This is the first announcement of the fourteenth annual Condensed Matter Physics Meeting which is to be held at the Riverina campus of Charles Sturt University, previously the Riverina-Murray Institute of Higher Education. Wagga is easily reached by road, rail or air. The campus is about 8 km from the town and most of the local taxi drivers know how to find it.

The Meeting will consist mainly of poster sessions, with a few invited review-type lectures and some shorter contributed lectures to be allocated by the organising committee. Accommodation will be in student halls of residence, which are near the Union building, the dining hall and the swimming pool.

At present, the following invited speakers are slated:-

Dr Earl Callen (metastable metallic phases),
Professor Tony Guenault (low temperatures),
Professor Geoff Opat (Aharonov-Casher effect),
Dr Chris Rossouw (electron beam analysis of semi-conductors),
Dr Brett Sexton (scanning tunelling microscopy),
Dr Ian Snook (liquids).

The registration fee will be of order $40.00. The cost of full board (three meals a day) and lodging in the halls of residence will be $40.00 per day. Students who are AIP members and wish to attend should ask their local AIP branch secretary about financial assistance.

A second circular with fuller details and a call for papers will be distributed in mid-November. If you wish to be kept informed, please fill in the reply slip and send it to the organisers:

Tim Bastow or Steve Stuart
CSIRO Division of Materials Science and Technology,
Locked Bag 33, Clayton, Victoria 3168.
Phone: (03) 542 2777 Fax: (03) 544 1128
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Enquiries
Judith Nikoleiski
Production Manager
Hunter Technology Press
263A Pennant Road
PO Box 189
Jesmond NSW 2299
Phone (049) 62 0911
Fax (049) 60 1137

Advertising
Wayne Thompson
Hunter Technology Press
Phone (049) 62 0911
Fax (049) 60 1137

Editorial Address
Australian Physicist
Department of Physics
University of Newcastle
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Australian Physicist Volume 26, Number 11, November 1989
PRESIDENT'S COLUMN

WE'RE IN A BAD WAY......

It's official! Physics in Australia has had it. According to a mammoth 460-page report by the Australian Science and Technology Council, (ASTEC), tabled in Parliament last month, all basic science is in a pretty bad way. Physics, in particular, is said to be at great risk. It even says so in the cover letter submitting the report to the Prime Minister.

Elsewhere it states: "The situation represents the most parlous state of any of the fields of scientific research in Australia" and ..."over the past ten years the staffing of university physics departments has declined by about 25%, with some falling by 50%." The conclusions are based on carefully researched data such as input of research funds, output of publications, citations and other such performance indicators, as well as interviews with scientists. (Although it must be said that the committee of 16 authors contained not a single physicist and the name of only one could be found among those interviewed. Thus, some of the detailed conclusions may be debated.

This clearly calls for some reply on the part of the profession — a careful, well-thought-out reply, not just a howl of protest saying "what do you expect for peanuts..." and "...we need more money". The Science Policy Committee will, by now, have submitted such a reply to the appropriate quarters. It will, in due course, appear in the Australian Physicist.

That we have been seriously starved of funds for well over a decade and that no significant new research facility has been built here for several decades are well known facts. But have we stopped doing good physics? I maintain that we haven’t, altogether. Quite a few of us have taken our serious research work "offshore" (not unlike some manufacturers who found local conditions equally hostile to new enterprise.) Others have taken themselves, as well as their work, "offshore", or simply didn’t or couldn’t return from overseas and are doing good physics there. Yet another group, a very large one I would guess, simply left basic physics where the hours were long and the pickings were slim and the job prospects dismal, and have moved into various peripheral areas. They are now, if they are still doing research, publishing in journals which may not be classified as physics by the ASTEC report.

All of the above means that there are still quite a few good Australian physicists around but their work is not currently done much for Australian physics, as such. So, when we scream for more money, new large facilities, secure career structures for young scientists, and so on, we should be able to prove that we have the people as well as the ideas to justify such demands. Otherwise, the total collapse of Australian physics will have become a self-fulfilling prophecy.

We must convince the government (if not this one, then the next one) that technology without basic science is doomed to stagnation and, eventually, failure. We must help Barry Jones convince his colleagues that basic research is not, to use his words, some middle-class wank, akin to basket weaving in Balmain. We must convince them that basic physics is the cradle in which new technology is nurtured and physicists are the nurses who make it grow into technology.

There is ample evidence that physicists make excellent technologists and their use in this capacity may even be justified in emergencies such as wars. But to force them into these roles in peacetime is lunacy, tantamount to eating up one's seed corn. Yet, that is what my reading of the ASTEC Report tells me about the present state of affairs. Was this the Button Plan for physics?

Now, please don't get me wrong. If you, solid state physicist colleague, have left solid state physics for materials technology and are enjoying it, good luck to you. And if you, nuclear physicist colleague, went to do hospital physics and are enjoying it, good luck to you too! (All of the new accelerators in Australia are to be found in hospitals, anyway.) But did you have a choice? Or was the giving up of basic research the price of staying in, or returning to, Australia? And wouldn't you, both, prefer to be working on an Australian synchrotron? Or on a modern, upgraded neutron source?

I think that the overall conclusions of the ASTEC Report are painful but, by

Continued on page 255
This issue of the *Australian Physicist* is a departure from our normal offerings. The main content of the issue is intended to bring the journal to the attention of teachers in our secondary schools. There will be a distribution of copies of the issue to high schools and we hope that the effort will kindle an interest amongst teachers in the *Australian Physicist* and the Australian Institute of Physics.

We aim to continue and expand this exercise, with the ultimate goal of material of interest to secondary teachers in every issue. This may be as regular articles or perhaps as an insert. We are therefore, actively seeking the submission of items of interest to those involved in high school physics; i.e., from teachers themselves or from other members of the physics community with some understanding of the needs and resources of secondary schools.

The material we seek can be articles on aspects of physics, particularly those related to the interpretation of fundamentals of the subject. Tips on experiments for physics students which can be set up from the sometimes meagre resources of a secondary school would be very welcome.

Indeed, the *Australian Physicist* is willing to consider a role as a limited supplier of such items (e.g., simple printed circuit boards) to be used in school experiments, if the designs are freely available and we consider the idea behind the experiment is of sufficient merit.

We still seek reviews and this is an ongoing concern. Any review of topics of interest to physicists, written so as to be readily understandable to general physicists, will be of interest and possibly use to school teachers. If we can coax such contributions from our readers, we may also consider introducing a reprint service for schools to allow supply of topical articles to the students themselves.

We do not make these offers in any entrepreneurial way. If we can help the teaching of physics through the journal attempting to reach teachers and secondary students, we will do so. If costs are involved, we will seek to cover these costs. We cannot do it alone. Professional physicists must take on the considerable task of using their expertise in a given topic within physics, to present to others a readable and enjoyable review of the physics involved, the current state of the art, the possible applications and the place of their topic within the development of physics as a discipline.

A brief word on another matter. Our President refers to the ASTEC Profile of Australian Science which was recently released. That volume must be carefully studied. Physics does not do will in terms of ASTEC's assessment of our contributions to world science. Earlier statements from Minister Jones and others about Australia contributing 2% of the world's papers, etc., mean little if those papers are not cited and if the work involved does not attract attention from our international colleagues. All too often of course, the contribution of a group or groups is linked to the reputation of an individual. This means good researchers must be given support if their contributions are to be amongst the best internationally.

The report also raises once more the equipment question. There are many items Australia cannot afford to give to every researcher in a particular area. It would be better to have a few laboratories well equipped with access available for other researchers, than many laboratories all starved for equipment, maintenance and personnel.

R.J. MacDonald
Honorary Editor

and large, accurate. Things are in a bad way but not yet hopeless. In my opinion the directions are clear: Let's start with some serious new money, and not just Maytime rhetoric. Let's go for new national facilities, and for the restoration of basic physics in the CSIRO, ANSTO and other national laboratories so that Australian physicists can have access to first class research facilities, on a competitive basis, here at home where it can benefit Australian students, Australian industry and Australia's scientific culture. Any other ideas? Write to the Editor, or bring them to the Congress in Perth, or both!

Tony Klein
President

Letter to the Prime Minister

The Hon. R.J.L. Hawke, AC MP
Prime Minister
Parliament House
Canberra ACT 2600

Dear Prime Minister,

The ASTEC Report "Profile of Australian Science, 1989", was tabled recently. In it the dramatic weakness of physics in this country is highlighted and, in his covering letter to you, Professor Martin drew your personal attention to this finding.

For example, on p.236 we find:
...world output in physics is growing ten times as fast as ours" while over "the past ten to twelve years the staffing of university physics departments has declined by about 25%, with some falling by 50%.

We view these findings with the gravest concern. There are in Australia a number of physicists whose research is of the highest international standing but who have to take their work "offshore" in order to gain access to competitive facilities. There has not been a single world-class physics research facility built in this country for well over a decade. There exist no secure career structures for young Australian physicists currently overseas. Basic physics in the CSIRO and other government laboratories is being abolished for the sake of short-term gains.

It is not an exaggeration to say that we are approaching a national crisis. Basic physics is the gateway through which new technology enters society. We will have become a third world country when we no longer understand the basic principles which underpin the technology that we buy from abroad.

The Australian Institute of Physics stands ready to advise and be consulted on the long-overdue measures required to remedy the situation. However, there is no point in yet another review, yet another inquiry or yet another set of recommendations unless your government is willing to make a commitment to act on those recommendations.

Mr. Prime Minister, physicists have made outstanding contributions to Australia in times of war and in times of peace. Please give this matter your urgent consideration and advise us how we can be of help again.

Yours sincerely,

Prof. A.G. Klein
President

Prof. A.W. Thomas
Vice-President

Prof. B.H.J. McKellar, F.A.A.
Science Policy Advisor

on behalf of the Science Policy Committee of the Australian Institute of Physics

Australian Physicist Volume 26, Number 11, November 1989 255
A SCALE OF FEES FOR AUSTRALIAN PHYSICISTS

Many Australian physicists—or their employers—have encountered the problem of establishing a fee for a service performed by a physicist for a client. It may be time for the Australian Institute of Physics, as the body concerned with the professional welfare of its member physicists, to establish a recommended scale of fees for such work.

Advantages and Disadvantages

The advantages of a recommended fee scale are numerous:

1. Physicists and their employers will be able to establish a fee-for-service with confidence, knowing the relationship between their quoted charges and the recommended scale;

2. Many physicists, new to the job of establishing the value of their work as a consultant, will be supported in their negotiations for adequate fees by referring clients to the published scales;

3. The existence of a regularly updated scale of fees and associated guidelines will enhance the professional image of physicists;

4. Physicists working in government-funded jobs (government laboratories, universities, etc.) will be able to advise their administrative wings of the recommended fees for their work;

5. Physicists’ professional associations and unions may be able to use the fee scale to support cases involving relativities between professions;

6. A fee scale provides an opportunity for the AIP to develop a code of practice for physicists undertaking work for a fee—this could be of value to those who wish to understand the scope and nature of their legal and ethical responsibilities.

There are a few disadvantages. The AIP Executive would need to concern itself with Trade Practices legislation in the Commonwealth and the States, and it would need to consider the matter of professional ethics. The fee scale would need to be published and revised regularly. Some physicists might be disadvantaged by publication of a fee scale inconsistent with their present fees.

On balance, it is likely that the members of the AIP would be significantly aided by the publication of a state of fees and an associated code of ethics.

Development of a Scale of Fees

The Association of Consulting Engineers Australia (ACEA) publishes Guideline Fee Scales for Consulting Engineering Services. These scales may form a useful basis for considering appropriate fees for physicists, since there are close parallels between the two professions.

Some of the main points in the December 1988 reprinting of the ACEA document are:

1. The scales are guidelines, and consultants and prospective clients are free to negotiate fees on any basis whatsoever.

2. Fees may be established in many different ways, depending on the nature of the job and the character of the client-consultant relation. Some models include:
   • a percentage of the cost of the project;
   • on a time basis (perhaps with a fixed additional fee);
   • a lump sum;
   • a combination of the above.

3. Percentage fee scales are recommended as a function of the cost of the project—larger projects involve a lower percentage.

4. As an example, the scale of charges for a straightforward consultation job charged on a fee-plus-time basis would involve the sum of the following components:
   • Time cost: the sum of the remuneration paid to the physicist and their staff, overheads on these charges, and practice operating overheads;
   • Fee: to cover experience, responsibility and contingencies;
   • Disbursements: including travel, accommodation, test costs, telephone, tele, provision of specialised equipment, and so forth.

Time costs are often estimated by the formula:

\[
\text{cost per hour} = \frac{\text{annual remuneration}}{1950}/f \times f
\]

where \(2.8 \leq f \leq 2.4\). There may be advantages in linking any scale of fees established by the AIP to that of ACEA. Indeed, the Executive may wish to discuss with ACEA the possibility of using their material in developing a fee scale for physicists.

Ethical Matters

When a physicist offers advice of a professional nature, ethical and legal obligations may be implicitly or explicitly involved. Members of the AIP would be substantially advantaged were the Executive to commission a paper or opinion from an expert in these matters, for publication in the Australian Physicist.

