as possible but probably before the beginning of August 1991.

The successful candidate must produce satisfactory evidence (preferably in the form of examination certificates, etc.) of reasonable fluency either in the language of the country where he/she will work during the tenure of his/her scholarship or in English.

Note

Researchers who applied unsuccessfully for previous Welch Scholarships may apply again for the 1992 grant.

Applications for renewal of the Scholarship are not accepted.

Gordon Godfrey Workshop on Condensed Matter Physics

Strongly Correlated Electron Systems

17-21 June 1991
University of New South Wales

It is becoming apparent that different phenomena associated with strong electron correlations in condensed matter systems exhibit similar features. Physical phenomena and condensed matter systems to be covered will include:

- Electronic phase transitions (including Mott and Wigner transitions)
- Metal hydrides
- High temperature ceramic superconductors
- Heavy fermion systems
- Low dimensional electronic systems
- Quantum Hall Effect

Participation: This workshop will provide the opportunity for research scientists in these fields and Australian postgraduate students to discuss with seven leading overseas researchers new ideas and the most promising techniques for treating some of these challenging problems.

Format: 21 lectures for 1 hour each. Panel discussions. 5 Group discussions.

The Proceedings of the Workshop will be published as a book.

Invited overseas speakers:

The following distinguished speakers have agreed to participate:

- P. Fulde (Max Planck Institute, Stuttgart Germany)
- D.J.W. Geldart (Dalhousie University, Halifax Canada)
- T.V. Ramakrishnan (Indian Institute of Science, Bangalore)
- M. Rasolt (Oak Ridge National Laboratory, USA)
- K.S. Singwi (Northwestern University, Chicago, USA)
- P. Vashishta (Argonne National Laboratory, USA)

Registration Fee: $150 (includes cost of refreshments, Harbour excursion, Workshop Dinner and a copy of the Proceedings of the Workshop).

For further information contact:

Ms. D. Bock, School of Physics, University of New South Wales, Kensington 2033, Australia.
Fax (02) 663 3420; Tel: (02) 697 4564

D. Neilson
Convener
New 8 Watt 'Small Frame' Ion Laser - An Ideal Pump for Titanium:Sapphire

Traditionally, researchers requiring an argon ion laser have had to choose between a small-frame laser (plasma tube length around 1 metre), with a maximum power up to 6 watts, or a large-frame laser (plasma tube length around 2 metres), with a maximum output power between 10 watts and 25 watts.

Coherent Inc. recently released a product to fill the gap between large-frame and small-frame lasers. The Innova 318 delivers a guaranteed 8 watts of blue/green output power from a small-frame package.

The 318 is ideally suited as a pump for tunable lasers; for example, Coherent's Ti:Sapphire laser is guaranteed to deliver 1 watt of output power when pumped by 8 watts from a 318, and typically delivers up to 1.8 watts.

This combination of the 318 pump laser with a Titanium:Sapphire laser means that experiments that could previously only be performed using a dye laser pumped by a bulky and expensive large-frame laser can now be done more easily and at lower cost.

More power from diode-pumped lasers

ADLAS have expanded their range of diode-pumped solid state lasers with the addition of several new models offering higher power and pulse energy. The lasers are available with YAG or YLF as the gain medium, and with optional Q-switched or frequency doubled output. Maximum CW output powers are 750mW at 1064nm, 250mW at 1319nm and 140mW at 532nm. Q-switched pulse energies to 150 microjoules are available, depending on wavelength.

The solid state design of these lasers eliminates the need for high voltage power supplies, flashlamps or cooling water and results in exceptional reliability in a compact, maintenance-free package.

Modular photo detection system

Melles Griot has released a new range of products for sensing and measuring visible and near infrared radiation. The products form a modular system which can be easily adapted to a wide variety of light measurement applications. Components include mounted and unmounted silicon photodiodes, lenses, optical filters, integrating spheres and transimpedance amplifiers. All components are compatible with the wide range of existing Melles Griot optical components and hardware. A brochure is available which presents the theory and application of the above devices in tutorial fashion as well as detailed product specifications.

Detector Products from Melles Griot

For more information please contact:
Coherent Scientific Pty Ltd
138 Greenhill Road, Unley SA 5061
Phone (08) 271 4755
Fax (08) 271 1202
New Improved Lasers from Spectra Physics

In keeping with a corporate philosophy of continual product evolution, Spectra-Physics announce enhancements to three popular laser models - The 3900S Titanium:Sapphire, the GCR-11 Nd:YAG, and the 2040E large-frame argon ion laser.

