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The cover picture this month shows the echo of light from Supernova 1987A.
© 1989 Anglo-Australian Telescope Board. The photograph was taken and submitted by
David Malin. Please see page 31 for more details.

Australian & New Zealand Physicist Volume 29, Number 3, March 1992
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PRESIDENT'S COLUMN

AIP

The national Congress was a marvellous event. It brought together more than 900 participants eager to share their excitement over new discoveries and to be reminded of just how important our discipline is to the development of new technology. There was also a chance to reflect on new ideas and challenges in physics education.

A number of other physical societies were represented. Professor Walls, the President of NZIP and Professor Yang, the President of AAPP, both attended and presented superb plenary lectures. While Professor Blin-Stoyle, the President of the UK Institute of Physics, was unable to attend, the IOP was ably represented by their secretary, Dr Alun Jones and the Past-President, Professor Cyril Hilsun. Alun did a superb job of presenting Professor Blin-Stoyle's address on physics education in the UK.

One of the aims of our Institute is to recognize outstanding achievement in physics. At its annual meeting, before the Congress, Council gladly accepted a South Australian offer of a new medal, the gold Bragg Medal, which will honour the student producing the best Ph.D thesis each year. Look for details in the next Physicist! During the Congress a number of awards were made. Dr. Haritharan of CSIRO, Division of Applied Physics (Sydney), received the Thomas Young Medal from IOP as well as our highest award, the Walter Boas Medal. His address not only reminded us of the beauty and subtlety of modern optics but also its utility, with applications as diverse as a modern inertial guidance system (based on an optical fibre rather than a gyroscope) and a new method for testing the design of objects as different as boilers and violins!

Dr. Basi Briggs of the University of Adelaide, received the Harrie Massey prize for his contributions to our understanding of the upper atmosphere - work whose significance is suddenly being appreciated more widely in the light of global problems like the hole in the ozone layer and the greenhouse effect. One evening, Paul Davies (also from the University of Adelaide), presented a public lecture on wormholes in space-time - a subject that until five years ago would have been pure science fiction! These three examples give some idea of the power and breadth of modern physics.

This particular Congress was made even more exciting by the presence of several hundred secondary physics teachers. There is no-one teaching university physics or engaged in physics research who does not appreciate the crucial role that teachers have in ensuring the future of our discipline. Without bright, enquiring young minds whose teachers have kindled an excitement in understanding how the physical world works, there is no future. We all owe a debt of thanks to Dan O'Keefe and Fred Armfield (who with many others) put together a stimulating education program.

There is another reason too why the attendance of so many teachers was timely. As an Institute we are very keen to improve the relationship with physics teachers throughout Australia. With its regular "Fix on Physics" feature, much of which is contributed by secondary teachers, it should be in every school. By taking out Associate Membership at $30 per year (down from $70 last year), teachers can get the Physicist below cost. Spread the word!

A. W. Thomas
President, AIP

NZIP

It was my great pleasure to attend the congress of the Australian Institute of Physics in Melbourne this February. I enjoyed this Congress very much, a feeling I am sure would be endorsed by all those who attended. My congratulations to the Conference Chair John Leseuang, the Conference Secretary Geoffrey Taylor and the Programme Chair Tony Klein.

It was very nice to see a sizeable number of delegates from New Zealand present. For me it was an opportunity to meet Tony Thomas, the President of the Australian Institute of Physics. I wish to take this opportunity to thank him for continued on next page
Where are we going?

At the Physics Congress in Melbourne there were quite good numbers of attendees at the two sessions devoted to a discussion of the Physics Strategy Plan. Perhaps more will be said by others about the meetings themselves and the effect of the reasonably lively discussions on the next (final?) draft of the plan. I want to comment here, however, on two very important issues which were raised in the course of the discussions and which deserve a fuller airing in their own right. The first of these will deal with what we mean by a career in Physics, the second with the role of the AIP (and NZIP also) as a learned or a professional society.

It was pointed out by several people that the emphasis of the Strategy Plan is primarily on research in Physics and as such, the career element is a progression through training to a PhD and a position as a researcher. The question quite rightly asked was: "What is being done to provide for a career for the Physicist who graduates with a pass degree?" Indeed, the question which might well have been asked is: "Does such a career exist?" Think back yourself and try to remember your colleagues or your students who did graduate with a first degree and went to paid employment rather than unpaid slavery as a postgraduate student.

Those who I can recollect became teachers (not many alas), entered medical instrumentation facilities (e.g., x-ray labs, radiation therapy centres), became public servants and some became experimental officers (or similar). You may easily add to the list, but are those who occupy such positions classified as Physicists? Is there enough such positions for the AIP to begin a real campaign directed towards firstly getting employers to recognise people in such positions with Physics qualifications as Physicists, then publicising these opportunities as part of the career structure awaiting Physicists? There should be no barrier to this, since a graduate with a degree in Engineering is an Engineer independent of the level of award of the degree - similarly a graduate in Psychology is a Psychologist, again independent of the level of award of the degree.

The group which classifies a person satisfying certain requirements as an Engineer or a Psychologist is the respective professional associations. If we can achieve a similar recognition of Physicists, what are the benefits to the Physics profession? If one considers NSW alone, about 10,000 students attempt the 2-Unit Physics subject at the HSC. Reasonable performance in this with some appropriate level of Mathematics is the usual advisory entry level for tertiary Physics. Suppose half the students satisfy this advisory level of prerequisite and of these, half again manage to major in Physics. We then have in NSW alone over 2,000 students trying for a Physics position. Some will go off to Engineering, etc.; indeed, suppose 90% do - we then have 200 possible Physics graduates. This will leave about 100 looking for a job as a Physicist.

Career terms, I would suggest that this would currently be a hopeless task.

It is essential that a proper career structure at all levels of performance as a Physicist should be identified. If we follow our professional colleagues, the AIP must play a major role in this. So to my next point, Are we a learned society or a professional society? At the Congress there were obviously two polarised points of view. Proponents of that which I call the learned society, advocated complete removal of the AIP from involvement in any decision which required choices to be made between the interests of different Physicists. The alternative view was that the AIP must make these decisions, otherwise we would run the risk of having major decisions which affect or indeed determine the course of Physics into the future being made by people without qualifications, except perhaps those of the professional committee sitter.

My own belief is that Physics as a profession will continue to suffer badly from all its current malaise unless the AIP as the Physicists' organisation gets to and seizes the opportunity to develop Physics. The AIP in my opinion must develop into proper accreditation, define what is to be a Physicist's job, determine courses to meet standards the AIP imposes, lobby Government, demand the right of input and indeed, representation on all the places which effect Physics and Physicists. We must do what the Engineers, the Psychologists, the Lawyers have done for many years. We must also get the job done before other groups, such as the emerging paramedical groups, move into areas which should use Physicists, but could be lost to such groups.

These are my opinions. As the disclaimer on page 1 says, they are not necessarily the opinions of the AIP or NZIP. Perhaps for once we might find out what the opinion of the AIP or NZIP ought to be. This is your chance, as a member of the AIP, to advise the AIP of the course it should take.

Letters to the Editor are open - let the community of Physicists read your ideas on a matter of quite fundamental importance to the Institutes.
I am a little surprised - even disappointed - that my paper has evolved into a defense of the Australian university system which I have known for 35 years; upon reflection, I have been forced to conclude that, while some sympathetic adjustment and sympathetic alteration of the system would have been very desirable, the wholesale enslavement and abuse which the Hawke government has visited upon us is absolutely disastrous. It will take, I suggest, at least half a century to rectify the damage when they are eventually thrown out of office.

Indeed, "renewal" in the form now required would not have been necessary if the bureaucrats of Canberra who are ignorant of the system had kept their fingers away from the workings.