The advice of such an expert could also be woven into a recommended Code of Practice for Consulting Physicists. Although ACEA does not become concerned with such codes, the Institutions of Engineers and their many Chapters do publish and enforce strong guidelines and codes, covering such matters as

- the degree of training and experience required to undertake certain tasks,
- the ethics of practicing outside one’s area of specialisation,
- the nature of common and sound practice,
- the value of seeking specialist advice.

Few Australian physicists are presently familiar with the issues involved in defining and maintaining the ethics of a profession. There are, however, increasing numbers of physicists involved in professional consulting work. It is vitally important for the profession that the AIP take steps now to advise members on the scope of possible obligations under common and statutory law, to help ensure that members do not deliberately or inadvertently engage in practices which might tend to give the Institute a bad name, or tend to encumber members with unforeseen litigation.

Summary

It may be timely for the AIP Executive to consider the establishment of a code of ethics and a scale of fees for physicists working in a professional capacity. The practices of the professional bodies of Australian engineers may provide good models, although the advice of a legal expert should also be obtained.

Members of the AIP may wish to comment on my proposals through this journal, or to the National or Branch Committees.

Acknowledgement

I thank Malcolm Castle for raising the matter discussed above, and for discussions regarding the best course to follow in debating the matter among AIP members.

L. Cram
Chairman
NSW Branch

Australian Physicist Volume 26, Number 11, November 1989
No Change of Venue For WAGGA 1990

Contrary to the conclusion of J.F. Dobson (Australian Physicist 26, 186), the next annual Condensed Matter Physics Meeting will be held as usual at Wagga, 6-9 February 1990, in the week following the National Congress in Perth. The meeting is being organised by Tim J. Bastow, CSIRO Materials Science and Technology, Clayton, Victoria.

ACT Branch Student Prizes: 1989 - Recognition of Women in Physics

For some years past it has been the practice of the ACT Branch to present prizes to the previous year's best second-year physics undergraduates at the three tertiary institutions: Australian Defence Force Academy (ADFA), Canberra College of Advanced Education (CCAE) and Australian National University (ANU). In recent years the prizes have been augmented significantly by the presentation from Hewlett-Packard of one of their latest hand-held calculators to each winner. This year HP proposed that an additional prize should be awarded to the second year female physics student judged by a panel representing the three institutions to be the best from among the three. This, therefore, was the inaugural year for presentation of this additional prize. The winners were each presented with the Branch prize of $100 and the Institute prize of a year's student membership by the Branch Chairman, Dr Edwards, and the Hewlett-Packard prize by HP's Mr David Holland.

Before making his presentations, Mr Holland spoke briefly of HP's global activities (75,000 employees, $10B turnover) and its place as the 12th largest Australian exporter. He emphasised that their continued growth in this country will require the recruitment of 800 Australians over the next 7 years. HP expects that a significant proportion of these will be women scientists and therefore the encouragement of Australian women to pursue a career in science is both a contribution to Australian science and an investment in Hewlett-Packard's future in this country.

This year's winners of these four prizes were Christopher Huet (ADFA), Graham O'Neil (CCAE), Tedor Petrov (ANU) and Adrienne Fairhall (ANU).

---

1991 ANTARCTIC EXPEDITIONS

UPPER ATMOSPHERE PHYSICISTS

($44618 to $55124 in Antarctica)

The Antarctic Division invites applications from qualified men and women to participate in the 1991 Australian National Antarctic Research Expeditions (ANARE).

There are several positions available for Physicists to carry out research programs and to operate and maintain observatory equipment. The Physicists will undertake experimental studies in the fields of radio propagation, magnetic pulsations, electric field measurement or photometric observations of the aurora and aurora.

Successful applicants will join the Antarctic Division in Tasmania in July 1990, and leave for Antarctica in about December 1990 for a period of approximately 12 months. On return to Australia expeditions may be required to spend up to 12 months at the Antarctic Division, compiling the results of research undertaken.

Applicants must have a Degree or Diploma in Physics and Mathematics. A good knowledge of FORTRAN programming and familiarity with LSI 11 systems is desirable.

For further information and application forms, please contact the Expedition Recruitment Officer by telephoning 008 030 755, or Dr Gary Burns on (002) 200315.

Applications close on 15 December 1989.

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

Department of the Arts, Sport, the Environment, Tourism & Territories.

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OF INTEREST

VICTORIAN JUNIOR SCIENCE & TECHNOLOGY FESTIVAL

Last year, during the first ANZAAS Junior Science and Technology Festival, over 2000 primary school children participated in half day sessions of hands-on science- and technology-based activities. Following this initial success, it was decided to extend the festival to run over four days this year. Some 4000 students from 80 metropolitan and country schools were allocated to one of two venues (Heidelberg Civic Centre on the 18th and 19th of July for eastern suburbs schools, and Altona Civic Centre on the 25th and 26th July for western suburbs schools). As with last year the festival was very popular and unfortunately about 1500 extra students had to be turned away.

The festival followed the same format as the previous year, where students were encouraged to participate in workshop, discussion and demonstration activities. The program was designed to be educational, enjoyable, and to stimulate interest in science and technology, both at the festival and back in the classroom. Once again, the Victorian branch of the AIP financially supported the festival and ran two activity tables which explored the properties of air.

In addition to the usual festival activities, a 'straw bridge building' competition (sponsored by ANZAAS and Swinburne Institute's Physics Department) was organised as a classroom activity for the weeks leading up to the festival. The task was to build a bridge with the minimum number of plastic straws capable of supporting a 1 kg mass over an uninterrupted span of 28 cm. The most efficient bridge (which used only 8 straws) came from our Lady of Good Counsel Primary School, Deepdene, Melbourne.

The 1989 festival was very well received with positive responses from both the participants and the student teachers from Footscray Institute and Victorian College who managed many of the activities.

Unfortunately, the last day of the festival (in Altona) had to be cancelled due to power restrictions arising from a statewide industrial dispute. In response to the cancellation, a mini-festival (Science Exhibition) sponsored by Footscray Institute's Teacher Education Department, was held on the 25th of October. Over 800 students from the western suburbs attended the exhibition. The success of these science festivals again highlights the need for more science activity in primary school education.

Alex Mazzolini

---

The winning straw bridge entry

Michelle Scalzo and Anthony Quin with the winning straw bridge entry
Let's reflect on the week that was.

**Why is it so?**

Dear Editor,

In our humble research department, five minutes of time for afternoon tea is often barely enough to allow our allotted quantity of stimulant to cool. Sometimes, rather than quietly cogitate fiercely on ways and means of increasing national productivity, we actually break out into open conversation and the exchange of ideas, as in good old BB (Before Brotherhood) days (pre-1984).

Recently the conversation turned quite naturally to what seemed like a very large contribution made by the French to science generally—even disproportionately large—and to physics and mathematics in particular. In five minutes the two of us compiled the following list of distinguished French scientists. We make no promise as to the overall accuracy of country of birth, or errors of commission and omission (more likely). Somewhat in the vein of The Times' 'first cuckoo in Spring', therefore, or 'at home I have a black plastic disc with a hole in its centre—is this a record?'—we ask our Brothers [sic] out there to add to and delete from this list. Moreover, is it true that more polynomials à la principes dé PHYSIQUEs fly the tricolor than any other?

| Legendre | Matthieu | Bessel |
| Jacob | Comu | Laplace |
| Lagrange | Fresnel | Airey |
| Struve | Le Chatelier | Fourier |
| Hermit | Poisson | Poincare |
| Laguerre | Lavoisier | Ampere |
| Peltier | Lissajous | Lande |
| Langevin | de Broglie | Coulomb |
| Biot | Savart | Thieven |
| Galvani | Courant | Fermat |
| Lefevere | Maupertuis | Cartan |
| Pascal | Napier | Cauchy |
| d'Alembert | Bouguer | Laurent |
| Navier | Bonnet | L'Hopital |
| Decante | Boole | Lebange |


Lewis T. Chadderton and Joseph Barbara
Laser Physics Centre
Research Institute for Advanced Studies
Australian National University

**Threlfall, Pollock and Early X-Ray Investigations**

Dear Editor,

Professor H.C. Bolton's work on the Development of Physics in Australia has sparked interest in the particular topic of early X-ray investigation and he has gone to considerable trouble to set the record straight as his recent addenda in the Australian Physicist show (September 1988, p.203 and August 1989, p.192). He has kindly suggested that I write a further postscript concerning the place that Sydney holds in this development.

The easily accessible publication of Threlfall and Pollock On some experiments with Røntgen's X-ray did not appear until December 1896 in the Philosophical Magazine (S5 43, 453-463). What is not widely known is that on April 29th, 1896 Threlfall gave a lengthy address to the University of Sydney Medical Society 'On the Reductions of Lenard and Røntgen', suitably illustrated, which presented the properties of the phenomenon and discussed three rival theories of its nature. After considering the evidence from their investigations the view we now hold was put forward as everything for and nothing against. The full text of this address was published in a medical supplement to Hermes, May 28th 1896, 38-55 (a University of Sydney undergraduate publication).

Threlfall had been alerted by cable of Røntgen's discovery as soon as it became public in Europe. He knew of no evidence that would displace W.D. Miller from his priority in the investigation stakes, but the amount of work that Threlfall and Pollock had already accomplished in the less than three months since the discovery was announced (4th January 1896) does suggest that they proceeded just as promptly as anyone else in the other centres, but as befitting the 'first physicist in Australia' (Home) the investigation had been more thorough.

What emerges from all this historical sleuthing is the acumen with which the scattered and isolated scientific community took up this discovery. Professor Bolton remarks that such an effort was unparalleled until recent times with the advent of high-temperature superconductors.

J.B.T. McCaughan
University of Sydney

**Why Physics?**

Dear Editor,

Charles Lamb, the English essayist, once wrote, "Nothing puzzles me more than time and space; and yet nothing troubles me less, as I never think of them." I dare say the reason I took up physics was that, unlike Lamb, I was always fascinated by time and space, and saw in physics at least a glimmer of an explanation for natural things.

Now that I have spent nearly a lifetime in physics, it is both comforting and depressing to look back over my career.

Comforting, because I can see how my work fits, in however small a corner, into the general body of knowledge that is called science.

Depressing, because so many opportunities to do better were lost, through carelessness, or lack of foresight, or simple incompetence.

In the end, the best memories are of friends and colleagues, who have convinced me that humanity after all is the most vital quality; that love, and life, and sharing of good and bad experiences, are real; that perhaps Lamb was right after all, and one is better off never thinking of time and space...

Now I must get back to the Lab, there is a whole new range of superconductors waiting to be tested. You never know, one of them might be a Nobel prizewinner!

John MacFarlane
CSIRO Division of Applied Physics

**R versus D**

Dear Prof. Klein,

Congratulations on the excellent R versus D analysis from the economic perspective.

Few people appreciate that the level of effort/work involved in D is an "order of magnitude" greater than R.

Not of course, because D is harder, but simply because D has to meet so many external requirements to make a product that will sell and is reliable.

Cutting pure R to fund D does seem nonsense.

It would never fund D properly but would destroy R, which is the seed for D.

The answer to getting value is not trading one for the other but in controlling the quality and efficiency of each.

So often it is not lack of money that is the problem, but the control and quality of the end product, be it R or D. (I would even go so far as to speculate that a lot of high tech R and D in Australia is really D, wherever it’s performed. The D is done in countries like Japan, and it shows.

My latter day experience at Quentron had a lot to do with underestimating the cost of D and the lack of control of the quality of both, hence the disastrous result.

Alex Stanco
Lastek
Adelaide
DO NEW ZEALAND'S UNIVERSITIES FULFIL THEIR ROLE OF PRODUCING PHYSICS TEACHERS?

John Campbell
(Physics Department, University of Canterbury, Christchurch NZ)

Invited Address to the Royal Society of New Zealand's Forum on Science Education
• Wellington 1988 •

Do the universities fulfil their role of producing physics teachers? No!

Firstly, let us define our terms. As any good Minister of the Crown will tell you there is no shortage of science teachers. The so-called shortage is a fallacy. Very few positions are vacant. One is filled by a friend of mine. After an honours degree in zoology she taught for some years before leaving to raise a family. Last year she went to Training College asking to sit in on some courses to update on syllabi. "Sure", they said, "let's have a look at your record. Hullo, you took stage I physics 20 years ago. Great! We're desperate for physics teachers—we need you for that."

So we are not dealing with a shortage of science teachers but a shortage of 'qualified' science teachers, whatever qualified means. Let us look at the 1988 quotas set by the New Zealand Government for recruitment of graduates to train as science teachers.