**Model 3900S : Ti:Sapphire CW tunable laser**

This solid-state near-IR laser now features a sealed optical path to allow for nitrogen purging, with Brewster-angled input and output windows. An optional regulator assembly, model 3910, incorporating a molecular sieve, pressure valve and flow meter is also available.

Nitrogen purging provides smoother tuning across the 675-1100 nm tuning range of the laser, and longer maintenance intervals.

**Model GCR-11 Nd:YAG laser**

The GCR-11 adds a Gaussian coupled resonator to the proven design dependability of the Quanta-Ray DCR-11. The result is spatially smooth high energy pulses in a single transverse mode.

Like the DCR, the GCR employs an unstable optical resonator. The key difference is in the output coupler: in the GCR, reflectivity decreases as a function of distance from the centre of the optic in a Gaussian-like manner. The GCR is thereby able to sustain a large mode-volume in the Nd:YAG rod while discriminating against higher order transverse modes.

This improvement increases the efficiency of harmonic and other nonlinear conversions and enhances the reproducibility and accuracy of experimental results.

**Model 2040E Argon-ion laser with BeamLok**

The Spectra Physics family of large frame argon ion-lasers now features an improved passive resonator design for unequalled angular and length stability.

In addition, a new option which actively controls beam position has been released. Known as BeamLok, the systems picks off a fraction of the output beam and senses any slight change in position. Feedback electronics are employed to adjust the output mirror to keep the beam locked on target. BeamLok acts in real-time to maintain beam position without otherwise disturbing the cavity, unlike systems which employ continuous mirror dither to optimise output.

For critical applications requiring precise and repeatable alignment such as dye or Ti:Sapphire laser pumping, BeamLok eliminates beam wander at warm-up and assures consistent performance hour after hour, day after day.

For further details on these product developments, please contact John Holdsworth or Simon Miles at:

Spectra Physics
2-4 Jesmond Road, Croydon Vic 3136
Tel: (03) 723 6600 Fax: (03) 725 4822

LETTERS

Small Country - Big Science

Dear Editor,

In its April 1990 report to the Prime Minister 'Small Country–Big Science' ASTEC recommended:

"That $2.70 million be provided over the first three years to the Minister for Industry, Technology and Commerce for the purpose of establishing an Australian Beamline at the synchrotron light source known as the Photon Factory at Tsukuba, Japan".

The report also recommended large scale funding to enable Australian participation at Grenoble (Neutron source) and CERN (high energy physics).

While it is hoped that the Government will see the wisdom of implementing these recommendations as a significant step along the way to making Australia a technologically 'clever country' the report’s recommendation appears to disadvantage a significant number of actual and potential users of synchrotron radiation (SR).

The SR beamline proposed for funding is intended specifically for X-ray crystallography. As such, it is urgently needed and the recommendation deserves wide support. In itself, such a beamline would be of no relevance, however, to the Australian community of scientists who utilise SR for spectroscopy in its many and varied forms (IR, UV, photoelectron, XAPS etc etc). A beamline equipped for surface analysis is a vastly different object to one intended for crystallography.

Australian involvement in SR instrumentation is overdue, and it is probably unrealistic to expect the construction of two beamlines in the first instance. Nevertheless there is a real risk that the spectroscopic community’s needs will be overlooked if the Photon Factory crystallography beamline is all that is funded. The report attempts to allay such fear (p 12) when it suggests that the needs of users (other than crystallographers) “can be addressed through additional travel funds recommended in this report”.

The provision of travel funds to the most relevant SR source for a given spectroscopy is, of course, a vital ingredient. Recent moves by the Government of provide for such travel are appreciated, but this alone does not address the more difficult problem of the funding of beamtime itself. Indeed, the report gives the impression (p 7) that “access to the facilities is usually provided free of charge if its peer-reviewed of a research proposal submitted by the Australian investigator is successful”. I strongly challenge this conclusion. In my experience, foreign nationals seeking access to a SR facility in their own right are expected to pay for their own beamtime as well as being expected to propose a scientifically competitive program. Whereas, in the past, I and many other Australians have enjoyed free access to various SR facilities, this has almost inevitably been in collaboration with scientists from the host country with no certainty of continuity–this is what I have come to call 'begging bowl mode'. In such an arrangement, the Australian scientists are inevitably the junior partners with limited opportunities to initiate their own unique research programs or to establish commercially sensitive investigations.