1 Research

I first became fully aware of the impending disaster in 1988 when the Hawke government was emasculating the CSIRO. A CSIRO researcher leaving permanently for Holland wrote for The Age newspaper in Melbourne (29 Aug. 1988) an article headed "A rationalist quits science's sinking flagship. Do politicians understand science? Do they even care?"; while The Weekend Australian (1 Oct. 1988) published a long article which began "Australian science has entered a new Dark Age in which its funds, community support, staffing, physical resources and scientific morale are being whittled relentlessly away".

There is a long, tortuous and infrequently-travelled road from a discovery in fundamental research to a development which changes a society. Australian industry has been one of the worst in the developed world in contributing to this process. Everyone - except a few industrial apologists - is in agreement on this point, and I shall not pursue it further.

Having failed to convince Australian industry to play any significant role in changing Australia's economic base, the governments turned to the CSIRO and the universities; they would be forced not only to do the original research, but also develop the discoveries and, if at all possible, save the Australian economy! But this supposed strategy shows a monumental ignorance of the nature of the process, and particularly of research. True, primary-school children "research" a project, journalists "research" a story, MPs do "research" in the parliamentary library, but none of this is the research I am talking about. The research we pursue in universities is an attempt to discover new knowledge and to uncover new understanding.

This is an enormously difficult process, which requires trained and excellent minds, resources adequate to compete realistically against overseas laboratories, and time. To expect university staff to add the "D" of R&D to their existing load is simply stupid. It reminds me of the reply I wrote recently to my own university administration when it sought our views on a 50% reduction in mail and stores deliveries to departments and invited us to collect our own: we could also do the gardens around our building and clean the toilets, I said, if only the gardeners could do our teaching and the janitors could do our research.

It is also naive and ignorant to suppose that most of the meagre government research funding should be awarded to projects selected by bureaucrats to be "in the national interest". There are ample examples of the idiocy of this policy; here let me quote instead the recent words of one of America's leading research managers, John Gilman (Physics Today, March 1991):

Decision making about what research is worth doing illustrates how research activities are very different from development activities. For long-term scientific research...such decisions should be left to the practitioners. The wise have known this for a long time...Results cannot be generated by management, and especially not by the sponsor.

[Gilman then quotes at some length Peter Medawar's description of what has happened in the United Kingdom.]

This is a powerful condemnation of the current scene in research management at nearly all levels. The "Big Brother knows best" approach is irrational because in reality Big Brother knows nothing. That is, he knows nothing about the most important aspect of the research enterprise, namely, the unknown.

When the politicians, the bureaucrats and the public relations hustlers get into the research laboratory, then disaster is not far behind. It is easy for John Dawkins, Don Aitkin and others to claim to be wiser than the accumulated experience of 200 years of modern scientific research, but their arrogance will surely find them out. If you doubt me, read Frank Close's hastily written, poorly edited, but nevertheless frightening account of the cold fusion fiasco, entitled Too Hot to Handle (W.H.Allen, 1990).

I also wish to add a comment about postgraduate research students - or the lack of them - in our university science departments. Many, including our own, are populated by a high proportion of overseas students, some of them fee-paying, which our government encourages. In a recent discussion with an Australian entrepreneur who offered to recruit even
more of them, I asked if he had ever considered trying to encourage Australian students to stay on to undertake postgraduate studies. He admitted he didn't have a clue what I was talking about. I could have shown him the following item from a recent issue of the New Scientist magazine (6 April 1991); it is written for the U.K. but it applies equally well to Australia:

The fuss over the plight of the PhD student which surfaced in the late 1980s has largely dissipated. This is certainly not because PhD students are any richer...; it is because more of those with an eye on meeting the future demands of mortgages and other forms of domestic debt have voted with their feet and eschewed the delights of three years of poverty at the hands of a research council.

Germany does infinitely better, and you can read about their approach even in the newspapers (e.g. The Age, 19 Feb. 1991, 15 March 1991), but Australia's policy formulatores blindly follow British and United States models; but then I guess it's easier to read the documents in English rather than those in German!

2 Teaching

I now turn to teaching, one area where some sensitive and thoughtful intervention from government could have been very influential and may even have been welcomed. Instead, we have the jackboot approach and the Unified National System. The Minister, full of high-sounding rhetoric, says he wishes to improve teaching, and the stem has now been in place long enough for us to see some of its fruits:

a The average quality of students entering universities and their subject-specific knowledge base have both dropped alarmingly. In my own discipline of physics (supported by mathematics), for example, there is no doubt that students leaving secondary schooling have spent far less time studying it and know far less of it than their parents' generations did. At the same time, the frontiers of knowledge have now advanced far beyond where they were when I was a student. In quite simple terms, there is no way that we can take some of our students from high-school physics to worthy and productive physics graduates in the three years allocated to us - but we try.

b Because of these and other factors, teaching has become a far more intense activity. It is no longer adequate to open windows and doors for students, as scholars have done for centuries; it is now required and demanded that we teach like school teachers, so that our students never learn to study, to explore, to come to understanding, or to learn, in the full meaning of these terms.

c As you will all be aware, the numbers of students entering our universities has jumped substantially. Physically we cannot cope - lecture halls are too small, library facilities are inadequate, tutorials are a farce, and existing equipment is quite inadequate for laboratory classes.

d One might look at an increase in academic staff to help solve the problems, but the Flinders University study, of which you will also all be aware, has made it clear that there will be a massive shortfall in this area. Minister Baldwin, in perhaps the most ignorant response yet from a Ministry noted for its facility in this area, replied that the study had exaggerated the need for higher degrees, and that if only 50 percent of academics were required to have higher degrees, then the shortfall problem would virtually disappear. He would no doubt feel entirely at home in some departments of which I am aware: with the pool of qualified graduates small, and unable to compete against government and private-enterprise salaries and conditions, these departments have had to settle for second best. Some tutorial staff of my experience cannot even speak nor understand English adequately.

e I confidently assert that standards are dropping all over the country - in every university; given the factors that I have outlined above, what other result would you expect? But most of all, standards have been sacrificed at the altar of EFTSU-funding, the model which allocates funds to universities and departments on the basis of their number of students. Sounds reasonable; but think about it. What do you do if your subject is unpopular - like the sciences at present. You lower your entry standards and you make sure that as many students as possible choose your subject for a full three years; and to do this you make your courses as easy as possible, and you fail as few as your conscience will allow: so much for the "clever country."

f And finally there is the matter of resources. I have time for just two examples. Commonwealth operating plus capital grants per student have fallen some 25% in the last 15 years; and in the last three years in Victoria, which I know best, there has been a 28% growth in enrolments, a growth in recurrent funding of just 19%, and in space of a mere 5%. The Age newspaper noted: "Institutions simply do not have the cash or the classrooms to cope."

3 Reform?

I also want to say something about the Dawkins reforms - so called - in terms of their philosophy, but I hardly know where to begin.

On the question of forced amalgamations of universities with tertiary institutes and colleges, Professor Fay Gale, Vice-Chancellor of the University of Western Australia, has been one of the more eloquent critics (The Australian, 12 Sept. 1990, 14 Sept. 1991):

The so-called reforms had included a variety of mechanisms for increasing the levels of control and accountability... The kind of managerial processes talked about used terms like corporate planning, mission statements, strategic plans, etc.
she said. There was no evidence that such planning had been effective when attempted in various forms in education.

My main concern is that in today’s climate in Australia, quality is taken to mean not excellence but uniformity. If the traditional universities take the concept of excellence as their primary goal, then they are accused of being elitist. I think this is actually a very flattering accusation.

To me, two things stood out in my recent visit to German universities because they highlighted the dangerous paths down which I see Australian universities going.