<table>
<thead>
<tr>
<th>National</th>
<th>Christchurch</th>
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<tbody>
<tr>
<td>Maths</td>
<td>80</td>
</tr>
<tr>
<td>Biology</td>
<td>38</td>
</tr>
<tr>
<td>Chemistry</td>
<td>25</td>
</tr>
<tr>
<td>Physics</td>
<td>10</td>
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</tbody>
</table>

Point 1 By and large the quotas get filled
Point 2 There are few if any problems with biology.
Point 3 80% teach in the quota they enter
Point 4 With so few places available in Christchurch for physics, a fair fraction of physics graduates who apply for teacher training are put in the maths quota.
Point 5 Overall, 40% of graduate applicants for a teaching career are rejected as unsuitable.
Point 6 Fewer are rejected in maths and science.

So what lessons do we have here that are generally overlooked?

Lesson 1 Teaching is the biggest employer of maths/science graduates. The universities must recognise this fact.

Lesson 2 The quotas will always be filled.

Lesson 3 The average quality of a budding science teacher is lower than an arts applicant.

Are the universities fulfilling a role in producing qualified science teachers? No! To understand the reasons we must dissect the university system.

University staff are appointed and promoted on their research skills. Words like 'scholarship' are paramount. Phrases like 'the ability to communicate' enter the considerations in a very minor role, if at all. So universities are vast examples of genetic engineering. Staff clone themselves through the honours and research programs—and look at the progression towards that guaranteed job for life! School, undergrad, research student, 2 year postdoc and bingo—a faculty position. I am one of the few who doesn't fit this mould—I didn't even do a postdoc.

Amongst the many regrettable consequences of this incestuous system is the all-too-common view of academic staff that an average student is someone worth only a 2.1. Too often the BSc graduate is regarded as a failure. Someone not good enough for honours.

To give an example of the consequences of such elitism, some years ago a professor of history at Canterbury imposed extremely high standards in the Master of History program, catering only for the very best academic students. As a consequence, average students opted to do Masters in Geography resulting in a decline in the quality of new history teachers but a marked increase in enthusiastic teachers of geography.

Yet the lifeblood of science should be the BSc degree, a large pool of people going into the community with this first degree and feeling—"Wow I enjoyed that. Isn't science fun/wide-ranging/useful/exciting".

I will consider mainly physics and maths. These are the two subjects I know something about, the two which have the largest shortage of qualified teachers, the two which are most arrogant and elitist and therefore the two which need to change their attitudes the most.

BSc graduates in physics and mathematics too often come out of the system not with a sense of elation and wanting to spread the gospel but they emerge trying to make the decision, "Holy cow, was that a cement lorry or a petrol tanker that hit me?"

The community at large regard physics as elitist/far too hard/not relevant to everyday life. As a physicist I am quite used to the social conversation that goes as follows.

"And what do you do for a crust?"

"I'm a physicist."

"It looks like rain again/I could never understand that/so you're one of the chaps that makes bombs."

The public perception of a scientist is not a favourable one. Think of the television shows. Scientists are too often portrayed as dills; bumblefoots who lack physical coordination, unworlidy and often downright nutters. Also, scientists are the people who kill animals, invent dangerous drugs, scaremonger about the lifetime of the universe and the ozone layer, invent the next generation's weapons of war, and contribute to this generation's nuclear pollution.

A member of the Learning in Science Program at Waikato University did a survey of children's perception of scientists and science teachers. It wasn't favourable. White coat, away with the fairy tales, a wet. A person in charge of recruitment of graduates at a teachers' college told me his overall view of
DO NEW ZEALAND'S UNIVERSITIES FULFIL THEIR ROLE?

applicants in the physical sciences were that far too many were wimps, pebble lenses, remote/distant people.

Rejects from another system.

In the public perception, physicists are about as useful as a third hole in a nostril. We scientists have only ourselves to blame. We don't talk to the public. We don't write for the newspapers. We don't assist teachers to inspire their classes. I analysed the articles in the last ten years editions of the quarterly New Zealand Science Teacher. Not one physicist had written an article to inspire teachers and classes through exciting developments in physics. Not one. What a shocking record for a profession.

There is a purist view of physics and mathematics which is capable of killing two useful subjects. For example, the Working Party of the UK Institute of Physics had this to say, (Phys. Bull. 38, 204, 1987):

If present trends continue, there is real fear that physics will eventually be just an obscure subject concerned with the stars and elementary particles, and the rest of it will be absorbed into engineering.

Alas, this attitude is also prevalent in New Zealand. I have heard many examples of this short-sighted attitude at universities and schools. For example, an extremely good science teacher (a biologist) taught a 4th form physics course through the physics of motorbikes. The class were enthralled and many inspired to take physics at 6th form. To their horror they then found that true physics consisted of difficult equations written on a blackboard.

There are many methods of teaching. In physics we generally use the cork method. We take a student, usually by the throat. Formulæ, jargon and symbols are poured into one ear while a cork is bunged into the other to stop it all flowing straight through. The syllabus from the sixth form up is designed for those few going to a PhD at that particular university. Those who leave to go into the community with a three year BSc have thus been sold short.

In general, all university staff do is complain about the poor quality of students coming forward. They ignore changes that have happened in school, and in maths have been known to fail up to 50% of people in third-year classes. Failure rates for the larger stage II maths classes at the University of Canterbury in 1987 ranged from 21% to 40%.

The following statement is by a physics tutor at Canterbury, someone at the sharp end of university teaching:

Physics is the most difficult optional subject in the university course, students come from school unprepared and very few of them take the trouble to work.

This is a typical statement one often hears. What makes this one of more than passing interest is that the tutor's name was Ernest Rutherford and he said this in 1894—nearly 100 years ago.

Have we still not learnt how to motivate average students?

I say no—the methods of selecting and rewarding university staff are not commensurate with this goal. Our role in schools and universities should be as follows:

- Inspire people to want to learn.
- Teach them how to learn.
- Train them in useful skills.

Too often at university we offer merely the trade training required by a research scientist in that university's fields of specialisation. As Anatole France said:

Do not satisfy your vanity by teaching a great many things. Awaken people's curiosity. It is enough to open minds; do not overload them. Put there just a spark; and if there is some good inflammable stuff, it will catch fire.

What qualities are sought in graduates applying for a career in secondary school teaching? The Teachers' Training Colleges in New Zealand work on a points system in assessing candidates during an interview as follows:

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To fill the quotas in 1988 they accepted totals down to 30 for history but as low as 22 for maths. Under no circumstances will teachers colleges accept someone scoring 20 or less, so some maths trainees are very marginal to say the least. This does not augur well for the future. One bad teacher can do enormous damage.

We must raise the quality and quantity of the maths/science candidates by broadening their experiences and teaching them skills universities usually ignore.

Academic

Andrew Boorde, in the 16th century, summed up the public's view of academic qualifications: A master of Art is not worth a fart.

This section is designed to give Brownie points to those with academic qualifications in shortage areas. Applicants with physics or maths to at least stage II should score well. For the teaching profession we must produce people with a broad-based degree who are confident in their abilities. Too often examinations show our graduates have assimilated only 60% of the syllabus they think they know best. Let's give them a lesser amount but make them good at it. Give them confidence in their abilities.

My feelings are similar to Geoffrey Howson of Southampton University who proposed for 7th form maths a new syllabus covering 80% of the present one. A pass would give a C grade representing "mathematical competence and confidence on a limited but secure foundation" rather than 'a very insecure grasp of an over-taxing syllabus'. Too often our examining is designed to rank the top few for scholarships rather than check the many for competence.

Background

The Teacher's College divide this into two:

- Experience. Background of experience, employment, voluntary work.
- Involvement. Cultural, sporting, social, welfare, multicultural.

They are looking for coaches for sports teams, people who have mixed with all classes of society, people who understand other races, and who have been around and thus better able to advise students on all manner of life's problems.

Australian Physicist Volume 26, Number 11, November 1989
Welcome to the CSIRO Science Education Centre.

Seven years ago, CSIRO opened a single Science Education Centre in Melbourne. The Centre was aimed at providing a stimulating science experience for school students while demonstrating the real and applied side of the science that they learned in school.

The Centre was such a great success that CSIRO decided to open Science Education Centres in other capital cities and now there is a network of Centres operating in Adelaide, Brisbane, Hobart, Sydney and Melbourne. Darwin and Perth should be up and running very soon. Besides providing a unique service to the school system, the Science Education Centres provide the operational base to CSIRO’s Double Helix Science Club.

One feature which distinguishes CSIRO’s Science Education Centres from other science centres like Scitech and the NSTC is that the Science Education Centres are specifically targeted at school groups and school students. Visiting groups need to book first and students are given preparation material before the visit, experiments to perform while actually at the Centre and follow-up work to consider after their trip. While this makes a visit to the Centre a highly educational as well as an interesting experience, it also means that the general public rarely get to see what happens in the Centres because their time is exclusively devoted to school groups.

CSIRO Science Education Centres: Australian Science Australia Wide

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<tr>
<th>State</th>
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<tr>
<td>NSW</td>
<td>Janele Griffin</td>
<td>(02) 413 7532</td>
</tr>
<tr>
<td></td>
<td>CSIRO TAFE Science Centre</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PO Box 216, Lindfield, NSW 2070</td>
<td></td>
</tr>
<tr>
<td>Vic</td>
<td>Pat Naughtin</td>
<td>(03) 956 2396</td>
</tr>
<tr>
<td></td>
<td>CSIRO Science Education Centre</td>
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<tr>
<td></td>
<td>PO Box 56, Highett, Vic. 3190</td>
<td></td>
</tr>
<tr>
<td>Tas</td>
<td>Darrel Harington</td>
<td>(002) 30 7889</td>
</tr>
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<td>CSIRO Science Education Centre</td>
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<tr>
<td></td>
<td>PO Box 256, Nth Hobart, Tas. 7002</td>
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</tbody>
</table>

SA - Phil Allan
(08) 268 0125
CSIRO Science Education Centre
PO Box 4, Woodville, SA 5011

WA - Robert Nampatis
(08) 481 6285
CSIRO Science Education Centre
PO Box 155, West Perth, WA 6005

NI - Terry McCaffery
(09) 22 1706
CSIRO Science Education Centre
PMB 44, Winnellie, NT 7089

Qld - David Maynard
(07) 377 0860
CSIRO Science Education Centre
PMB 3, Indooroopilly, Qld 4068

In physics we must show our BSc graduates physics in the community by taking them on visits to the Medical Physics Department of the local hospital, the Wool Research Organisation, the Meteorological Service, etc. We should give them training in organisational skills, for example in running undergraduate seminars and class dinners.

Communication

- Command of spoken and written language.
- Fluency.
- Quality of speech, clarity, flexibility, knowledge of another language.

In maths and physics we seldom give undergraduates practice in these skills. Look at a typical exam paper. Seldom do we ask students to string a couple of words together. We must. It is only in the last 5 years that we have given training in essay writing at Canterbury, and that only after I had read an American article on how to do it. Physics in everyday life is not writing down mathematical derivations of formulae. It’s verbally answering questions such as:

"Mum, why are there colours in soap bubbles?"

"If the moon goes around the earth once a day, why are there two tides a day?"

We must train our undergraduates in the art of answering such everyday questions clearly and concisely and pitched at the level of understanding of the questioner.

Personal Attributes

Note that quite rightly most weight is given to this section. Listed are confidence, sense of humour, maturity, social skills, adaptability, industry, self-assertion, initiative, reliability, integrity, emotional stability, health, general appearance and manner. All are qualities we ourselves would demand of our children’s teachers. Enhancing these attributes in our undergraduates is an investment in the future health of science education.

What of the Future?

The health of a branch of science is dependent not on the quality of esoteric research done at our universities but on the quality of the school teachers we put in front of pupils. The sooner universities learn this lesson, the sooner we will have an abundance of well-qualified, enthusiastic teachers in our schools.

A district senior inspector told me of a head of a university physics department who stated bluntly "I am not interested in producing teachers". That attitude is not only arrogant, it is stupid. Look after the undergraduates and research will look after itself.

Our school children are suffering. If we do not produce the teachers, who will? The Picot report places teachers colleges as faculties of education inside universities. If we do not change our attitudes, a science teacher of the future could be a
BEd graduate with a unit or two in science. In New Zealand the teachers' colleges regard second year university level as quite sufficient to teach to 7th form.

Earlier this year I was in Australia. Teachers there train in colleges of advanced education. Australia has no physics teachers. They only have science teachers. All do Stage I in three of math, chem, biology and physics and major in one of these. But the Stage I course is regarded as sufficient training to teach to form 7. In the whole of NSW, just two science teachers have physics degrees. Their problem is much worse than ours. Just to drop names, I was chatting to the Australian Minister of Science, Barry Jones, who told me "You know, Australia needs NZ. When I am talking to industrialists and people involved in science-based industries I can point to NZ and say — look, if we don't pull finger we will end up like them." Let me turn that around, point my finger west at the crisis in science teaching in parts of Australia and say to you "Look — unless we pull finger we will end up like them". Charles Dickens summed up defective teaching in the preface to Nicholas Nickleby: We hear sometimes of an action for damages against the unqualified medical practitioner, who has deformed a broken limb in pretending to heal it. But what of the hundreds of thousands of minds that have been deformed forever by the incapable petitfoggers who have pretended to form them!

The lack of enthusiastic and qualified teachers of mathematics and physical sciences at schools is not a school's problem. It is a university problem. It is a problem the universities ignore to their peril.