When the final decision is made, I urge the government not only to support the crystallography beamline but also to put in place a mechanism which will provide Australian spectroscopists of proven capability the funds to enable them to purchase time on overseas facilities in their own right and to end their current dependence on the generosity of other scientists and of other countries.

Dr Robert Leckey ▶

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PEATERS

Non-physicist's point of view!

Dear Editor

As a non-physicist, I should like to take issue with Rod Boswell in his criticism of The Fourth State of Matter by Yaffa and Shalom Eliezer (April 1990—Book Reviews).

I found this book to be a most helpful introduction to plasma physics, and would respectfully suggest that as a lay person, and a representative of the group for whom it was written, I am in a better position than a physicist to assess its effectiveness.

I am glad that these two people have taken the trouble to describe, in comprehensible language and concepts, the basics of a subject which would otherwise have remained unknown to me.

Simplification and popularisation of one's own area of competence may well be irritating to the expert, but to the 'non-cognoscente' can be a welcome step in the direction of improving interdisciplinary understanding.

Surely scientists, and especially physicists, should welcome attempts to make their subject more accessible to the lay public, without whose support, after all, they cannot function.

Louise Mathieon

TASMANIAN BRANCH

Professor P.A. (Pip) Hamilton has been awarded a personal chair in Physics at the University of Tasmania. Pip is the Head of the Physics Department and his award was for his research in radioastronomy, particularly his study of pulsars.

The branch held an AIP lecture on Chaos earlier in the year. Professor I. Procaccia of the Weisssmann Institute spoke on 'FRACTALS' and Professor M.J. Feigenbaum of Rockefeller University spoke on 'Universality in Chaos'. The talks were open to the general public and so many attended that it was necessary to change the venue at the last minute from the large Physics lecture theatre to the University Centre to accommodate everyone. Even then we had people sitting in the aisles. It was estimated that over 300 people attended these two well presented talks.

WA BRANCH

June has seen two very different but equally well attended evening meetings. On Wednesday 6 June at 5.30 pm the Branch presented a seminar to a large audience (50+) on the topic of intellectual property rights and protection entitled "Protect, then Publish or Perish". The speakers, from Perth law firms Parker and Parker, and Wray and Associated, were Mr Rory Argyle, Mr Richard McCormack and Mr Errol Harwood (and AIP member) and between them they explored the broad themes of defining intellectual property rights and where, why they should be protected and the general procedures for achieving this. This is an area we all should be conversant with; how dearly we all hope to devise something valuable to protect!

IMPRESSION

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POLYMER 91

10-15 February 1991, Melbourne

Polymer 91 is an international symposium which will focus on Polymer Materials, the central theme of polymer research and technology. New polymer materials are essential for innovation in many technologies, and their development depends on research into their preparation, characterisation and properties. Polymer 91 will provide participants with an insight into the future directions in polymer science around the world.

The scientific program will extend over four full days from Monday 11 February to Thursday 14 February 1991 and includes invited lectures, contributed short papers, special seminars, poster sessions and an exhibition. Three specialist workshops will be held in conjunction with Polymer 91 on Sunday 10 February 1991.

For further information and registration brochures, contact Dr G.B. Guise, Polymer 91 Secretary, PO Box 224, Belmont, Vic 3216, Australia, tel: (052) 47 2695, fax: (052) 21 7971.

POLYMER 91

IUPAC INTERNATIONAL SYMPOSIUM

10-15 February 1991, Melbourne

The formal presentation concluded with a lively panel discussion and wrap-up and thanks to the speakers from Brian O'Connor, the Branch Vice Chairman. Despite the counter attraction of Stephen Hawking on the ABC, most members, or at least those with VCR's!, and other attending stayed on for a light snack of sandwiches and wine and further discussion with the speakers. We thank them all three for a most interesting and well presented seminar which sent most of us away with many new thoughts.

On Wednesday 20 June, Dr Roger Price of the Department of Endocrinology and Diabetes at the Queen Elizabeth II Medical Centre spoke to the Branch on the topic "The Applied Physics of Human Calcium Metabolism". Roger gained his PhD from UWA in 1977 in 'very pure' physics and is now deeply immersed in a correspondingly very applied area, in clinical medicine, using techniques of mass spectrometry, radioactive tracers and sophisticated polarised microscopy in the study of calcium metabolism. This is a key feature of a number of biological functions and in particular of osteoporosis which was chosen as the example for the lecture.