The first factor was the considerable distance between traditional universities and Fachhochschuler. Germany has retained quite distinctive differences in its tertiary institutions because of its belief that the German society and economy need quite different forms of educational opportunity. The pride in each kind of institution and the importance of that difference were obvious everywhere.

The second thing that struck me most in Germany was the contrast between the western and the eastern universities. The collapse of eastern universities I found to be quite shocking. The crippling intellectual grasp of central planning in eastern Germany all done in the cause of equal opportunity, of egalitarianism, of freedom for the working classes, in fact all done, it would seem, from the highest of motives, led to imprisonment of knowledge and the withering of ideas.

The controls in the name of quality actually became controls in the name of intellectual death.

With many more students making the transition from secondary to tertiary education, what they need most of all is variety, choice and flexibility. Instead, they are increasingly faced with a common blandmange of mediocrity.

The most penetrating and nerve-tingling critique, however, has come from Hugh Streton, in the Sixth Wallace Wurth Memorial Lecture at the University of NSW in September 1989, and at a University of Adelaide graduation ceremony in 1990 (Aust. Universities Review, no.2, 1989; Lumen, 19(9), 1990). These scholarly orations should be read in their entirety, for I cannot summarise them. Let me make just one observation. In the former address, Streton asserts that the government’s plan “threatens the political and intellectual independence of much Australian scientific, social and political research”, and creates “powers which are evil if they are to be used, and if they are not, are a waste of money and public servants.” They are being used, and they are evil, in the full meaning of that word.

4 AVCC

One body which has remained strangely silent throughout the recent troubled times is the Australian Vice-Chancellor’s Committee, although its individual members can be quite vocal. I am told they have been working behind the scenes, but publicly the AVCC does very little more than produce a series of media releases, which usually support government actions.

One major reason for this approach is not hard to find: most vice-chancellors have ceased to be supporters and spokespeople for their staff and students and have become instead “managers” of their institutions in an outdated sense of that term. Thus, for example, when academic salaries and conditions had deteriorated to a disgraceful extent and university staff began exercising their limited industrial muscle, the vice-chancellors met at Erskine House at Lorne on the Victorian coast and agreed to continue their opposition to any improvements in staff conditions. Pressured by individual staff associations, a few vice-chancellors eventually rebelled against the enforced caucus, their secret agreement split wide open, and university staff were quickly granted the improvements to which even the government realised they were entitled.

But, of course, I am naive to have hoped that the AVCC could speak with a united voice on the plight of Australian higher education, although I am not alone in my naive One of Melbourne’s most experienced journalists noted in The Age recently (25 March 1991):

> The big question is why some of the most powerful education organisations in Australia allowed Mr Dawkins to have his way. Opposition to the Dawkins’ plan was certainly fierce, yet the opponents ended up looking like students at their first flagwaving protest and almost everything Mr Dawkins wanted was accomplished.

The vice-chancellors have far too much at stake individually and personally to be subjugated to a wider good. Let me give three brief examples:

a First, the obscene rush to acquire the trappings of the 1980’s entrepreneur: a chauffeur-driven car, a $2M house on Sydney Harbour or, to quote a Canberra newspaper (Canberra Times, 21 June 1991), “and then, in the event of the Vice-Chancellor of the University of Canberra being so unwise as to make frequent visits to his campus, Red Hill [the site of his new mansion] is no distance at all from the campus when traversed in the helicopter one feels sure the university will furnish.” And all, as the same article says, “at a time when the vice-chancellor is preaching cost-cutting and frugality, and is trying to have the university’s courses taught by barefoot academics.”

b Early in 1988, Mr Dawkins met with the AVCC in Perth, where he was asked quite directly what would happen if all the universities refused to join his proposed Unified National System. He replied that he would have to resign. (This story has been confirmed to me by more than one person who was present.) A golden opportunity was apparently lost.
COMMENT

As part of the process of forced amalgamations, colleges and institutes have become targets for take-over or for indifference. Sometimes universities have been in fierce competition to woo a prospective partner, at other times they have been cold and aloof. Attempts have been made to fracture some institutions, so that a “desirable” department can be captured by one university while leaving its less desirable departments to amalgamate with another or to flounder alone.

Following the release of the report of the McColl Committee, which recommended a major reduction in the number of “providers” of agricultural education in each Australian state, an odious battle has broken out in some states in order to capture the favoured status for a particular university. Competition has become the watchword of the vice-chancellors and cooperation has been a notable casualty, just when it was most sorely needed.

5 University?

What sort of university, then, do I have in mind? The answer, I have to say, is not new; it has, in fact, been around for about 900 years. Others are so much better than I at giving expression to these ideas; I mention just a few from my “cuttings” file:

Universities seek to produce graduates who, to quote Professor Ward, the late Vice-Chancellor of Sydney University, “can combine reasoned enquiry and criticism with a large tolerance, can enjoy debate without partisanship and can be articulate on great subjects without embarrassment.”

Sir Gustav Nossal lists four purposes of a university: as a repository of accumulated knowledge; to transmit knowledge; to create new knowledge through the process of research; and to use its knowledge and wisdom to test and challenge society’s values. And what is knowledge? To Dr Davis Mc Caulghey, churchman, academic, and currently Governor of Victoria:

...knowledge satisfies a direct need of our nature. Human life is only tolerable if we prefer the truth over a lie, information rather than ignorance, correction rather than mistakes. That commitment is institutionalised in universities: their end is knowledge.

The philosopher Peter Herbst wrote recently:

The university is a place for teaching and enquiry. It brings students into contact with their own and other people’s cultures; it expands horizons and it enriches people’s lives.

University education does not consist in the mere dissemination of information. Neither does it stop at training students in set skills. On the contrary, the critical faculties and the creative powers of the students are involved. University education aims at a depth of understanding beyond mere technical competence.

Education is quite distinct from training.

In conclusion, may I remind you that, in 1988, the University of Bologna in Italy celebrated its nine-hundredth anniversary, and ceremonies were held during which the universal and long-standing moral and intellectual values and the independence of university teaching and research were reaffirmed. In Australia, after the histrionics and grand-standing of the current changes and debate have subsided, perhaps the visions and lessons of history will quietly rise to the surface and reassert themselves. Then “renewal” will have been truly accomplished. •

THE ECHO OF LIGHT FROM SUPERNOVA 1987A

THE FIRST COLOUR PICTURE

by David Malin at the Anglo-Australian Observatory

This picture, reproduced on this month's front cover shows two complete rings of light surrounding supernova 1987A. They are from light which is scattered towards us from two sheets of gas, each of which contains many tiny dust particles. Small irregularities in the orientation and thickness of the dusty veils produces the splitting and variations in brightness of the rings. The material which makes the inner ring lies about 470 light years in front of the supernova, while the outer ring is about 1300 light years from the star that exploded. The supernova and the tenuous material revealed by its light are in the Large Magellanic Cloud, the nearest galaxy to the Milky Way at a distance of about 170,000 light years.

The colour picture is a fairly accurate reproduction of the colour of the extremely faint light echo, which in turn reflects the colour of the supernova when it was at its brightest, in May, 1987. The picture was made by subtracting the photographically enhanced images of three AAT plates taken in red, green and blue light three years before the supernova exploded from three similar plates taken in February, 1989, two years after the supernova was first seen. The subtraction process cancels that part of the image that is common to both plates, in particular the stars and nebulosity in the region, and reveals the differences between the two photographs, the light echo itself. This process is new and was devised for this application.