Editorial Comment

The Australian Institute of Physics has been concerned about the problem of teaching qualifications for teaching of physics for some time. The AIP has advised state education authorities that in the opinion of the Institute, no teacher should teach physics in the later years of schooling with less than two years of full tertiary level physics as background. In NSW a teacher is considered qualified to take physics at the Year 11 or 12 level, if they have only one year tertiary level subject given by the department of physics in a tertiary institution. Similar rules apply in other states.

"It's a pet theory of mine".

EDUCATION

WHAT'S IN A PHYSICS COURSE?

R.J. Macdonald

There has been a lot of comment lately on what should be taught in a physics course. There are many points of view on this — the student's, the teacher's or lecturer's, the employer's; but sometimes this presents a difference of viewpoint which is difficult to resolve. To give an example, we contrast below a point of view expressed in New Scientist in May, 1985, with the results of the survey conducted by the Institute of Physics in England which we reported on last month.

New Scientist, May 1985
(written by Christine Sutton):

"Physics has a tough time in the world at large, being regarded as dull, difficult, or down right obscure. But most scientists acknowledge the basic role that it plays in many subjects, from animal physiology (how kangaroos jump) to aeronautics (how 747's stay up in the air). Moreover, many students decide to study physics at university, though not, perhaps, as many as the physics departments, or even the government, would like. So, given the general horror of the subject, why do people choose to study it?

I generally claim that I took up physics because my father advised me not to, but this probably says far more about father-daughter relationships and Yorkshire stubbornness than it does about the teaching of physics in schools. On the other hand, I recall that I found physics dull, difficult and down right obscure until about half-way through the sixth form, when I discovered "wave-particle duality". Now, this was difficult and certainly obscure, but, my goodness, it was exciting!"

A survey published recently in the Institute of Physics' Physics Bulletin (vol 36, p 168) shows that my experience was fairly typical, at least of physics students now at university. The survey, conducted by Peter Kalmus, professor of physics at Queen Mary College, London, reveals the major influences on students who entered physics departments in the autumn of 1984. Kalmus sent a multiple-choice questionnaire to 3500 first-year students in 53 colleges and universities in Britain, asking two main questions:
what influences stimulated your interest in physics; and what three topics (in order) influenced you most in choosing the subject? In each case, the questionnaire offered items for the students to tick, but it left room for them to list additional items. The 11 stimuli listed in the questionnaire included teachers, parents, TV and magazines; the 14 topics ranged from relativity and gravitation, to optics, to computing. A total of 2354 students, from 45 departments, replied.

The results of the survey indicate that important influences on students of physics are school classes, books (other than text books), TV and magazines. But first come the teachers, despite claims that the teaching of physics in schools is often not of a high standard because of a dearth of people with appropriate qualifications. It is surprising, too, to see TV rank highly, when physics, with the exception of astronomy, gets so little coverage.

The answers to Kalmus's second question are equally intriguing. They indicate that the subject category with by far the most influence on students is relativity and gravity, the keywords being spacetime, $E=mc^2$, black holes and twin paradox. Not far behind come astronomy, elementary particles, the nucleus and quantum theory ('wave-particle duality'). The message, then, is clear: It is the fundamental aspects of physics that attract students. With the notable exception of electronics, 'applied' topics, such as medical physics, chemical physics and energy resources, come well down in the pecking order.

All of which leads me to a couple of personal observations. First, I am surprised that medical and biological physics should have come bottom of the list of influences among the students who replied to the survey. Had I not pursued research in particle physics, I think these subjects would have run a close second. After all, they are not totally unrelated, as many of the techniques developed in particle physics have been adapted for medical use, from the cyclotron to high-resolution gamma-ray 'cameras'. The implication is that, while at school, students do not encounter the role that physics plays in the medical sciences. If the results of the first part of the first survey are correct, this would seem to be the fault of teachers, TV and magazines.

Secondly, it is remarkable that fundamental concepts should prove to be such an attraction, especially when these are just the areas of research that the Science and Engineering Research Council, under financial pressures, would seek to curtail. The powers that be should take note." End quote.

The Institute of Physics survey was of some 500 firms and the survey sought opinion both on what should be taught, at least in a university level course, and on the numbers of physicists likely to be needed by industry over the next few years.

The latter indicated that industry in the United Kingdom would take all the first degree students which were likely to be provided as well as having a need for substantially more Masters and PhD graduates than were likely to be available. When it came to the area of speciality of the higher degree graduates, however, the universities were over-supplying some areas, while significantly under-supplying others. The areas of over-supply were more identifiable with the fundamental aspects of physics in the New Scientist article above; The areas of under-supply were the applied areas of image analysis, solid state electronics, etc. It seems that what turns students 'on' might not be what will get them jobs.

We must not rush in and compensate for what seems to be, from the industry point of view, wrong areas of emphasis in the teaching, while at the same time we should not cut the fundamentals from our courses in favour of all the current 'hot-shot' areas of technology. Physics is a subject in which it is often not easy to differentiate between 'basic' and 'applied'—it is a subject in which a very strong foundation of basic physics (apparently what the students want) is necessary to a complete assimilation of the potentials for applied work (which is what the employers apparently want).

A sensible balance in courses between basic and applied topics would seem to be called for at both the undergraduate and postgraduate level. In particular, the postgraduate course must be seen to be more a training/teaching experience, using a particular topic with a subject area in physics as the exercise, rather than a training for a career as a physicist in a very limited subsection of the whole subject. Both students and employers must be coached to be users of the training given, and not rely so specifically on the research field used for that training.
EDUCATION

INTRODUCTION...
During the last ten years a unique educational facility has materialised in Australia. In 1980, Australia's first hands-on science centre - Questacon - was established in Canberra under the auspices of the Australian National University. Its appeal was immediate and universal, and people of all ages were captured by what it offered.

From humble beginnings, Questacon expanded rapidly and its influence was soon felt right across Australia, eventually resulting in the establishment of the National Science and Technology Centre.

IN THE BEGINNING....
The dream that materialised via Questacon into Australia's National Science and Technology Centre began in San Francisco one mid-December day back in 1975. Questacon was established under the auspices of the Australian National University, and was modelled on the Exploratorium in San Francisco. Questacon opened in Canberra in September 1980 and its subsequent success resulted in the Federal Government's decision to establish the National Science and Technology Centre (NSTC) which late in 1988 took over Questacon from the care of the Australian National University.

QUESTACON
THE NATIONAL SCIENCE & TECHNOLOGY CENTRE

It is for this reason that the NSTC's logo is a Q combined with the word Questacon and indeed many people continue to refer to the new institution as Questacon. The new centre, like its predecessor, is a veritable Aladdin's cave, filled with a vast range of equipment with which visitors can perform simple experiments. It is a hugely fascinating and totally absorbing place - and a three-hour visit does little to quench the thirst for 'doing things' that its atmosphere creates for its visitors.

Questacon/NSTC goes far out and beyond the set 'experiments' that are possible with glass-cased exhibits operated using push buttons and cranking handles. Rather it contains a series of 'props', with which visitors could ask the question, "What if", and then immediately carry out an experiment of discovery.

Originally Questacon was located in an old primary school in the inner Canberra suburb of Ainslie, but since its opening in November 1988 by the Prime Minister Bob Hawke, it is located in resplendent new quarters between the National Library and the High Court on the shores of Lake Burley Griffin.

Questacon established a team of people known as Explainers who helped run the centre in a friendly and informal way. The NSTC not only took over Questacon in 1988 but it also took over the Explainers. There are many who assert that Questacon Explainers are equally as important as the interactive exhibits in the vitally important task of promoting science to the public.

THE QUESTACON/NSTC BUILDING....
The building contains five exhibition galleries, a 220-seat lecture hall, workshop for the construction and maintenance of exhibits, a science shop and cafeteria.

The building is located in Canberra's Parliamentary triangle only a short distance from the new and old Parliament Houses. It stands on the shores of Lake Burley Griffin in close proximity to the National Library of Australia, the High Court and the Australian National Gallery. It is an ideal area for a school excursion to the National Capital.

WHAT DOES QUESTACON/NSTC CONTAIN....
The Centre specialises in exhibits with which visitors can interact. One of the five galleries contains the IBM Mathematica exhibition. Approximately 20 exhibits deal with a range of topics including mathematical shapes like catenaries, cycloids, paraboloids and ellipsoids, topology, rotational mechanics, binary notation, and the conservation of momentum and kinetic energy.

Up to the end of May 1989 a second gallery contained eight robotic dinosaurs, but as part of the Centre's policy of moving its exhibitions all over Australia, these fascinating beasts travelled to Brisbane to go on display in the Queensland Museum in July 1989. The dinosaurs were replaced by the ICI Microcosm exhibition. This comprises fourteen interactive microscopes. Each unit has a colour television camera attached to its eyepiece and the image is displayed on a large high-resolution television monitor. Using a joystick control, visitors are able to 'move' about the slide and it is also possible to adjust the magnification.

Each microscope unit is equipped with eight slides which the visitor can change and it is also possible to obtain the colour printout of the image on the TV on demand.

A third gallery contains interactive exhibits centred on the theme of Forces. These include electric, magnetic, fluid dynamic and gravitational forces. A very impressive moving electrical arc, known as Jacob's Ladder is the central feature of this gallery, and this will shortly be joined by another dramatic electrical discharge exhibit in the form of a Tesla Coil. To add to the excitement this gallery also contains an hydraulically driven >
vibrating platform which allows visitors to experience a simulated earthquake.

Gallery five contains interactive exhibits dealing with wave motion. There are over twenty exhibits in this area dealing with sound and electromagnetic radiation. Exhibits in this gallery are some of the very popular ones from the old Questacon. They include colour mixing, where visitors can investigate the primary colours and gain an understanding of the difference between additive and subtractive colour mixing. The original monograph that has proved so popular with thousands of schoolchildren over the eight years Questacon ran in the old Anslo School in Canberra is now creating its spellbinding patterns in the wave motion gallery.

AIMS OF QUESTACON/NSTC

The Centre is working to become a very powerful vehicle aimed at influencing the public's perception of science and technology.

Its particular role is to provide entertaining and instructive ways of introducing the public, especially young people, to scientific concepts through the medium of interactive exhibits. Questacon's philosophy is to show the relevance of scientific concepts by illustrating how they are used in everyday situations. The new Centre will provide a unique science laboratory where people of all ages can experience the human experience that is science, and gain some feeling of the excitement and thrill of discovery.

The interactive science centre provides an excellent way of presenting basic scientific facts in a way that makes the transfer of information an enjoyable experience. Its director, Dr Gore, tells of a bumper sticker he once saw, which succinctly sums up the basic message of the National Science and Technology Centre/Questacon—Science is FUNdamental.

HOW TO BOOK A SCHOOL VISIT TO THE QUESTACON/NSTC

It is essential to make a booking for a school group because the number of groups allowed in the building at any one time is limited, and the new Centre is proving even more popular than the original prototype.

The Centre is open daily from 10 am to 5 pm. Admission is $2.50 for schoolchildren; teachers free of charge; and accompanying parents $2.50.

School group bookings can be made by contacting the Booking Officer on (062) 702 893.
The story of the blind man

In the physics classes I teach, we begin the year studying optics. On the first day of class, before any materials are passed out or procedures discussed, I do the following activity.

I tell the class I am a member of a blind society. I have never seen nor have I met anyone who has sight. The class has stumbled upon this society, and since they keep talking about seeing and light, the society is accusing them of witchcraft. The class is on trial and, in order to prove themselves not guilty of witchcraft, they must answer the question “What is light?”.

After describing this situation, the students are permitted to give testimony in their defense. As students attempt to answer this question, they soon realize that it is not as easy as they originally thought. After a few false starts, students begin to make comments like the following:

- Light is emitted from some objects (e.g., sun, fire, etc.)
- When light lands on your bare skin, it feels warm.
- Light can travel from one point in space to another.
- Light can bounce off objects.

1. Light is detected by the orbs on their head.
2. Light is like sound.

During the discussion the teacher must remember to play the role of a member of the blind society. In particular avoid telling students they are right or wrong. It is better to let students point out unclear remarks made by their classmates. The teacher must also be patient, and give students time to think about how to answer the question.

At the conclusion of the discussion, I suggest to students that it is premature to try to answer the question. “What is light?” Instead, as the students have naturally done in their testimony, it is better science to ask the question, “How does light behave?”.

As the first assignment, I ask students to find the definition of light in a dictionary, and to comment on how this definition would be received in the blind society. Students now will realise that the dictionary definition of light amounts to Light is Light!

This activity lays the groundwork for several ideas and procedures that will be part of the physics course:

1. The difference between an operational definition and a conceptual definition.
2. Prepares class to begin a unit where they experimentally investigate the properties of light.
3. The answer to the question, “What is Light?” will be discussed again when the class is ready to consider the particle and wave model of light. In fact as students answer this question they are actually building a scientific model.
4. Knowing a definition does not imply understanding.
5. This activity prepares the students for a discussion approach that will be used when many topics are introduced in class. Research shows that a student’s understanding and ability to solve problems are enhanced when the student can describe the situation or phenomena in his or her own words.