The topic was very close to home for many of the ageing members of the audience all of whom sat engrossed in both the physics and the physiology involved in the complex study, and many of whom I am sure went straight home and raided the refrigerator for milk to supplement their deficient calcium intake. It was also most appropriate for students to see how a basic pure physics training can lead into what at first sight seems an unexpected area for a career but in which that very pure physics training, coupled in this case with physiology, is essential.

At the conclusion of the talk the speaker presented suitably engraved pens to the WA Branch AIP prizewinners for 1989. The prizewinners were

Mr Amos Maggi, Curtin University (Physics)
Mr Kim Sebo, UWA
Mr Fred Bowden, Murdoch University
Mr Roland Hill, Curtin University (Geophysics)

We congratulate all four on their achievements and wish them well for their careers in physics.

Severin Crisp
WA Branch Correspondent
BOOK REVIEWS

A Physicist's Desk Reference
The Second Edition of Physics
Vade Mecum

H.L. Anderson (Editor in Chief)
American Institute of Physics, New York, 1989
356 pp., £22.50 (paperback)

Where do you quickly find the necessary numbers and formulae you need to solve a problem? If you are like me you have an array of references which include textbooks which have the formulae, appendices of books and separate references for physical constants or physical properties of the elements. When I saw the first edition of the Physics Vade Mecum I felt sure that here at last must be THE collection of essential formulae and constants in a special purpose reference of 330 pages covering 22 discipline areas designed by physicists for physicists. While the first edition did not live up to my expectations it does have a place on your shelf to act as a quick source of information on subjects on which you may have only a passing acquaintance. It collects together the essential formulae of many areas of physics and includes some physical properties of materials but on the latter it is not very comprehensive.

The second edition has been introduced to catch up with the changing face of some of the topics with major additions to the chapters on Energy, Elementary Particles and Surface Physics, and additional material on high-Tc superconductors. The index has been improved with an almost twofold increase in the number of entries; however it is still too small for such a concentrated collection of material and some of the entries are not the most common terms used in general physics. This book can best be summarised as a useful reference but not an essential tool.

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

An Introduction to Solid State Diffusion

Richard J. Borg and G.J. Dienes
Academic Press, San Diego, 1988
xvi + 360 pp., US$49.50 (hardcover)

Diffusion studies have long been used in solid state physics to elucidate basic transport mechanisms in solids and to modify the properties of a solid for practical purposes. This book is a remarkably clear and well developed description of diffusion and its study in solids. It is aimed at what would be senior undergraduate or beginning post graduate students in our system. It provides for that audience a concise but complete description of diffusion.

The book not only considers the basic mechanisms of diffusion in well characterised solids, such as metals or alloys and ionic crystals, it also describes diffusion associated with irregularities, such as grain boundaries and surfaces. In all cases the basic mechanisms are described, the basic theory given and examples well described. Any student would find the appropriate section a very adequate starting point from which to develop an understanding of the topic.

It is also very pleasing to see a brief but adequate description of the various methods of measuring diffusion profiles. There have been very significant developments since the early techniques of radiotracer coupled with sectioning by polishing. These developments have often enhanced the sensitivity of the experiment, only to reveal additional complexities as other factors exercise an effect on the diffusion process.

The book is a very worthwhile addition to the local collection of reference material in any laboratory concerned with solid materials and their properties. It will be particularly useful if that laboratory is concerned in any way with atomic transport processes.

R.J. MacDonald
Department of Physics
University of Newcastle

The Physical Basis of the Direction of Time

H.-Dieter Zeh
Springer-Verlag, Berlin, 1989
viii + 166 pp., DM 56 (paperback)

When Fred Hoyle came into the Bonython Hall of Adelaide University in 1962 to deliver his Einstein lecture on "The Arrow of Time", he was horrified to discover that the hall was so full that even standing room was scarce. His prediction that they would understand little of what he said was almost certainly true but that did not mean that the largely lay audience was not fascinated.

The problem of the 'Arrow of Time', as Eddington called it, presents a never ceasing challenge to philosophers and physicists, and this book, by one of the latter, is an attempt to confront it with all the knowledge which modern physics provides. His approach is technical, eschewing all but passing references to intuitive notions such as the historical nature of the world or the role of memory in characterising the difference between past and future.