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NZIP ANNUAL REPORT

Minutes of Annual General Meeting

Date 12 noon, Wednesday
18 December 1991
Venue University of Auckland
Present Dan Walls (Chairman)
Graeme Putt
Matthew Collett
Paul Barker
Chris Tindale
Alex Chisholm
Alan Stamp
Jack Storey
Gary Bold
Dennis Burchill
Apologies John Harvey
John Clare
Paul Callaghan
Howell Round
Wes Sandle
Graeme Fraser
Keith Dawber
The Chairman welcomed members to the meeting.

1 Confirmation of Minutes of 1990 AGM
RESOLVED that the Minutes of the 1989 AGM be approved.
Barker/Tindale

2 Matters Arising
(i) Associate Membership - Wes Sandle
This matter had not yet been considered by Council and was referred for action to the next Council Meeting.
(ii) Student Travel Fund - Alan Poletti
The suggestion to use some of the reserve reported at the previous AGM to establish a fund to support students has been essentially thwarted because of the substantial reduction in the reserve incurred by deficits for the past two years. NZIP has met all requests for student travel assistance this year from general funds. It was agreed that it was presently not possible to consider this a viable proposition, and that student member travel requests continue to be considered on the basis of merit and existing funds.
(iii) Paul Barker enquired of action on
David Beaglish’s suggestion that Physics Department exchange Newsletters across the country. It was agreed that the Secretary initiate this from Auckland through Mrs Warde, the Auckland departmental Administrative Secretary for 1992.

3 President’s Report
The President’s report was read to the meeting. A written copy of the report is attached as an appendix to the minutes.

4 Branch Reports
Written reports from the Auckland, Wellington, Canterbury and Otago Branches were presented to the meeting. Brief comments of their activities were described by the Secretary. The meeting noted and commended the Wellington Branch on the success of its “Bringing Physics Research to Schools” project and on the vigour of its activities over the past year.

5 Education Sub-Committee Report
No report was presented to the meeting. This was accepted by the meeting subject to the Education Sub-Committee forwarding a report to Council at its first meeting in 1992 for acceptance at the next Annual General Meeting.

6 ANZ Physicist Report
Graeme Putt, who had acted as the New Zealand Associate Editor for the major part of 1991, reported on this item. Despite something of a hesitant start from the NZ side to the combined journal due to dislocations caused in the overlapping sabbatical leave periods of himself and Scott Whineray, there has been no difficulty in having NZIP news and items of interest published promptly. Newsworthy copy suitable for publication is always welcome and members are urged to contribute such information to the Associate Editor, Scott Whineray, for inclusion in the ANZP.

The cost of printing of the combined journal to NZIP members has been kept at the modest rate of $275 following an agreement he had negotiated on behalf of NZIP with the AIP earlier this year. That agreement essentially charges NZIP bulk membership printing costs of A$275 per issue for 1991, increasing to A$475 per issue for 1992. Air freight costs across the Tasman are typically A$250 per issue. The first three issues of 1991 were posted directly to NZIP members from Australia on the publisher’s presumption that this convenience for NZIP members would involve little if any extra cost. However posting and postage within New Zealand was resumed in May when it was found that annual savings of about A$1,000 would result. Whilst this method involves more work for the Executive it nevertheless provides a source of monthly postings to the membership which can be usefully exploited for other reasons.

7 Treasurer’s Report
The Treasurer, Matthew Collett, presented a balance sheet with accompanying notes to the meeting for the 15 month period covering 1 August 1990 to 31 October 1991.

In reply to a question concerning Royal Society charges, the Treasurer said the $2,554 figure listed was solely due to the administration charges for the period. There is an additional charge of $982 for affiliation fees that does not appear as the invoice for payment arrived after 31 October 1991. The Treasurer also agreed to obtain clarification from the Royal Society on how affiliation fees are determined.

It was RESOLVED that reports covered by items 3, 4, 6, 7 be received, the latter (Treasurer’s Report) subject to an approved audit.

Barker/Tindale

8 Annual Subscriptions for 1991/1992
A fax message from Keith Lassey, Graeme Coote, Rodger Sparks and Ian Vickeridge of DSIR protesting the subscription rates recommended by Council, namely, $120 (Fellows), $100 (Members), $50 (Retired Members) and $30 (Students), was read to the meeting. The President...
spoke of the need to increase subscriptions to meet the increased costs of running the Institute to produce a modest surplus in view of the substantial deficits incurred over the past two years. Alan Stamp cautioned that despite the need to rationalise current subscription levels the recommended increases were sufficiently high to result in resignations because of difficult economic times. Chris Tindall and Alex Chisholm, in consultation with the Treasurer, suggested an amended rate of fees for Fellows and Members of $100 and $85 that they felt would cover the projected costs for 1992 operation. The meeting then approved subscription rates for 1991/92 as: Fellows $100; Members $85; Retirees $50; Students $50.

Tindall/Chisholm

9 ELECTION OF OFFICERS
 RESOLVED that the existing officers be re-elected.

Bold/Stamp

10 OTHER BUSINESS
 A letter received from Keith Dawber (Otago) suggesting that NZIP combine with The Royal Astronomical Society of NZ in organising a tour to Bolivia in November 1994 to view the forthcoming solar eclipse was referred to the next Council meeting for consideration.

The meeting concluded at 1.45pm, there being no further business.

G D Putt
Honorary Secretary NZIP

President's Report

This year was the first year in which we joined with the Australian Institute of Physics to produce a single publication, "The Australian and New Zealand Physicist".

The response to receiving this journal has been positive and it gives our members access to activities in a larger physics community. I would like to see the New Zealand content of the journal increased. The onus is on us to send more items for publication. A consequence of this new journal has been increased costs. This together with a greatly increased expenditure on school prizes has lead to a deficit for the third month period of $9,102. This followed on a deficit for the preceding nine month period of $3,119. Clearly this could not continue and the Council has recommended to increase the fees to $100 for members, $120 for Fellows and $50 for Students and to retire members. I note that this is still below comparable fees for other scientific societies, e.g. NZIC Members $140, AIP Members $120. This new fee structure will allow our society to operate within its budget.

The number of Physics Teachers joining as members continues to increase. They now make up over one half of our members and are a special strength of our society.

In keeping with our closer co-operation with the Australian Institute of Physics, John Harvey attended their AGM in Melbourne in February 1991. Both John Harvey and myself will attend their AGM in an February 1992 which will be held during their Congress in Melbourne. I have been invited to present a Plenary Lecture at this Congress. In return we have invited Tony Thomas, President of the AIP to give a Plenary Lecture at our Conference next August.

Graeme Putt and myself represented the NZIP at the opening of the Rutherford Birthsite project. This is a magnificent tribute and I can strongly recommend it to all members to visit if they are in the Nelson region. I congratulate John Campbell on his efforts which originated this project and brought it to fruition.

Preparation is well underway for our National Conference which will be held in Auckland in August 26-28, 1992. A call for papers and registration forms will be mailed in March 1992. I look forward to seeing you all at this meeting. We will have some exciting talks from local and overseas physicists.

The Education Committee of NZIP has once again been very active and I thank its Chairman Trevor Castle for his tremendous work in promoting Physics in New Zealand High Schools.

Finally I wish to thank all members of the NZIP Council and especially the Honorary Secretary Graeme Putt and the Honorary Treasurer Mathew Collett for their work for the Institute.

D. Walls
President

Treasurer's Report

FOR THE PERIOD ENDED 31ST OCTOBER 1991

1 Because the accounts were closed early last year (for the NZIP conference), these accounts are for a five month period, including the period of the conference.

2 The cost of the NZ Physicist given ($1689.65) is for printing only, while that for the Australian Physicist and ANZ Physicist includes postage from Australia to New Zealand. Postage within New Zealand is itemised separately. The Australian Physicist was supplied to us at run-on cost for the latter part of 1990; we paid a flat charge of AS4425 for the ANZ Physicist for 1991.