Reprinted from Physics Teacher, Sept 1989

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Newport's 1989/90 Catalogue of Precision Laser/Optics products is now available. This indispensable laboratory reference includes extensive tutorial and applications notes and many new products:

- Optical Isolators
- All Stainless-Steel Stages
- Laboratory Automation Software
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- Bragg Cells
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Student: “I memorised the formula relating star distance to its apparent and absolute magnitudes, but I don’t see what it means. Isn’t there an easier way to understand what’s happening, and why?”

When teaching the Astronomy elective for the NSW HSC Physics examination, it has been my experience that the typical student question, above, shows a lack of understanding of the basics of Astronomy. Without these, there can be no appreciation of the H-R Diagram, nor of the stellar evolution.

I present here a typical revision session in narrative form, involving student questions (ST) and teacher responses (T).

The hope is that teachers of this elective will find some new ideas.

T: I use a system of approximations for magnitudes. This enables me to estimate a star’s distance from us, knowing its apparent and absolute magnitudes, in a matter of seconds.

When I apply the distance formula: \( M = m - 5 \log_{10} (D/10) \)

I already know the approximate answer, so it ensures that I don’t make a fearsome ‘button error’ on my calculator.

ST: That’s not the distance formula I memorised.

T: There are four or five different ways of writing the same equation. That’s simply the one I remember. Remember also that D is given in parsecs, and not in light years or kilometres.

Now, you recall that apparent mags are a way of comparing star brightnesses. Many centuries ago, the Greeks labelled the brightest stars Mag.1, and the dimmest ones Mag.6.

ST: Is that only for stars viewed with the naked eye? What about when you use binoculars or a telescope? Does that change a star’s magnitude?

T: No. It doesn’t change the relative magnitude. Apparent magnitudes give us a system for comparing star brightnesses as seen from Earth. A telescope simply collects more light, because it is wider than the eye’s pupil. We can then see stars which are dimmer than Mag.6, which is roughly the limit of the faintest star that can be seen with the naked eye.

ST: How many stars can we see without optical aids?

T: At most, about three thousand.

ST: Last night I counted nine stars from my backyard.

T: Was there a full moon?

ST: Yes.

T: Could you see a lot of city lights from your backyard?

ST: Yes.

T: These are two major sources of light pollution in the night sky, that swamp most of the naked-eye stars. When you’re out in the bush away from cities, or even small towns, and there’s no moon, then you’ll be able to see your three thousand stars.

Back to magnitudes. Last century, with the development of photography, it was clear that those bright stars labelled by the Greeks as Mag.1 were close to 100 times brighter than the faint Mag.6 stars. It was decided that five mags difference in brightness corresponded exactly to 100 times difference in brightness. You can take that as a definition.

Because of the way the eye ‘sees’ light, each Mag. is the fifth root of one hundred times brighter or dimmer than the next. This is a 2.511886432 times difference in brightness. Two Mags. is one hundred to the power two fifth, or 6.309573445 times difference in brightness. Thus five Mags. is one hundred to the power five fifths, or exactly a one hundred times difference in brightness."

ST: That’s logarithmic change, isn’t it?

T: Yes. You can compare it with human hearing and the decibel scale. Now, I use the approximations as follows for magnitude differences. Let me write them on the board for you:

<table>
<thead>
<tr>
<th>Mags.</th>
<th>Brightness difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.5×</td>
</tr>
<tr>
<td>2</td>
<td>6.25×</td>
</tr>
<tr>
<td>3</td>
<td>16×</td>
</tr>
<tr>
<td>4</td>
<td>40×</td>
</tr>
<tr>
<td>5</td>
<td>100× (exact)</td>
</tr>
</tbody>
</table>

ST: What about stars that are more than five magnitudes apart in brightness? For example, if one star is Mag.4 and one is Mag.12, how many times is one brighter than the other?

T: Because the number of magnitudes corresponds to logarithms, then adding Mags. means multiplying the brightness difference. The Mag.4 star is eight mags brighter than the Mag.12 star. Eight mags is five plus three, which corresponds to 100 times 16 in brightness difference. So Mag.4 is sixteen hundred times brighter than Mag.12. This is approximate, but I’ll show you when we deal with absolute mags and distance that it gives remarkably close estimates. The answer using a calculator for eight mags is 1584.893192 times brighter or dimmer.

That reminds me of a question in a Cambridge University Entrance Exam Physics Paper some years ago. It asked: How many times brighter is the sun than the full moon?

Fortunately, the student I had taught for this exam had remembered that the apparent mag. of the sun is between minus 26 and minus 27, and for the full moon is between minus 12 and minus 13. This makes the sun about 14 mags brighter. Fourteen mags is 5×5+4, which corresponds to 100×100×40, or approximately 400,000 times brighter than the full moon.

That’s a fairly hard question if you haven’t studied apparent magnitudes!

ST: How can you have negative magnitudes? What do they mean?

T: The Greeks’ listing of mags grouped all the brightest objects as first magnitude. Many stars however (and some planets, the sun and full moon), are brighter than the stars we label as Mag.1. Mag. zero is two and a half times, or one mag., brighter than Mag.1. One mag. brighter than this would be Mag.–1, another mag. brighter would be Mag.–2 and so forth. >
ST: About relative magnitudes. Does it mean that a star of Mag.3 will still be Mag.3 when seen through a telescope or binoculars?

T: Yes. Through a telescope it will appear brighter than a naked-eye view, because we are focussing more light, from a larger lens area, to make the star image. But so will all the other stars appear brighter.

ST: How can we tell which are the brighter stars on a photograph?

T: The brighter stars appear as bigger spots on the photograph.

ST: I tried to get a photo of star spots but it finished up as a lot of lines. Why did this happen?

T: You must have used time exposure, and you got what are called star-trails. These are caused by the rotation of the earth around its polar axis. The stars, except for the sun, are so far away that they seem to stay in the same positions relative to each other from one year to the next. As you stand in your backyard looking at the sky, you are rotating with the earth around its north-south pole rotation axis. This is why stars appear to rise from the east and set in the west. The same thing happens with the sun, our nearest star, all because the earth rotates into the east.

When you open the shutter of your camera at night, let’s say it’s fixed on a tripod and pointed towards a certain star, the earth’s rotation sweeps your camera across the sky and each star appears to move.

ST: How can the big telescopes produce point-star images like the ones in all the glossy textbooks?

T: By rotating the camera at the same rate as the earth is spinning, but in the opposite direction, so as to track the star - one full circle of the sky every day. Most larger telescopes have an accurate motor rotation system on them to do this. It’s called sidereal drive. This counters the rotation of the earth.

ST: But how can you tell from a photo how many mags. one star is brighter than the next?

T: By comparing a pair of photos of the same stars taken with different exposure times. Here’s an example:

In photograph 1 the camera shutter was open for one minute. In photograph two of the same two stars the shutter was open for one hundred minutes. Star B is brighter than star A because it appears as a bigger spot relative to A on the same photograph. We already know star B is, say, Mag.4. We then measure the spots. We find star A after a one hundred minute exposure is the same size as star B was after a one minute exposure. This means that star B is one hundred times brighter than star A, or 5 mags brighter. Star A is therefore Mag.9.

A similar process is applied electronically to all the millions of stars that have been photographed, and computers produce apparent mags for each star, usually to two decimal places of a magnitude.

ST: Do you mean that Star B is five mags brighter than star A, whether you look at photograph 1 or 2?

T: That’s right. They always have the same relative brightness, which is independent of the method of observation, whether it is naked eye, binoculars, telescope or different time-exposure photographs.

ST: From these photos can we say that star B is bigger than star A?

T: Perhaps. If they are the same size and brightness, intrinsically, then B would have to be closer to us than A.

ST: What does ‘intrinsically’ mean?

T: An intrinsic property of a star is a feature of its physical character; for example, its mass, size, surface temperature and chemical composition. None of these properties are affected by the star’s distance from the earth.

ST: Is brightness an intrinsic property of a star?

T: Absolute brightness, or absolute magnitude, is an intrinsic property of a star. So far we have talked about apparent magnitude which is the brightness of a star as seen from earth, no matter how far that star is from us. It might be a large, hot, intrinsically bright star which is very far from earth, thus appearing as a dim star in the night sky. Apparent brightness, or apparent magnitude, is not an intrinsic stellar property.

In the previous photos star A could be a very bright giant star and star B could be a dim dwarf star. If this were the case, star >
A would have to be much further from us than B, making B appear the brighter of the two. Apparent magnitudes do not give us information about intrinsic stellar properties.

ST: What is absolute magnitude?

T: Absolute magnitudes give the brightness of stars as if they were all the same distance from earth. We can compare the stars to see which ones are intrinsically very bright and which are intrinsically very dim. This fixed distance from earth was chosen to be ten parsecs.

ST: What's a parsec?

T: It's equal to about three and a quarter light years and we define it by using the concept of parallax. Each year the earth orbits the sun which means that as the year goes by we see the stars from a slightly different point in space. Over a three month period we move a quarter of our orbit around the sun. This means that we are in a different position in space from where we were three months earlier. When we observe stars on evenings three months apart, some stars will appear to have moved relative to others. This is called parallax shift and we can illustrate this principle by doing a simple experiment.

Position your index finger vertically at arm's length in front of your face and level with your eyes. Close your left eye and line up the index finger with a fixed vertical line on a distant object, such as a far wall or a tree trunk. Without moving your index finger open your left eye and close your right. Your index finger appears to move to the right of the distant object - this is its parallax shift. Repeat this experiment with your index finger closer to your face, and the parallax shift will be greater. You can estimate the angle of the parallax shift for each index finger distance. You should find a parallax shift of between thirty and sixty degrees, when your index finger is actually touching your nose.

A distant tree trunk will have a small parallax shift against the far distant hills on the horizon when viewed with each eye separately.

Now, consider the earth's positions in space three months away from each other as two different viewing points (points A and B in the diagram).

The average radius of our solar orbit is one astronomical unit (1 A.U.) and is approximately 150 million km.

Even the closest stars are so distant from the earth that a straight line from point A to the star will be nearly parallel to a straight line from B to the star, and the parallax shift will be very tiny. A photograph of star S taken in, say, June when the earth is at position A in its orbit shows it to be close to star X. A photograph of the same four stars taken in September when the earth is at position B in its orbit shows star S to be close to star Z. Stars X, Y and Z are so far distant that they show no parallax shift relative to each other through the year.

Let's look at the geometry of the situation of these four stars. AC is perpendicular to BS and equals one solar orbit radius, or 150 million km (Because A to C equals Sun to B).

The angle ASB is the parallax angle of the star S. It is equal to the angle through which S moves in the previous photographs of X, Y, Z and S taken in June and September.

This can be measured on photographs because the angular diameter of the photos can be calculated from the focal lengths of the optical systems used.

We define the distance AS as one parsec when the parallax angle of star S is equal to one second of arc.

There are 3600 seconds of arc to one degree, (or 60 seconds of arc in one minute, $60^\circ = 1'$, and sixty minutes of arc in one degree, $60' = 1''$).

You have no doubt realized that parsec comes from parallax of one second.

From trigonometry,

\[
\sin P = \frac{AC}{AS}
\]

therefore, \(\sin 1'' = \sin (0.0002777777^\circ)\)

\[
= 0.000004848
\]

\[
= \frac{1}{206,265}
\]

\[
= 150 \text{ million km }/ \text{ parsec}
\]

therefore, 1 parsec = 206,265 x 150 million km

= 206,265 A.U.
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The largest parallax angle known is $0.785$ (you say it as 0.785 arc seconds, which means seconds of angle. This makes it clearly different from seconds of time).

This is for the star Proxima Centauri, the closest star to our sun. Knowing its parallax angle we can work out its distance from us.

If the distance to star S were doubled so that
$\text{AS} = 2$ parsecs (2pc is the unit abbreviation) then: $\sin q = 150 \text{ million km}/2\text{pc}$ where $q$ is the new parallax angle

$$= \frac{1}{2} \times 206,265$$

This gives $q = 1/2''$ for $D = 2pc$

You can show that when $p = 1/3''$ then $D = 3pc$ and when $p = 1/4''$ then $D = 4pc$ hence the general formula:

$$D = \frac{1}{p}$$

with $D$ in parsecs and $p$ in arc seconds.

Thus, the distance to Proxima Centauri is $1.0/0.785 = 1.274pc$.

**ST:** I'm beginning to understand now. In maths we were told that for small angles, the tangent and the sine are approximately the same. I've just gone through the parsec definition using tan $p$ instead of $\sin p$ and it works! Because $P$ is so small, the distances $AS$ and $CS$ are virtually the same so $\sin p$ must equal $\tan p$.

**T:** Well done!

**ST:** Well why did you give us that detailed derivation instead of the simple definition, one parsec equals 206,265 A.U.?