He takes as the most important classes of phenomena which have been used to demonstrate the asymmetry of temporal succession in contrast to the temporal symmetry of the fundamental laws the following six: 1. Radiation; 2. Thermodynamics; 3. Evolution; 4. Quantum mechanical measurements; 5. Exponential Theory; and 6. Gravity, and subjects them to a searching analysis. With careful and scholarly scrutiny he shows that all of them contain, implicitly or explicitly, an assumption about a very special initial state of the universe. How such a state comes about is a matter for further speculation, not covered in this book.

It is a book of solid and sound scholarship which is prepared to criticise many accepted views, and demanding close attention from its readers. Space does not permit a more thorough critique of its message, but it is a book every library should have, and from which many individual readers would profit.

C.A. Hurst
Dept of Physics and Mathematical Physics
University of Adelaide

An Introduction to the Upper Atmosphere

M.H. Rees
Cambridge Univ. Press, Cambridge, 1989
ix + 289 pp., A$51.00 (paperback)

This monograph is a succinct and coherent appraisal of present knowledge on energy deposition and transfer processes occurring in the thermosphere and ionosphere. It aims to bridge the gap between student texts and the research literature, but the degree of specialisation embodied would not allow me to recommend it as a text suitable for advanced undergraduates, as suggested on the back cover. Where the book focuses on current understanding of chemical processes in the thermosphere and ionosphere, little attention is given to allied observational techniques, and introductory or background material.

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BOOK REVIEWS

There is no description of high latitude topology, such as the cusp and auroral oval, although the nature and spectrum of auroral precipitation is frequently discussed. The words ionosonde, interferometer, and photometer do not appear in the index, and although optical spectroscopic and radar wind data are frequently referred to in the text, knowledge of these techniques is assumed.

On the other hand, the book has four features which elevate it above others. First, the topic is treated with a precision and cohesion often lacking in monographs comprising chapters contributed by different authors. Second, the book is modern, filling in gaps on recent work not alluded to in other texts and often reading like a detailed review. For example, Chapter 7, entitled Spectroscopic Emissions, has sections dealing with the auroral, dayglow and twilight spectrum, and is based on the interpretation of recent results, much of it originally published during the 1980s. Third, where this book really shines is in the meticulous referencing. The majority of the 137 figures describe experimental observations and are fully referenced. Each chapter also features a bibliography, which, while not exhaustive, is annotated so that the relevance of each cited reference is clear. The final notable feature of the book is the Appendices, which can be best described an essential toolbox for the thermospheric modeller.

The text throughout is crisp, authoritative and concise. The book will serve well as a review of current knowledge of problems in the physics and chemistry of the thermosphere, for researchers in the field or some allied area of endeavour. I would not, however, recommend the book as a first-off general introductory text to upper atmosphere physics.

F.W. Menk
Department of Physics
University of Newcastle

Laser Spectroscopy IX
M. Feld, J. Thomas and A. Mooradian (eds)
Academic Press, San Diego, 1989
xii + 509 pp, US$49.95 (hardcover)

This book contains almost the entire selection of papers from the Ninth International Conference on Laser Spectroscopy (ICOLS) held in New Hampshire, USA in June 1989.

These papers cover recent developments in most major research areas of laser spectroscopy, and have been collected into fourteen groupings.

by the editors ranging from fundamental measurements and new laser cooling mechanisms through the expected atomic and molecular spectroscopy papers to laser spectroscopy for biomedicine.

A total of 134 papers (including both oral and poster presentations) have been included and each is typically only three or four pages long. Therefore these are closer to expanded abstracts than full length journal publications.

The quality of the presentation is variable, as are all compilations made from 'camera ready' contributions by the individual authors, and range from excellent to quite uncomfortable to read. However the quality of the content is consistently good albeit at an advanced level.

While it may be reasonably expected that many of these proceeding papers will be followed by journal papers in the future, this volume remains a valuable update to researchers in the laser spectroscopy area.

J. Webb
Division of Science and Technology
Griffith University

Each article is in effect a review of one area of the field. It will be mainly of use to specialist researchers and graduate students seeking to obtain an overview of recent developments and inspiration for future research directions.

F.P. Larkins
Department of Chemistry
University of Tasmania

Book Notice
End. Cosmic catastrophe and the fate of the universe
F. Close
242 pp, $18.99 (paperback)

The hardcover edition of this book (Simon and Schuster, 1988) was reviewed in the Australian Physicist for June, 1988 (p.140).