3 Expenditure on school prizes has increased from $920.00 to $3010.00, reflecting the increase in the number of school members of the Institute.

4 The overall deficit for the period is $9102.96, representing a reduction by almost half of the accumulated funds of the Institute.

M.J. Collett
Honorary Treasurer NZIP

The 14th Triennial URSI International Symposium on ELECTROMAGNETIC THEORY
Sydney, Australia
17-20 August 1992

For further information contact:
Chairman of Organising Committee
Dr. G. L. James
CSIRO Division of Radiophysics
Marsfield NSW Australia
Ph: (02) 868 0222
Fax: (02) 868 0400

Australian & New Zealand Physicist Volume 29, Number 3, March 1992
## NZIP ANNUAL REPORT

### NEW ZEALAND INSTITUTE OF PHYSICS (INC.)

**Balance Sheet as at 31st October 1991**

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<td>Accumulated fund as 1st August 1990</td>
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<td>Deficit for year to 31st October 1991</td>
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<td>10,800.86</td>
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Represented by:
- BNZ Current Account: 2,688.77
- BNZ Autocall Account: 3,109.06
- BNZ Term Deposit: 4,003.03

$10,800.86

### STATEMENT OF INCOME AND EXPENDITURE

**For the period 1st August 1990 to 31st October 1991**

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<th>Expenditure</th>
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<td>Deficit</td>
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</table>

NZ$28,779.48

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### ATTENTION

**NEW ZEALAND VACUUM USERS**

The Vacuum Society of Australia

is interested in contacting the

New Zealand Vacuum Representative Society

to discuss amalgamation and other issues of mutual interest.

Please address responses to

Dr Don Swingler
CSIRO, Materials Science & Technology,
Clayton VIC 3168
Phone (03) 542 2883
Fax (03) 542 2883

OR

Assoc. Professor D.J. O'Connor
Department of Physics
University of Newcastle NSW 2308
Phone (049) 21 5439
Fax (049) 21 6907

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### FIRST ANNOUNCEMENT

of the

ICPE

Conference on

Physics Education for Development

to be held in

the Philippines

from

1-5 December 1992

For further information and registration forms immediately contact

Prof. Geoffrey I Opat
School of Physics
The University of Melbourne
Parkville, Victoria
Australia 3052

Phone: (03) 344 5121
Fax: (03) 347 4783

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**Writers of Articles**

**to be published in**

**the Physicist**

please supply your full christian and surname to be printed directly under the title of your article and a short blurb of your affiliation and contact address for inclusion in the tinted box at the foot of the first page of your published article.
Plane Transverse Electromagnetic Waves?

G.J. TROUP & M.A.B. DEAKIN

Very recently, experiments involving laser beams focussed by lenses of focal-length to diameter ratio $F$ of $\sim 1.5$, have required taking into account the longitudinal components of the electric field in the focal region, in order fully to explain the results.

A simple, essentially perturbative, calculation for a plane wave with cylindrically symmetrical distribution of intensity about the direction of propagation gives expressions for the longitudinal field components. This treatment is shown to agree exactly with an earlier, more rigorous method.

The perturbative treatment is easily assimilated by 3rd year B. Sc. students. In view of the experiments referred to above, this should be taught routinely, not as a curiosity. Another field where these longitudinal components must be taken into account is quantum electrodynamics.

Introduction

The fact that the electromagnetic field in the focal region of a lens may have longitudinal components of the electric field $E$ and the magnetic induction $B$ is simply not discussed in most modern textbooks on optics. Nor is the fact that this can be true also of essentially plane, unguided electromagnetic waves discussed in modern books on electromagnetic theory. Since, for a lens, these components only become 'appreciable' for a focal length to diameter ratio $F < 4$, and since the first work on this topic appeared in 1919 (Ignatowski, 1919)$^5$, this is perhaps not surprising. It would be fair to say that the phenomenon was regarded as a curiosity, with perhaps some use of the advent of very high power lasers (Bois and Wolf, 1965)$^6$. However, this is no longer true, since recently (Boreham and Hora, 1979; Boreham and Luther-Davies, 1979)$^7$ experiments have been performed which require the inclusion of these longitudinal components for a full explanation of the results (Cecchielli, Hora and Postle, 1990)$^8$. We therefore contend that those of us who teach electromagnetic theory or advanced optics can no longer ignore the presence of these components, and should teach students about them if we are (as we should be) teaching 'at the cutting edge'.

The experiments involved measuring the distribution and energy of electrons ejected radially from a plasma excited by a high power laser beam focussed by a lens for which $F = 1.5$. There is a non-linear 'ponderomotive force', $\phi_{NL}$, given by Hora (1969)$^9$ as

$$\phi_{NL} = -\nabla (E^2 + H^2) / 8\pi,$$

which acts on the electrons. If the exciting focussed field is plane polarised, and the longitudinal components of $E$ and $B$ are ignored, an asymmetry in the energy and distribution of the electrons ejected from the plasma is predicted. However, this is not what is observed: the electrons are ejected symmetrically, and the energy distribution is symmetrical. This is explained only if the longitudinal components are taken into account.

In what follows, we derive the presence of the longitudinal components for plane waves having a symmetrical distribution of intensity, with the maximum along the direction of propagation, by a simple, essentially perturbative, technique. Our results are compared with those of a more rigorous treatment of the problem by Lax, Louisell and Knight (1975)$^9$, and are shown to agree for the Gaussian beam profile. Finally a discussion is given together with further references.

Simple Derivation of Longitudinal Components

Assume an electromagnetic wave (nominally plane) propagating along the $z$-axis, such that

$$E_x = iE_0 e^{j\omega t - jkz},$$
$$B_y = jB_0 e^{j\omega t - jkz},$$

where $\omega$ is the angular frequency, $k$ is the wave number and $i$, $j$, $k$ are unit vectors along Ox, Oy, Oz respectively. MKS units are assumed so that

$$E_0 = c B_0, \quad c = (\mu_0 \varepsilon_0)^{-1/2}$$

where $c$ is the speed of light in vacuum and $\mu_0$, $\varepsilon_0$ are respectively the permeability and permittivity of free space.

G. J. Troup is in the Department of Physics, and M. A. B. Deakin is in the Department of Mathematics, Monash University, Clayton, Victoria, Australia.

Australian & New Zealand Physicist Volume 29, Number 3, March 1992

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PLANE TRANSVERSE ELECTROMAGNETIC WAVES?

Suppose now this plane wave has a cylindrically symmetrical variation of \( E \) and \( B \) about the \( z \)-axis, with a maximum on the \( z \)-axis. There will be a characteristic 'beam-width' \( W_\phi \), e.g. the half-power beam-width, or the distance between the 1/e points for a Gaussian beam: we suppose \( W_\phi \) is large, and that we may approximate the maximum by a parabolic distribution (this is indeed the generic case; it holds with probability 1). Then, for some constant \( a \), \( E_0 = E'_0 [1 - a(x^2 + y^2)/W_\phi^2] \) with an identical expression for \( B_0 \) and \( B'_0 \) (see Fig. 1).