**T:** To help you understand the limitations of the parallax method.

**ST:** Can we measure the distance to all stars using the method of parallax?

**T:** No. Only the closest ones. The best telescopes in the world can give a precision of $0.003$ of arc with repeated measurements. If we measure a star at $0.010$ then the error is considerable. Its distance falls within:

$$D = 1/0.007 = 143pc$$

and $1/0.017 = 77pc$

The most probable value is $1/0.010 = 100pc$, so the error could be up to $23\%$ below this or up to $43\%$ above this. This variation is too large to be useful. We are therefore restricted to stars within about thirty parsecs of our earth for the parallax method to give a reliable distance measure.

**ST:** How many stars are there within thirty parsecs of the earth?

**T:** Approximately two thousand. This is not many when you think that in our galaxy alone there are about one hundred thousand million stars.

**ST:** How far apart are the stars?

**T:** We can work out from the fact that there are about two thousand stars within about $30$ parsecs of us. Imagine the sphere of space around us, radius $30$ parsec. If we assume that the two thousand stars are evenly spaced between each other then the average density of stars close to us is:

$$\text{density} = \frac{2000 \text{ stars}}{4/3\pi \times (30\text{pc})^3} = 0.01768 \text{ stars per cubic parsec}$$

We can express our answer as $17.68$ stars per one thousand cubic parsecs. Now, one thousand cubic parsecs can be thought of as a cube of space with each side of length ten parsecs.

To give $17.68$ stars in this entire volume we would need the cube-root of $17.68$, or about $2.6$ stars along each side of length ten parsecs. Thus the distance between each one would be $10/2.6$ which is approximately $3.8pc$.

We have assumed stars to be evenly spread which is not the case in space. More than $50\%$ of stars are members of binary or multiple star systems, held quite closely together by gravitational forces. However, it does give you a rough idea of the emptiness of space.

**ST:** Do I use parsecs or light years for astronomical distances?

**T:** Parsecs are the accepted standard units nowadays.

**ST:** How does all this help us to understand the distance formula?

**T:** Some types of stars seem to have the same absolute magnitude no matter in which part of the galaxy they are found. Cepheid variables are an example (most of them having an absolute magnitude of -3 to -5). If we can identify the type of star and thus make an estimate of its absolute magnitude then we can get its apparent magnitude from a photograph, as described earlier, and use the formula to find its distance.

Let me give you an example using the approximations for magnitudes and brightness ratios. Once you understand this method you should be able to check your calculator answer in a matter of seconds.

Absolute mag is denoted $M$, and apparent mag is $m$.

If a star has $M = 8$ and $M = 5$ then its distance, $d$, must be greater than ten parsecs. This is because it is three magnitudes, or $16x$, dimmer at $d$ than at ten parsecs.

Light spreads out in straight lines so if you double your distance from a light source, it becomes four times dimmer. If you triple your distance it becomes nine times dimmer, and so on.

If the star is sixteen times dimmer at $d$ than at ten parsecs then it must be four times further away than ten parsecs.

Therefore, $d = 40pc$

Try another one. If a star has $m = 13$ and $M = 6$ then at its real distance, $d$, it is $7$ mags or about $625x$ dimmer than at ten parsecs. $625x$ dimmer means $25x$ further away.

Therefore, $d = 10pc \times 25 = 250pc$

One more. A star has $m = 21$ and $M = 6$ at its real distance $d$ it is $15$ mags, or one million times dimmer than at ten parsecs. One million times dimmer is a result of being one thousand times further away. Therefore $d = 10pc \times 1000 = 10,000pc$. I have chosen numbers which I think are realistic. You can approximate even without such 'nice' numbers.

One last example.

A star has $m = 7.5$ and $M = 1.0$. At it is $6.5$ mags dimmer than at ten parsecs. Now, $1.5$ mags is approximately four times dimmer, thus $6.5$ mags is $400 \times$ dimmer. The star is therefore $400 \times = 20$ times further than ten parsecs.

Hence $d = 10pc \times 20 = 200pc$

I think this work is a good starting point for the Astronomy Elective. Similar sessions covering stellar spectra and chemical compositions, colour index, the radiation laws (Stefan's and Wein's), and the H-R Diagram lead directly into stellar evolution, nuclear reactions in stars, and variable stars.
Physicists are continually developing new methods to allow them to penetrate the structure of various media and probe into the fine details of the individual atoms which make up the actual medium itself. For many years the optical microscope was the 'state-of-the-art' for studying the finer details of matter. Physical optics limited the detail to distances of the order of the wavelength of light (say 0.1 to 1 mm). The invention of the electron microscope in its various forms meant the objects whose individual details could be resolved could be extended to diameters approaching individual atoms. In certain cases molecules could be seen and in others the rows of atoms in crystalline material could be resolved.

The early electron microscopes were transmission devices; i.e., the beam was transmitted through the specimen, so the specimen had to be thin (~100 nm) and detail arose from contrast induced by diffuse scattering effects in different local regions of the specimen. The scanning microscope was introduced, with the ability to work in reflected rather than transmitted modes and with contrast arising from different secondary electron emission characteristics of different parts of the medium or when the secondary electron arose from the Auger effect and was hence characteristic of the medium, from the different atomic composition of the medium.

A new device has been developed called the scanning tunnelling microscope, or STM, which has revolutionised the study of atomic detail on surfaces. This microscope relies on the quantum mechanical effect called tunnelling. This effect is also used in electronics (tunnel diodes) or in voltage standards (Josephson junction) and arises when we have a situation indicated schematically below. If two atomic energy level systems exist a long way from each other, there is no evident interaction. As the two systems approach each other (so the separation becomes of order atomic dimensions; i.e., ~nm), there exists a finite probability of an electron from a level in one system appearing in the empty level of equal energy of the other system even though there exists a potential barrier between them. A tunnelling current will then occur.

If the one system is the atoms on a surface and the other is a very sharp tip (whose radius is of atomic dimensions) then as the tip is brought very close to the surface, a tunnelling current will flow. If now the system is adjusted so that the tunnelling current is a constant, and the tip is moved in a raster over the surface, the rise and fall of the tip relative to the surface will represent the position of the levels involved in tunnelling, relative to the atomic site, and the movement of the tip will trace out the surface corrugations due to individual atoms.
Other modes of use are possible. Using positive or negative bias on the tip, one can have tunnelling from the surface to the tip or vice versa. By varying the bias, one can map out the occupied and unoccupied state distribution of the atoms on the surface.

Several STMs are under construction in Australia and the results from one of the first, developed by Dr. Brett Saxon of CSIRO Division of Materials Science in Melbourne, are shown below. The data is in 'raw form; i.e., a series of scans in raster mode traverses an area of the surface in which the height of the tip above the surface is measured. For the following case:

(a) the sensing head on a compact disc player—the area scanned is about 1.5 mm x 1.5 mm;
(b) a highly oriented piece of pyrolytic graphite showing the hexagonal array of atoms on the surface (interatomic spacing ~0.126 nm), and
(c) a 100 x 100 nm scan of a thin film of Au deposited on mica shows numerous steps, each one atomic layer (0.24 nm) in height.

Commercial instruments are now available which use sophisticated image analysis packages to convert the line scan above into (false colour) images of atoms. One such common example is the so-called 7 x 7 structure on a Si (c) surface. This structure is interesting because it is a departure from the structure expected by simply terminating the bulk lattice of a Si crystal.

It is interesting that the developers of the STM, Bennig and Mueller of IBM Zurich, were awarded the Nobel prize for Physics for this development within about two years of having published the first scans. This represents probably the most rapid recognition for a scientific development to be awarded something as prestigious as a Nobel Prize.
The eye and basic camera become increasingly similar as technological advances refine the camera. Indeed many features and functions are identical. One such function is the image formation. In the camera, no matter how complex its operating mechanisms, image formation is in conjunction with either a photo sensitive or magnetic medium. These images are latent until treated chemically while those of the eye are automatically, and immediately, processed by the brain. Certainly a disadvantage is that no permanent images are obtained, but this restriction is compensated for by the subsequent mental processing important in our daily learning.

The human eye, a fairly spherical structure, consists of three distinctive layers of tissues. The extremely tough outer sclerotic coat is transparent in the front, forming a light-admitting cornea. This cornea refracts the light rays so they can be effectively brought into focus. The middle or choroid coat is deeply pigmented with melanin and richly supplied with blood vessels. Its important function is to inhibit internal reflection of stray light rays, as is similarly accomplished by the dull black interior of the camera. The choroid forms a coloured iris at the front of the eye. The opening or pupil of the iris can vary in diameter; this variability of diameter being under autonomic control and responds to the light environment—becoming larger as light intensifies. This compensatory behaviour both prevents over-illumination and improves image formation and depth of field.

When a camera is stopped down, the iris diaphragm (or aperture) is set a minimum size permitted for the amount of light available in order to obtain the sharpest picture. For interest, view a distant subject through the tiny aperture that can be formed with the forefinger and thumb, thus:

Light entering the eye is focused by a single lens system onto a sensitive film or retina. This 'film' contains enormous numbers of closely packed receptor cells, the rods and cones. The focused light pattern stimulates different receptor cells, just as the film in a camera is differentially stimulated.

Behind the iris a lens is held in position by suspensory ligaments, generally in a state of tension. This tension produces a flattened lens. The contraction or relaxation of the ciliary muscles attached to these ligaments allows the lens to assume different shapes. With the change in shape of the lens, objects at near and far distances can be readily and rapidly focused. Such a focusing mechanism does not exist in a camera and changes in focus must be obtained by shifting the position of the lens with respect to the film. (Some fish, amphibians, reptiles and molluscs display this more primitive mechanical focusing).

The interior eye is divided into two chambers by the lens/iris system. The front chamber is filled with a watery fluid or aqueous humour. The rear chamber is filled with an extremely clear, jelly-like vitreous humour.

**Sight**

For an object to be seen clearly it is necessary that a sharp image be formed on the retina. This is achieved by refraction of the light entering the eye as it passes through several transparent layers of greater optical density than air. High resolution vision depends largely on the precise focusing of light beams in a real and inverted image on the retina. 

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### Comparison Of The Eye And The Camera

<table>
<thead>
<tr>
<th>Eye</th>
<th>Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sclera</td>
<td>Camera Case</td>
</tr>
<tr>
<td>Choroid</td>
<td>Black Paint</td>
</tr>
<tr>
<td>Retina</td>
<td>Film</td>
</tr>
<tr>
<td>Iris</td>
<td>Iris Diaphragm or Aperture</td>
</tr>
<tr>
<td>Most refraction of light occurs at the air-Cornea boundary. A small amount occurs at the Aqueous Humor — Lens boundary.</td>
<td>Refraction of light occurs only at the Lens.</td>
</tr>
<tr>
<td>Focusing objects is automatic and is carried out by altering the shape, and thus the focal length, of the Lens.</td>
<td>Focusing different objects is achieved by moving a Lens of a certain focal length towards and away from the film.</td>
</tr>
<tr>
<td>The intensity of light entering the eye is automatically controlled by movements of the iris.</td>
<td>The intensity of light entering the camera is adjusted, using the Diaphragm or aperture of the Lens.</td>
</tr>
</tbody>
</table>
Likewise the same precise focusing of incoming light is a requirement of high resolution photography.

The lens system of the human eye consists of two major components—the cornea and the lens. The cornea performs most of the bending—or refracting since it is the alterable part of the system and allows rapid adjustments to focusing.

Near and Far Objects

Light rays from any given source travel away from that point source in all directions. If the cornea of an eye is placed close to this point source it will be struck by many light rays, some of which are travelling at strongly divergent angles. If, however, the cornea is situated further away, many of the most divergent light rays will miss it totally. For all practical purposes the cornea needs to be about 7 metres away from the source before the divergent rays will appear parallel.

It then follows that if all the divergent rays from a near object are to be focused on the retina they must be strongly bent by the lens system.

Those from a distant object require much less bending.

While most refraction is carried out by the cornea, the lens completes the essential subsequent focusing. The elastic, biconvex lens curvature can be altered by the behaviour of the ciliary body via the suspensory ligament. Tension on the suspensory ligaments flattens the lens hence reducing its refractive power. In fact, for a distant object, the almost flat lens has little influence on incoming light rays.

However, close viewing results in relaxation of the ligament so that the lens bulges out because of its own elasticity. The lens refractive power significantly increases so that, combined with the cornea, images can be brought into sharp focus. The closer the objects to be viewed, the more relaxed the lens. This power of ‘accommodation’ decreases with age as body elasticity decreases.

### Light Detection

Rods and cones are light-detecting structures found just below the retina. Both contain light-sensitive pigments.

A rod enlarged many times

The rods contain the pigment rhodopsin, possibly creating an electrical potential which is sufficient to induce an electrical impulse. This impulse travels to the brain in order to signal the presence of light. The rhodopsin then resumes its ground state.

A cone enlarged many times

The cones display a more complex mechanism. There are three operating types of cones, each possessing a different kind of pigment. Each of these three pigments is sensitive to light wavelengths covering a wide band of the visible spectrum. Each, though, has its maximum absorption in a different part of the spectrum so they are designated as blue-absorbing, green-absorbing and red-absorbing.