New Books
Groups, Representations and Physics
H.F. Jones
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R.A. Stradling and P.C. Klipstein (eds)
Adam Hilger, Bristol, 1990
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Radiation Exchange. An Introduction
J.H. Taylor
Academic Press, San Diego, 1990
xii + 127 pp, US$24.95 (hardcover)
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>Aug 2-8</td>
<td>25th International Conference on High Energy Physics, Singapore</td>
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<tr>
<td></td>
<td>Professor K K Phua, Department of Physics, National University of</td>
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<tr>
<td></td>
<td>Singapore, Kent Ridge, Singapore 0511 Rep of Singapore, Tel2710311,</td>
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<tr>
<td>Aug 5-10</td>
<td>15th Congress of the International Commission for Optics, Bavaria.</td>
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<tr>
<td>Aug 12-16</td>
<td>International Conference on Optics for the Life Sciences, Munster.</td>
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<tr>
<td>Aug 13-17</td>
<td>4th Asia Pacific Physics Conference, Seoul Korea</td>
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<tr>
<td>Aug 27-29</td>
<td>New Zealand Institute of Physics National Conference, Palmerston North,</td>
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<td>N.Z. Prof P.T. Callaghan, Department of Physics &amp; Biophysics, Massey</td>
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<tr>
<td></td>
<td>University Palmerston North, New Zealand. Tel: (063) 69 099, Fax: (063)</td>
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<tr>
<td>Sept 24-28</td>
<td>Joint Conference of Australian Radiation Protection Society and</td>
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<td></td>
<td>Australian College of Physical Scientists and Engineers in Medicine,</td>
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<td></td>
<td>Adelaide. SAPMEA, GPO Box 498, Adelaide, 5001.</td>
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<tr>
<td>Sept 25-29</td>
<td>International Symposium on 'Structures in Mathematical Theories', San</td>
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<td>Sebastian, Spain Andoni Ibarra (SSMT-90), Depo de Logica y Filosofia</td>
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<tr>
<td></td>
<td>de la Ciencia, Facultad de Filosofia y CCEB, Apartado 1249, E-20080</td>
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<td></td>
<td>Donostia-San Sebastian (Spain), Tel: 34-43-470003 ext 258, Fax: 34-43-47</td>
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<tr>
<td>Oct 1-4</td>
<td>11th European Conference on Surface Science, Salamanca, Spain.</td>
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<td>Laboratorria Fisica de Superficies, Instituto Ciencia de Matematicas</td>
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<tr>
<td>Oct 8-12</td>
<td>5th Australian Remote Sensing Conference, Perth. Dr Norm Campbell,</td>
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<tr>
<td>Oct 15-19</td>
<td>Course in Temperature Measurement, CSIRO Div. of Applied Physics,</td>
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<td>Sydney. Mr Robin Bentley, CSIRO Div. of Applied Physics, PO Box 218,</td>
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<td>Lindfield 2070, Tel: (02) 413 7764.</td>
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<td>Oct 16-18</td>
<td>Communications '90. Electronic Communications in the 1990s.</td>
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<td>Oct 22-27</td>
<td>Asia Pacific Conference on Optical Technology, Singapore. APCOT</td>
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<td>Secretariat, Conference &amp; Exh. Management Services P/L, 1 Maritime</td>
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<td>Square 809-43/20, World Trade Centre Rep. of Singapore 0409 Tel: 2788</td>
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<tr>
<td>Dec 4-7</td>
<td>Fourth International Symposium on Neutron Capture Therapy for Cancer,</td>
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<td>Sydney B.J. Allen, Nuclear Applications, ANSTO, PMB 1, Menal, NSW 2234</td>
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<td>Dec 27-31</td>
<td>International Conference on Teaching Physics - &quot;Changing Face of</td>
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<td></td>
<td>Physics Education in Developing Countries&quot;, Karachi. S.A. Hasnain,</td>
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<tr>
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<td>Department of Physics, University of Karachi, Pakistan.</td>
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<td>Feb 6-8</td>
<td>15th AIP Condenced Matter Physics Meeting, Wagga, NSW I.K. Snook, P.J.K.</td>
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<td>Feb 10-15</td>
<td>Polymer 91, IUPAC International Symposium on Polymer Materials,</td>
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<tr>
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<td>of Physics, University of NSW, Kensington NSW 2033, Australia, tel: (02)</td>
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