The curl equations are

\[
\text{curl } H = j\omega c E \quad \quad (4)
\]
\[
\text{curl } E = -j\omega c B \quad \quad (5)
\]

From Equations (2) and (4) we see that the \( z \)-component is given by

\[
\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} = \frac{1}{\mu_0} \frac{\partial}{\partial x} \left( B'_0 \frac{2ax}{j} \right) - \frac{\partial}{\partial y} \left( B'_0 \frac{2ay}{j} \right) = -j\omega \varepsilon_0 E_z
\]
whence, using \( c = \omega/k \) and Equation (3), we obtain

\[
E_z = \frac{E'_0}{j} \frac{2ax}{kW_\phi^2} = E_{z0}^* \quad (6)
\]

Similarly, using Equation (5), we obtain

\[
B_z = \frac{B'_0}{j} \frac{2ay}{kW_\phi^2} = B_{z0} \quad (7)
\]

If we now substitute \( E_z \) in (5) and \( B_z \) in (4), we obtain the contribution of the respective components to the original transverse components. If we call these contributions \( E'_x \) and \( B'_y \), we obtain:

\[
E'_x = aE'_0/(kW_\phi^2) \quad \text{and} \quad B'_y = aB'_0/(kW_\phi^2) \quad (8)
\]

which are clearly negligible when \( kW_\phi \) is large, as assumed.

Further, we observe that both \( E_x \) and \( B_y \) are in phase quadrature with \( E_x \) and \( B_y \), respectively. On a circle of radius \( r \), defined by \( r^2 = x^2 + y^2 \), we shall find that, if we choose the zero of the azimuthal angle \( \phi \) about \( Oz \) along the \( z \)-axis, we will have components

\[
E_x = E_{x0} \cos \phi
\]

Figure 1. The parabolic approximation compared with, as an example, a Gaussian. The width of the Gaussian has been normalised to unity. At this point, the width of the parabola is \( X = 0.795 \). The values of \( x \) such that the parabolic approximation is valid are \( x \ll X \), or in unnormalised units, \( x/W_\phi \ll 1 \).

\[
B_z = B_{z0} \sin \phi
\]

The result (6) is in total quantitative agreement with the more thorough treatment of Lax, Louissell and Knight (1975)² for a Gaussian beam: \( a = 1 \), who define

\[
E = E_t + kE_z = e^{jkr} (F_t + kF_z)
\]
and set \( V = F_t + k\delta \) \( \delta z \), where \( V_t \) is the transverse gradient. They then obtain equations for the transverse and longitudinal components, \( F_t \) and \( F_z \) using

\[
\text{curl } \text{curl } E = (\omega/c)^2 E
\]

and scaling the equations, using \( x = W_o^* t \), \( y = W_o^* \eta \) and \( z = t \zeta \)

where \( t = kW_\phi^2 \)

They then show that in terms of the parameter \( f = 1/(kW_\phi) \)

\[
F_t = fF_t^{(0)} + f^2F_t^{(2)} + \ldots
\]
\[
F_z = fF_z^{(0)} + f^3F_z^{(3)} + \ldots
\]

the superscripts here denoting the orders of the terms in \( f \).

Our previous simpler treatment is also in agreement with this. The question then arises: how large is 'large' for \( kW_\phi \)? Boivin and Wolf (1965)² suggest that the ordinary (scalar) wave solution holds for lenses of focal length to diameter ratio of 4 or larger; this implies a beam diameter between the first zeroes of the diffraction pattern of 8A x 1.22. Since we are concerned about orders of magnitude, we may take the approximation to be \( W_o^* = 4A \). In this situation, \( kW_\phi = 24 \), so we should not use either the solution we have derived, nor that derived by Lax et al., for \( kW_\phi < 20 \), say.

It may seem strange to have a plane wave front only 10 or 20 wavelengths wide, but it must be remembered that we are talking about an effective width, brought about by the distribution of intensity over the wavefront. The idea is constantly used in first year optics, e.g. in the Rayleigh criterion for the resolving power of a lens.

There is another approach to obtaining the ratios of \( E_{z0} \) to \( E_0 \) and of \( E_x \) to \( E_{x0} \); this is the Buckingham Pi Theorem 7 (see Fig. 1).

The formulae connecting \( E_{z0} \) and \( E'_0 \) will involve those two variables as well as \( x \), \( k \) and \( W_\phi \). There are precisely three independent dimensionless ratios that may be formed from these five quantities and these must be connected by a functional relation. Thus

\[
\frac{E_{z0}}{E_0} = \Phi(kW_\phi, x/W_0)
\]

We are interested in \( kW_\phi \) large and \( x \) sufficiently small in relation to \( W_\phi \) to ensure the validity of the parabolic approximation. If, therefore, we assume \( \Phi \) to be analytic in its arguments, we may truncate a Laurent series in the first and a Taylor series in the second and so reach

\[
\frac{E_{z0}}{E_0} = C \frac{1}{kW_\phi} \frac{x}{W_\phi}
\]

where \( C \) is a constant.

Equation (12) is the same as Equation (6) except that the latter also gives information as to phase. P-
PLANE TRANSVERSE ELECTROMAGNETIC WAVES

Discussion

It is clear that the simple, perturbative approach we have used to derive the presence of longitudinal components of $B$ and $E$ in plane waves where the intensity varies symmetrically across the wave-front could be appreciated by students at the third year B.Sc. level. It has the advantage of comparative brevity, while the more rigorous and elegant treatment of Lax et al. (1975) is somewhat longer by reason of its thoroughness. The presence of longitudinal components can also be deduced by the 'spectrum of plane waves' approach (see e.g. Stratton, 1941), but again the mathematics are more complicated than in the approach we have used.

Another field in which the inclusion of longitudinal components has become necessary is that of quantum electrodynamics. The so-called 'Volkov solution' for a Dirac electron in a plane wave not only does not involve the longitudinal component, but suffers from the further defect that the solution cannot involve the vacuum polarisation, since it is precisely the longitudinal components of $E$ and $B$ but not $B$ alone which can polarise the vacuum, while a plane wave cannot (Toll, 1952; Bunkin and Tugov, 1970; Troup, Derlet, Hartin and Perelman, 1991). A suitable method to include the longitudinal components of the field needs to be found for quantum electrodynamics.

Finally, we give a number of extra references for the interested reader. We do not claim that this list is complete.

References

8. See (e.g.) C. M. Fock, Dimensional Methods and their Applications (London: Edward Arnold, 1953), p. 43.

Further references

R. Burtin, Optica Acta 4: 124 (1957)

Acknowledgement

One of us (G. I. T.) is grateful for fruitful discussions with Prof. Laura Ronchi-Abozzo, Istituto di Richerche sulle onde Electromagnetiche del CNR, Florence, Italy, during an Outside Studies Program in 1990.

29TH ANNUAL GENERAL MEETING

The 29th Annual General Meeting of the Australian Institute of Physics will be held in conjunction with the April meeting of Victorian Branch, at 8.00 pm on Thursday 21st May, in the Hercules Theatre of the School of Physics, Melbourne University.

Agenda

1. Apologies, recording of proxies
2. Minutes of the 28th Meeting
3. Business arising
4. President's report
5. Treasurer's report
6. Appointment of Auditors
7. MOTION to rescind the motion passed at the 28th Annual General Meeting
8. Granting permission to transfer the AIP to being an Association incorporated under the Victorian Associations Act and so to leave the Australian Institute of Physics as an Australian Company limited by guarantee. The motion will be moved from the chair.

J. D. Riley, Honorary Secretary

Australian & New Zealand Physicist Volume 29, Number 3, March 1992
An Ode to Murphy's Law

The mighty names of science now with reverence we forth tell:
Democritus and Kepler, Aristotle, Becquerel,
Copernicus and Fleming, Kelvin, Lenz and Faraday,
And Rutherford, and Röntgen who discovered the X-ray.
'Twas Newton who revealed order and determinism,
And made a pretty pattern with a light-beam and a prism:
A man of principle indeed, and learned too in classics:
With his Principia he founded classical mechanics.
This sure illumination though was soon to be destroyed,
And nothing really was, not even "atoms and the void".
For Einstein changed the very meaning both of space and time,
With shrunken rulers, bended light and circular straight lines.
He also helped to bring to light the strange world of the quanta,
And abolished Newton's certainty, although he didn't want.
With a cat, a pot of poison and a source of radiation,
You could prove the paradox, if you'd enough imagination.
After Fermi, Bohr and Schrödinger, statistics proved the best -
Could the Word of St John's Gospel be Alea Jacta Est?