This three-colour, three-receptor mechanism of cone reception allows for colour vision.

Not all animals are receptive to colour. Most mammals only perceive in shades of grey, while many lower order animals perceive in other parts of the electro-magnetic spectrum.
Prompt Critical

Lifting the Veil of Obscurity

According to some, the PC-clone has taken over from the dog as man’s best friend. But the friendship can become a little strained if you have to poke around to discover how their inards function. The Average Busy Professional Physicist (ABPP) often lacks the time to delve right into the mysteries of the PC and, perforce, must rely on the high priests of PC-dom for solution if not salvation. The definition of a high priest is a person who knows important things that are not in the manuals and the principal manual which leaves us ABPPs completely in the dark on many vital matters is the one that contains the incantations needed to make things happen when the > appears on the left side of the screen.

Spare a thought for the BPP who had this verse displayed above his PC:
I really hate this damn machine.
I wish that they would sell it.
It never does quite what I want,
But only what I tell it!

Finding out what to tell a PC to make it do what you want is the purpose of a paperback with the title Tricks of the MS-DOS Masters published by Howard W. Sams & Company. The Sams Company have been publishing handbooks of various kinds for many a year, and have been rather successful at it. This is one of half a dozen MS-DOS related handbooks produced by the Waite Group, which specialises in presenting informative material about computers.

True to its title, this book contains many tricks of varying usefulness. The most part instructive, especially where they help circumvent some of the limitations of MS-DOS. For me the real value lies in the tables of hard-to-find information sprinkled throughout its 500-odd pages. There are MS-DOS disk format details with cluster numbering and how the file allocation table is organised; memory maps for XT’s and AT’s and page frame locations for expanded memory; numeric keypad second codes and alternate key codes; tables of information on ANSI.SYS screen control sequences; interrupt line and port assignments for XT’s and AT’s, and more. The accompanying explanations are often very lucid. The main deficiency is that the data is not up-to-date as it could be: the 386 series of PCs is not mentioned, and some of the newer disk formats are not listed.

The tutorial chapter on the MS-DOS DEBUG program is a valuable adjunct to the terse section describing its commands in the MS-DOS manual. Anyone with aspirations to becoming a machine-code surgeon with DEBUG should read both very carefully. The chapter on free and low-cost software is a handy descriptive reference to have if any of these are encountered: it can be risky running them without knowing what they might do.

Apart from a tendency toward ‘chatty’ text, Tricks of the MS-DOS Masters is very readable, even enjoyable (if books on computers can be so considered). The authors, John Angermeyer, Rich Fahringer, Kevin Jaeger and Dan Shafer, have a wealth of experience with computers and their presentation shows it. Containing xxvi + 542 pages, Tricks of the MS-DOS Masters costs US $24.95 in the States and A$49.99 here, unless the Prices Surveillance Authority moves in.

Colin Keay
Book Reviews Editor

NEW JOURNAL

The Institute of Physics (UK) has announced a new bimonthly journal Quantum Optics edited by Professor E.R. Pike of King’s College, London. It has a 27 member editorial board of international scope, including an east Western German and two New Zealanders but no one from the Soviet Union or Australia. There will be no page charges. Volume 1 (1989) costs £45, and Volume 2 (1990) £115, or both for £140, from the Journals Marketing Department, JOP Publishing Ltd, Techno House, Redcliffe Way, Bristol BS1 6NX. It can be ordered by major credit card.

New Books

Books marked with an asterisk are still available from the Book Reviews Editor by suitably qualified members of the Institute for their review.

J.H. Kiel (Ed)
440 pp. US $87 (hardcover)

* Atomization and Sprays
A.H. Lefebvre
Hemisphere Publishing Corporation, New York NY 1989
421 pp. UK £65 (hardcover)

Lithography in Microelectronics
T. Maksivlade (Ed)

The Early Universe - Facts and Fiction
G. Borner
Springer-Verlag, Berlin 1988, 439 pp. DM 125 (hardcover)

Neutrinos
H.V. Klapdor (Ed)
Springer-Verlag, Berlin 1988, 339 pp. DM 84 (hardcover)

Tricks of the MS-DOS Masters
J. Angermeyer, et al
Howard Sams & Co, Indianapolis IN 1988, 542 pp. A$49.99 (paperback)

Plasma Physics and Plasma Electronics
L.M. Kozhichynkh (Ed)

Solid State Physics Source Book
S. P. Parker (Ed)

Medical X-ray, Electron Beam and Gamma Ray Protection for Energies up to 50 MeV. Report No. 102.

The New Physics
P. Davies (Ed)

Reviews

The Delfin Laser Thermocouple Installation: Operational Complex and Future Directions
G.V. Skizkov ed.
(translated by K.S. Hendzel)
viii + 292 pp. US$110 (hardcover)

The importance of this book is due to the fact that the present development of 10 megajoule laser pulse installations, together with the results of underground nuclear testing, provides a safe basis for claiming that all physics problems are solved for the concept of indirect drive spark ignition pellet (capsule) fusion, leading to a fusion power plant for energy production at the same cost as light water reactors. (Magnetic fusion is at least ten times more expensive, according to the Pfirsch-Schmitter result. See Fusion Technology, 15, 1471 (1981)). In this regard, it is very interesting to receive such a comprehensive treatise about leading work on this topic at the Lebedev Institute in Moscow. G.V. D.
BOOK REVIEWS

Skilizkov has been known for many years as one of the most prominent pioneers in this field in his own country, together with the excellent team whose results and views are now presented. The book is not a textbook nor a monograph, more a report only of the work of Skilizkov's laboratory. References of outside work are very sparse; both of other Russian groups as for outside of the USSR. The foreign co-authors are from East-Germany's academy institute.

The book consists of eight articles, of which the first has 44 co-authors describing the development and future prospects of the 'Delfin' - laser. It is most instructive to read about past motivations and their views about further steps. The need for pellet compression was published by Korkhin, et al, in 1972. The differences to the Livermore scheme are rather minor: only that their needs tailored pulses while the Russian scheme works with rectangular pulses. In both cases, the problems for central ignition are the same: the initiation of thermonuclear combustion and its propagation to the periphery. Of the necessary computer codes, the only important one mentioned is the one which calculates the hydrodynamic instability of incompressible fluid shells. The net gains are similar to those published earlier from Livermore.

Laser pulses of 1 to 10 MJ are needed, CO₂ lasers as drivers are considered where compression "employs fast electron energy". Consideration is also given to a hybrid reactor. Further chapters are specifically about diagnostic methods and results, and about smoothing the interaction, where techniques are discussed and Obenshain's induced spatial incoherence is mentioned, but the Mima-Kato random phase plate is not referenced. The whole success of the direct-drive approach of McCrory, and Yamanaka and Nakajima is not mentioned. One may be surprised that the significant X-ray microphotography technique is discussed only marginally, though this is one of the highlights.

Further, the diagnostics of Zakharenko, et al, are mentioned as are the later similar results by Azéchi, et al, but it is not mentioned that these included the first proof of profile steepening and caviton generation due to the nonlinear (ponderomotive) force. Insufficiencies such as these and slips in translation, e.g., "state equations of matter" instead of Equations of State, should be not taken too seriously.

The importance of this book is to show that laser fusion is now a focal point of development and to see how advanced neodymium glass laser schemes may be developed in the future, especially the "optical pump systems" with efficiencies of 5%. The book will stimulate the experts in the field and it presents the activities of the Lebedev Institute in an excellent way.

H. Horo
Department of Theoretical Physics
University of New South Wales

Phase Conjugation of Laser Emission

N.G. Basov (Ed.)
Nova Science Publishers,
Commack, NY, 1988
vii + 240pp., US $91 (hardcover)

This book gives an introduction and survey of the physics of phase conjugation. In phase conjugation, a reflected beam is emitted whose envelope is phase conjugate to the input beam. Unlike specular reflection, this conjugate beam traverses a nearly exact time-reversal of the path of the input beam. Thus, phase conjugation has a remarkable freedom from the sensitivity to orientation of the mirror that occurs in conventional specular reflection. This allows new types of interferometers that are relatively immune to optical distortion. Of more utility is the promise that phase conjugation can be employed to reduce path-length or phase distortion in a variety of laser applications.

The book mostly treats research emanating from the Lebedev Physics Institute. In fact, there are two half to the work presented here: the first half of the book focusses on stimulated Brillouin scattering methods, while the second half treats phase conjugation of medium infra-red pulsed lasers. In both the sections of the book, there is an interesting combination of theoretical and experimental work. In the first half, the detailed theoretical topics include: fundamental equations of phase conjugation, phase conjugation using Brillouin scattering, zero-threshold phase-conjugation, phase-conjugation of pulses, four-wave mixing by Brillouin scattering, saturation effects. The experimental results include a general study of the theoretical predictions, together with a study of a phase conjugating interferometer. Some practical considerations in instrument design are also treated.

The second half of the book emphasises four-wave mixing as the phase-conjugation mechanism. The main type of medium treated is a near...
resonant semiconductor transition, although anharmonic effects in molecular media are also treated. This section is generally shorter than the first. Once again, there is a good mixture of theoretical and experimental results. The important topics of polarization properties and saturation effects are also treated. The most recent developments in this area are, however, omitted. The wavelength range and applications covered here are largely restricted to the medium infrared region.

In summary, the book covers in great detail the topics of phase-conjugation by Brillouin scattering, together with pulsed medium infra-red laser phase conjugation. This book certainly provides a window into Soviet research in this rapidly developing area. However, it tends to omit recent results discovered elsewhere, especially the theoretical discoveries by Wolf in developing general scattering-theory treatments of phase-conjugating mirrors. While it is a useful acquisition for any library, I would also recommend the perspective obtained by comparing it with Fisher's text 'Optical Phase Conjugation'.

Peter Drummond
Department of Theoretical Physics
University of Queensland

Properties of Selected Ferrous Alloying Elements: CINDAS Data Series on Materials Properties, Volume III-1
C.Y. Ho (Editor)
Hemisphere Publishing Corporation,
New York, 1989

This volume is a critically evaluated collection of data ('hard information') from the scientific literature on the physical properties of selected ferrous alloying elements. The data have been compiled through the work of the Centre for Information and Numerical Data Analysis (CINDAS) at Purdue University with the philosophy that reliable quantitative data provide the real value of scientific work and the most tangible contribution towards scientific and technological progress.

The chapters are based on the individual transition elements: Cr, Co, Fe, Mn, Ni and V, which are frequently involved in binary or multiple component alloys with iron. Data on 40 properties are presented either as a function of one or more variables (usually temperature or wavelength), as single-valued constants or as values at room temperature.

This space is available for classified advertisements which cost only $4 per line.
Copy must be with Hunter Technology Press by the 15th of the month before the issue is due.

The data are restricted to elements in the 4th Period and from Groups VA to VIII of the Periodic Table and are by no means comprehensive in terms of elements used in substitutional alloys with iron. The transition elements Ti, Zr, Nb and Mo, for example, are also common ferrous alloying elements, yet they are not considered in this volume. Although the data are based on careful and critical scrutiny of published values, little or no reference is made to the purity of the samples used for measurement of the physical and mechanical property values. Small amounts of interstitial impurities, which are difficult to remove from these elements, can exert significant effects on mechanical and physical properties.

Despite these reservations, the data presented are comprehensive, especially based on a critical evaluation of the scientific literature and provide an unmatched source of information on the physical and mechanical properties of the elements treated.

D.P. Danne
Department of Materials Engineering
University of Wollongong

VIDEO REVIEW

Concepts in Science: Physics Section
Produced by Television Ontario, Canada.
Distributed by Educational Media Australia.
Running time: 5 hours
Cost: $50 (High Schools $195)
The complete series on physics in this title, is made up of five sets of programs: one on each of the topics Electricity, Electromagnetism, Nuclear Physics, Structure of the Atom, and Wave-Particle duality. Each topic is dealt with by six ten-minute programs. One ten-minute program from each topic was provided for review.
The material consists primarily of computer animation with voice-over explanation. The scripting is precise and clear. The display is colourful and would clarify concepts such as, for example, the magnetic field produced by a solenoid. There is success in presenting some quite advanced ideas in a manner which would be understood by pupils in years 7 to 10. Indeed the presentation seems suitable for this group rather than years 11 and 12. The higher years particularly would find the pace slow and uninteresting. Certain illustrations could be made useful for years 11 and 12 if extracted and shortened, and a more sophisticated and faster-paced commentary used. ▶
The uninterrupted computer animation has limited appeal, and moreover wastes the potential of the video medium. Computer animation would be better interspersed between segments in which real people illustrate real experiments and demonstrations. Videotape lends itself to the use of historical material, and the equipment used for the original experiments has often been preserved and is available in scientific museums around the world. The Ascent of Man series, and Einstein’s Universe, are two examples which show the real potential of the medium, using a variety of resources.

To sum up: ‘Concepts in Science’ could be useful in years 7 to 10 but is of limited value for years 11 and 12. Generally there are better resources available, one being “The Mechanical Universe”.

Frank Bagnall
Physics Department
University of Newcastle.

**Reviews**

**Interaction of Ultra-short Pulses with Matter**
M.D. Galanin (Ed.)
Nova Science Publishers,
Commack, NY, 1989
vii + 132pp, US $57 (hardcover)

This book is another in a series of Proceedings of the Lebedev Physical Institute in Moscow with series editor Nobel Laureate N.G. Basov. The subject matter is one dear to Basov’s interest—the interaction of ultra-short pulses with matter—a topic relevant to research in laser-produced plasmas and laser fusion. In the context of this book ultra-short pulses have durations in the region 20-100 ps—values rather shorter than used for mainstream research in laser fusion where nanosecond duration pulses are normal but very much longer than the current generation of high-power ultra-short pulse lasers now being developed with pulse durations of less than 1 ps. Obviously ultra-short is subject to different interpretation from one laboratory to another.

The book contains three research papers covering different topics. The first chapter contains a description of laser hardware developed for short pulse generation. The authors concentrate on short pulse generation by passive mode-locking in Nd:YAG and Ruby at low temperature (100 K). The reasons for choosing low temperature operation are not well spelt out and in the case of Nd:YAG it is noted that room temperature operation would be more favourable for short pulse generation. Models are used to describe the evolution of the short pulse in the laser oscillator and the results of these models compared with experimental studies. The section concludes with discussion of various coherent interactions of the ultra-short pulses with the laser medium including self-induced transparency in Ruby. The chapter is well referenced and readable.

The second chapter deals with the development of automatic data recording systems for various of the diagnostics required for experiments on laser-produced plasmas. These include measurements of x-ray Bremsstrahlung spectra, calorimetric data and optical detectors for the plasma and laser emission. The section deals with descriptions of specific hardware systems employed at the Lebedev. For the reader outside the Soviet Union these descriptions of specific hardware systems employed at the Lebedev. For the reader outside the Soviet Union these descriptions are not particularly useful since and often Soviet manufactured components are used.

The final chapter deals with the use of the hardware described in chapters 1 and 2 for a range of plasma experiments. The laser system chosen was the ruby laser producing 20-100 ps duration pulses and energies of a few joules. Experiments to measure the absorption of laser light by the plasmas; the x-ray Bremsstrahlung spectra; x-ray images of the plasma, etc; are discussed and the data interpreted in terms of various physical mechanisms that might operate in this particular regime. The results are interesting and broadly in agreement with work over the past few decades from various other laboratories from around the world. Thus, although they do confirm many previous results they do not provide great additional insight into the nature of the laser plasma interaction.

In summary this is a book for specialists in the field of laser plasma interaction and one which such specialists will find an interesting although unexciting addition to their library. The translation is of good standard and overall the book is well referenced. Its value is perhaps greatest as a reference work in this series of Proceedings of the Lebedev Physical Institute rather than a stand-alone text to be purchased by the casual reader.

**Studies of High Temperature Superconductors, Volumes 1 and 2**
Arnt Narlikar (Ed.)
Nova Science Publishers,
Commack, NY, 1989
Volume 1, xiv + 381 pp, US $85 (hardcover)
Volume 2, xvi + 367 pp, US $85 (hardcover)

Since the discovery of the ceramic based high-Tc superconductors, the following question has often been asked. What will be the first industry to benefit from these new superconductors? The answer is clearly the publishing industry. These two volumes are the launch volumes in a new series on high temperature superconductors. The editor has given himself a broad charter as these volumes attempt to cover every possible topic. A brief selection from volumes 1 and 2 includes structural chemistry, ceramic engineering, metallurgy, thin film and bulk devices, superconducting and normal state properties, theory, thermal properties, wires and magnets. Each volume is composed of fifteen or so chapters, with each chapter a detailed review or extended paper focusing on one or more ‘frontier’ aspects of high-Tc superconductors. The majority of the contributions come from India and Japan, with a sprinkling from the US, France, West Germany and the UK. Unfortunately, the publisher has opted for camera ready manuscripts, which results in a lack of uniformity between chapters and detracts from the overall presentation.

The enormous diversity of the material covered makes it difficult to give a detailed review, so all one can do is give the flavour of some of the contributions. Volume 1 has useful contributions on the modification of thin films by ion beam techniques and on thin film processing, as well as a chapter on thin film devices based on the Josephson effect. There is a first class contribution by Yee, University of Tokyo, on fluctuation effects and flux creep phenomenon. Chemists will find solace in a number of chapters that are devoted to synthesis, substitutional studies and structural aspects of these ceramic based superconductors. C.N.R. Rao, again, enlightens us with an exposition on the oxygen hole mechanism of superconductivity in cuprates. Those who have interests in X-ray photoelectron spectroscopy studies and elastic constants will find timely contributions on these subjects.

Volume 2 appears to be more focused in its overall approach with solid contributions on the chemistry of these materials by Raveau and by Bordet who concentrates on the Bi-Sr-Ca-Cu-O
BOOK REVIEWS

System. Thermal properties are the subject of an excellent review by Gmelin, which is immediately followed by a review on the behaviour of phonons in these materials, making a nice combination of chapters. The final chapters of this volume are devoted to theory.

These volumes cover such a broad range of topics that the individual will have to browse through them to assess their usefulness. It is difficult to judge the worth of this series on just two volumes. If the editor ensures that each contribution is a detailed review of a topic then this series has a place in all libraries, but if it becomes just another forum for a re-cycled paper on high-Tc, that has already appeared elsewhere, then its value will quickly diminish. With so many new journals, conferences and monographs concentrating on high temperature superconductivity, one wonders if there is enough new material to go round.

Stephen Colloco
CSIRO Division of Applied Physics
Lindfield

Nonlinear Fibre Optics
G.P. Agrawal
Academic Press, San Diego, 1989
xii + 342pp, US $39.95 (hard cover)

This book is useful and well-written. In optical fibres, group velocity dispersion causes pulses to broaden as they propagate, while the Kerr-effect nonlinearity leads to self-phase modulation. It can be assumed that the nonlinearities do not substantially influence the transverse modal structure, so these effects are analyzed using the nonlinear Schrödinger equation (NLSE) and its variants. It is shown how a balance between the two can be achieved, thus producing a particle-like pulse which does not change shape while propagating, viz. the fundamental soliton. Higher order (periodic) solitons are also studied.

The author frequently repeats special cases of the NLSE and clearly explains consequences of including various terms. These features would make the book suitable for didactic purposes. Nonlinear fibre studies have been a major area of research recently. The author has collected the results of many papers and presented them in a convenient form. Experimental results are compared with theory wherever possible.

Of course there are difficulties in writing a book covering aspects of a subject which is evolving rapidly, and the selection of topics must always be subjective. For example, dark solitons could well have some advantages over bright solitons, but receive scant attention in Chapter 5.

The similarities and differences between stimulated Raman and Brillouin scattering are well explained. Phase matching methods in various fibres for parametric processes are also discussed at length.

This book only analyzes nonlinear effects occurring in single fibres. Apart from a brief mention in the epilogue, the use of two fibres to form a nonlinear coupler is not considered. This is a surprising omission, since many devices, such as high speed optical switches and transistors, will probably be based on these couplers.

In summary, this is a very good book for students and for those commencing research in the exciting field of nonlinear phenomena in optical fibres.

A. Ankieiewicz
Optical Sciences Centre
Australian National University

SELECTED PAPERS

Vol. 1: Stellar Structure and Stellar Atmospheres
Vol. 2: Radiative Transfer and Negative Ion of Hydrogen

S. Chandrasekhar
The University of Chicago Press, Chicago, 1989
Vol. 1: iv + 515pp, US $34.50 (paper)
Vol. 2: xvi + 621pp, US $34.50 (paper)

In a career spanning 60 productive years, S. Chandrasekhar has influenced the development of many different branches of astronomy. His monographs on Stellar Structure, Stellar Dynamics, Radiative Transfer, Hydrodynamic and Hydromagnetic Stability, Ellipsoidal Figures of Equilibrium and Black Holes contain an enormous amount of theoretical astrophysics, always clearly presented, and generally accompanied by succinct and accurate accounts of critical aspects of the observations. The monographs have often been constructed on the foundation of original research papers written by Chandrasekhar and his co-workers, and held together by additional connecting material and references to relevant empirical results.

Despite this periodic assembly of Chandrasekhar's views into monographs, there are many interesting and influential papers not collected together in this way. Selections of these papers, together with some of the most important and original of his life's work, have been made by Chandrasekhar and are now being published in six volumes by The University of Chicago Press. The volumes reviewed here are accompanied by interesting—but very brief—accounts which touch on the historical and human background to the selections, and it seems likely that this format will be continued in the future.

At first sight it might appear superfluous to publish these Selected Papers—after all, the original material is still available, albeit (in many libraries) shut away in less accessible 'old journal' storage areas. But the Selected Papers lay out the line of development of thoughts and controversies in a homogeneous way, difficult to achieve from the primary sources. Moreover, they contain important and interesting papers which could be overlooked—for example, I had never read the 1946 Gibbs lecture, published by the American Mathematical Society, and I found it to provide an extremely valuable overview of several key concepts in radiation transport theory. Equally, there are illuminating short comments from 'The Observatory' which set a backdrop for the papers on White Dwarfs by exposing the controversies with Milne, Eddington and others. At one point, Eddington is quoted as saying: 'I do not know whether I shall escape from this meeting alive, but the point of my paper is that there is no such thing as relativistic degeneracy.' Not all of the papers in these Volumes are likely to be of equal interest to all readers. However, I am sure that many astronomers will gain a great deal of pleasure by reading at leisure the lucid developments of many of the key concepts in astrophysics due to Chandrasekhar. In addition, the availability of these volumes provides a valuable resource for advanced courses in astrophysics or radiation transport—students would benefit by both mastering these papers and re-deriving the results using more recently developed computational techniques.

The University of Chicago Press and Professor Chandrasekhar are to be congratulated for making this valuable material readily available for following generations of astrophysicists.

L.E. Cram
School of Physics
University of Sydney

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Australian Physicist Volume 26, Number 11, November 1989
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  IE (Aust) (02) 327 4822.
Dec 4-8  Greenhouse and Energy Conference, Sydney.
  Ms Ann Whitaker, (02) 887 8204.
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  Secretariat, Department of Physics and Mathematical Physics,
  University of Adelaide, 5001.
Jan 15-Feb 2  3rd Physics Summer School on Nuclear and Particle Physics, Canberra.
  B. Robson, ANU (062) 49 2971.
Jan 29-Feb 2  9th AIP National Congress, Perth.
  Dr R.A. Anderson, Dept. of Physics, UWA, (09) 380 2738.
Feb 4-9  Chaos in Australia Conference, University of New South Wales
  Gavin Brown, University of NSW, PO Box 1, Kensington, NSW, 2033
Feb 5-7  6th Gaseous Electronics Meeting, Armidale NSW.
  M.P. Fewell, Physics Dept., University of New England, Armidale,
  NSW, 2351 (067) 73 2388
Feb 5-9  Conference on Solar, Terrestrial and Space Physics. Workshop on Ionospheric
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  Dr Essex, Physics Department, LaTrobe University, (03) 479 2644.
Feb 5-9  2nd International Conference on Nuclear Microprobe Technology & Applications,
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  Mrs M. Tate, Conference Secretary, tel (03) 344 5433.
Feb 6-9  5th International Symposium on Acoustic Remote Sensing of the Atmosphere
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  Dr S. Singal, Cl- NPL, New Delhi, 110012.
Feb 6-9  Fourteenth Australian Institute of Physics Condensed Matter Physics Meeting.
  T.J. Bastow, CSIRO, tel (03) 542 2777, fax (03) 544 1128.
Feb 12  Workshop on Millimetre Waves, Sydney
  Dr Bruce Thomas, Kieran Greene, or Lynette Loew, tel (02) 868 0222
April 1-6  Government, Engineering and the Nation, Canberra.
  Conference Manager, IE (Aust) 11 National Circuit, Barton ACT.
April 23-27  International Conference on Physics Education Through Experiments.
  Prof. Zhao Jinian, Nankai University, Tianjin, China, tel (086) 02 318264
  IREE (02) 327 4822.
July 9-12  3rd International Conference on the Structure of Surfaces, Milwaukee, USA.
  Dr M. van Howe, Fax 0011 1 415 486 4995.
July 9-13  5th World Conference on Computers in Education, Sydney.
  WCCE/90 PO Box 319, Darlinghurst 2010. Tel (02) 211 5855
July 16-20  Nonlinear Optics Conference.
  LEOS, 445 Hoos Lane, PO Box 1331, Piscataway, NJ 08855-1331, tel (201) 562 3895
Aug 5-10  15th Congress of the International Commission for Optics, Bavaria.
  Paul Hewitt (049) 62 0999.
Aug 12-16  International Conference on Optics for the Life Sciences, Munster.
  Paul Hewitt (049) 62 0999.
Sept 24-28  Joint Conference of Australian Radiation Protection Society and Australian College
  of Physical Scientists and Engineers in Medicine, Adelaide.
  David Paix, GPO Box 498, Adelaide, 5001.
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