But for physicists at A-level some certainty is left:
Of one fundamental principle at least we're not bereft.
There is one truth incorruptible of which we can be sure:
It's the absolute, immutable, eternal Murphy's law.

You'll achieve superconductance at around 300 K
With a twelve megohm resistor that worked fine the other day.
You'll get alternating current from a standard Weston cell
While a sinusoidal signal gives you DC very well.
Light rays will not interfere: ergo Newton got it right,
And it's plain old-fashioned corpuscles that give our eyes their sight.
Furthermore, momentum vanishes, and energy appears,
Thus disproving basic principles we've understood for years.
With some wax and a thermometer you'll come across cold fusion
Either that or Newton's cooling law is nothing but delusion.

Wheatstone bridges will not balance, and there's surely something wrong
When you calculate you'd need a wire thirty miles long.
Kirchhoff's laws hear no relation to the currents at a node,
Nor is EMF the total voltage drop across your load.
You will grow to hate the pendulum, simple, conical and torsional,
And beware of trying to demonstrate that two things are proportional:
Straight-line graphs become ellipses of alarming eccentricity,
And you cannot really argue that it's due to relativity.
Nor in practical exams, when you've become a nervous wreck,
Can your error be attributed to quantum effects.
No: the best thing you can do is simply fiddle your results -
I find logarithmic graph paper conceals a lot of faults.
But it's not just lab experiments to which the law applies:
It affects your theory just as much: your tans and es and rs
Murphy's Law of Integration states that in your mental fog
You'll get muddled up completely and write sinh instead of log.
Just remember that all variables are constants and vice versa,
And that as your maths gets better your arithmetic gets worse.
So feed all number crunching to your trusty calculator:
You may still get it wrong but thus your chances will be greater.

It's enough to drive you mad, and yet you've got to persevere -
A proficiency in doublethink will keep your judgement clear.
A particle-electron and a wave are both the same:
There is no paradox except our clumsy human names.
And both physics as a subject and the physics taught at school
Are full of fascination, though they make you feel a fool.
For at last all understanding fails, and but one fact remains:
That the ways of God, and of His universe, are very strange.

Jenny Coombs
Nottingham High School for Girls, Nottingham, UK
Reprinted From Physics World, January 1992
Cold, Muon-Catalyzed Fusion
Just Another Swarm Experiment?

R.E. ROBSON

Most readers will be aware of the intense but short-lived excitement generated in the scientific community by the announcement of Pons and Fleischmann (1989) concerning ‘cold’, room-temperature fusion putatively achieved by infusion of deuterons into a palladium electrode from an electrolyte containing heavy water. Another Utah group, led by Jones (1989), also reported indications of electrolytically-induced cold fusion, though with an associated neutron flux many orders of magnitude less. The story unfolded almost day by day in the press with much gossip in the electronic mail. At the time of writing, the situation, as perceived by physicists at least, seems to be that the Pons-Fleischmann results are not indicative of fusion (see, e.g., Close, 1991). However, there is a school of thought (Bockris 1991) which sees something more positive in their data.

We do not wish to dwell on this contentious issue but rather the purpose of this article is to deal with another form of cold fusion, known for over forty years (Frank 1947, Alvarez et al 1957) and free from any of the above-mentioned controversies. This is, of course, muon-catalyzed fusion (μCF), whereby the Coulomb barrier associated with positively charged nuclei is nullified to a large extent through tight binding with the negatively charged, relatively massive muon ($m_\mu = 207 m_e$), enabling fusion to proceed at much lower energies than for ‘bare’ nuclei. It is no coincidence that one of the previously-mentioned cold fusion advocates has been prominent in this area too (Jones 1986, Van Siclen and Jones 1986). As there are many excellent reviews of μCF available (Jones 1986, Rafelski and Jones 1987, Breunlich and Kammel 1989, Ponomarev 1990) only the minimum of detail will be given here. Instead, we wish to focus on the similarities between muons in heavy hydrogen and traditional ‘swarm’ experiments (Huxley and Crompton 1974, Mason and McDaniel 1988), where low-energy ions or electrons are driven through a neutral gas by an external electric field, and to examine if and how the experience in one field may be fruitfully applied to the other.

The technological importance of studying low-energy electron swarms in gases was the subject of a recent review in the Australian Physicist by Crompton (1988). Although the actual experimental situations are different (compare the μCF chamber shown by Rafelski and Jones, 1987, with the drift tube apparatus described by Huxley and Crompton 1974), it is no problem theoretically to replace electrons by muons in kinetic theory analysis, and thus from this perspective μCF may be considered as a problem in swarm physics (and even added to Crompton’s list of applications, to take a further liberty!) The role of the external electric field is particularly significant in this context, as explained by Ness and Robson (1989) and outlined further below.

Muon Catalyzed Fusion

It has long been known that the addition of muons to dense mixtures (number density $n_\mu \sim 10^{20} m^{-3}$) of hydrogen and its isotopes catalyzes nuclear fusion at low temperatures $T_\mu$ but it is only recently that the process has been viewed as a serious contender for an energy source. This re-awakening of interest has been largely due to perseverance by Russian researchers (Vesman, 1967; Vinitsky, 1978, 1980; Gerstein and Ponomarev, 1977) and the observation that fusion yield is quite sensitive to the temperature, density and composition of the isotope mixture. Attention nowadays is particularly focused on the reaction

$$D + T \rightarrow ^4He + n + 17.6 \text{ MeV}$$

just as it is in the ‘hot’ fusion program ($T_e \sim 10^8 K, n_e \sim 10^{20} m^{-3}$). The best result achieved so far is that a single muon can catalyze $x \sim 150$ fusions (Los Alamos Meson Physics Facility). An important distinction between ‘hot’ and ‘cold’ fusion processes, is that the latter involves only extremely dilute concentrations

R. E. Robson is in the Physics Department, James Cook University, Townsville, Queensland, Australia.
Figure 1 *Greatly simplified mCF cycle with process rates*

of muons (and their reactive derivatives) with no plasma behaviour *per se* due to space-charge effects. There are therefore no anticipated containment problems with feedbacks (instabilities) which plague the hot fusion devices. The equations are for the same reason all linear, making theoretical analysis much easier in many respects.

In the quest towards scientific break-even (i.e., energy out = energy in), the following fundamental limitations must be addressed:

- Finite lifetime (2.3 μ sec) of the muon;
- Sticking loss of the muon to the α-particle produced in (1);
- Cost of muon production, through pion decay π⁻→μ⁻+ν;

If one optimistically sets the latter at 5 GeV, it can be deduced that the number \( x \) of fusions (1) produced by a single muon must be around 300 for scientific break-even, or twice the current best value.

An abbreviated schematic diagram of the μCF cycle is shown in Fig. 1.

Only the most important features of this cycle will be discussed here.

Firstly, muons produced by pion decay collide with deuterium or tritium and may, if captured, produce small, neutral \( \text{d} \text{μ} \) or \( \text{t} \text{μ} \) - atoms respectively. The isotopic exchange reaction \( \text{d} \text{μ} + \text{t} \rightarrow \text{d} + \text{t} \text{μ} \) is energetically favoured and proceeds quickly to produce even more \( \text{t} \text{μ} \) atoms. These may then penetrate the electronic shells of other deuterium or tritium to form muomolecular complexes, as shown in Figure 2. ♦

Figure 2 *The resonant muomolecular formation process \( \text{t} \text{μ} + D_j \rightarrow x(\text{d} \text{μ} \text{d} e^*) \text{ (Vesman 1967)}*

Fusion of the closely bound nucleus then proceeds quickly and muons are regenerated to catalyze further fusions, unless lost by sticking to the α-particle.
Fusion of the closely bound nucleus then proceeds quickly and muons are regenerated to catalyze further fusions, unless lost by sticking to the α-particle.

The second stage of the cycle, i.e., muomorphic formation, is by far the slowest. It should be noted that the process is a resonant one and depends critically upon the kinetic energy $u_{\mu}$ of the incoming $\mu$-atom. This, in turn, is controlled by gas temperature $T_g$, the mole fractions $x_1$ and $x_2 = 1 - x_1$ of tritium and deuterium respectively and the recoil energy $u_{\mu}(\text{rec})$ of the $\mu$-atom following its formation. The muomorphic formation proceeds most rapidly when the average energy

$$\bar{\epsilon} = \frac{(m_\mu u_{\mu} + m_\mu \frac{1}{2} k T_{\mu})}{(m_\mu + m_\mu)}$$  \hspace{1cm} \text{(2)}$$

in the centre-of-mass of the colliding $\mu$-atom and gas molecule of mass $m_\mu$ is a few tenths of an electron volt (Cohen and Leon 1985). To a good approximation, the average energy of $\mu$-atoms in the μCF cycle after transients have died away is (Robson 1988)

$$u_{\mu} = \frac{\frac{1}{2} k T_{\mu} + r [x_1 u_{\mu}^{(\text{rec})} + x_2 u_{\mu}^{(\text{exch})}]}{(1 + r)},$$  \hspace{1cm} \text{(3)}$$

where $u_{\mu}^{(\text{exch})}$ is the energy of a $\mu$-atom produced in the isotopic exchange reaction and $r$ is essentially the ratio of the muomorphic formation rate to the non-reactive (i.e., elastic and inelastic) collision rates. (N.B. Equation (3) is deceptively simple in appearance, for $r$ itself also depends on $u_{\mu}$.) Equation (3), when solved with simple model cross sections and $u_{\mu}^{(\text{rec})}$ and $u_{\mu}^{(\text{exch})}$ fixed at 0.1eV and 1.4eV respectively, points to maximum yield for $T_g \geq 1200K$ and $x_1 = 0.6$ (Robson 1988). Temperatures of this order have yet to be achieved in experiment.

Apart from this 'bottleneck' in the μCF cycle, most work nowadays is concentrated on reducing the 'sticking' loss to the $\alpha$-particle, but a discussion of this aspect is beyond the scope of the present article.

μCF as a Problem in the Kinetic Theory of Swarms

In swarm experiments, a very low current comprised of sparse, low-energy (≈1eV) ions or electrons is passed through a drift tube containing a gas of neutral molecules, typically at room temperature. The applied voltage and/or number density $n_e$ of neutrals may be varied to give a range of energies $\epsilon$ in the centre-of-mass of the colliding swarm particles and neutral molecules. It is straightforward to show that the relevant field-strength parameter is $E/n_e$, usually measured in units of $\text{Td} = 10^{-21}$ V m$^{-2}$. Experiments determine transport coefficients (mobility and diffusion coefficients) which, with the aid of a suitable kinetic theory analysis, may be inverted to yield scattering cross sections. Both measurements and theoretical calculations nowadays aim at quite high precision with accuracies better than 1% in most cases.

In principle, as we have said, μCF may be regarded as a type of swarm experiment, complicated, however, by the myriad of processes which must be considered for the muons and their reactive derivatives. Energies (around a few tenths of an eV) are similar, but pressures (hundreds of atmospheres in μCF, a small fraction of an atmosphere in swarm experiments) are decidedly different. Both problems may be analyzed by the linear Boltzmann equation (or, in the case of μCF, sets of coupled equations), since mutual interactions between muons (and derivatives) in μCF and electrons or ions in swarm experiments are negligible. Gas temperatures $T_g$ are of similar magnitude and can and have been varied in both cases to influence the desired experimental outcome, but to date application of an electric field to optimize, μCF has not been considered by experimentalists. If $T_g > 10^9 K$ really is required to maximize yield in μCF, then engineers will have to face the difficult problem of containment of tritium at pressures in excess of one thousand atmospheres. The incentive for looking for an extra experimental handle, in the form of an external field, is obvious.

Instead of raising $T_g$ to even higher values to slot $u_{\mu}$ (and therefore $\epsilon$) into the optimal range for muomorphic formation we may also consider the possibility of fixing $T_g$ and varying $u_{\mu}(\text{rec})$ to achieve the same result. Straight forward calculations based on (2) and (3) indicate that increasing recoil energy from 0.04eV to 0.4eV while holding $T_g$ at 209K increases the efficiency of the cycle by over 27%. Ness and Robson (1989).
showed theoretically that recoil energy could in fact be influenced to this extent by application of an electric field which heats the muon swarm and thereby indirectly energizes the recoil muon following capture. The average energy $\bar{u}_r$ of the muons as well as $u_r$ (Rec) is shown as a function of $E/n_o$ for muons in pure deuterium at $T_e = 293$ in Figure 3. It can be seen that $u_r$ (Rec) increases by an order of magnitude (0.04 - 0.4 eV) as $E/n_o$ increases up to ~10^7 Td. The rate constant for mu-atom formation shows a pronounced maximum at $E/n_o$ = 800 Td (Figure 4) but this effect is of secondary importance to the 'field-tuning' of $u_r$ (Rec), which influences the real bottleneck in the cycle, muonmolecular formation.

Concluding Remarks and a Challenge

We have briefly reviewed the muon-catalyzed fusion cycle and have indicated how it may be likened to a swarm experiment. In particular, it has been pointed out that an external electric field can influence the properties of a muon swarm (and reactive derivatives), just as it can for ion and electron swarms. Since $n_o$, is typically around liquid hydrogen densities, very large fields, $E \geq 10^7$ V/m, would be required to achieve the desired outcome. This is presently achievable in small regions of intense laser focus, but it remains to be seen whether $\mu$CF experiments can actually be influenced in this way.

The challenge exists for experimentalists to see whether or not it is a practicable proposition to "field-tune" the $\mu$CF cycle in addition to (or instead of) the established practice of "temperature-tuning" only.

References

Rafelski J. and Jones S.E., *Sci. Amer.* July 1987, P. 66
Minutes of the 28th Annual General Meeting

held in the
Hercus Lecture Theatre
School of Physics
Melbourne University
on Thursday 14th March, 1991
at 8.10pm

1 Attendance
Prof A Klein (President) in the chair,
Dr J D Riley (Honorary Secretary) Dr
R Leckey (Registrar) Dr R Fleming
(Treasurer) and 22 members of the
AIP.

Apologies were received from
Professors A Thomas, J Collins, R
Crompton, F Smith.

2 Minutes
Minutes of the 27th AGM (Circulated
at the meeting) were approved (m J
Cashion, s R. O’Sullivan nem con)

3 Business Arising
No business arising.

4 28th Annual Report
The President formally presented the
28th Annual Report (Australian and
New Zealand Physicist April 1991) and
drew attention to some highlights.

5 Financial Statement
The treasurer presented the Financial
Statement and the auditors report. It
was moved that the financial statement
be accepted (m R Fleming, s J Cashion
nem con)

6 Appointment of Auditor
It was moved that Marquard & Co be
auditors (m A Klein nem con)

7 Notice of Motion
Notice was given of the following
motion.
That the Australian Institute of Physics
be changed from a Company Limited

by Guarantee under the Companies
(Victoria) Code (now registered as an
Australian Company) to being an
Incorporated Association under the
Associations Incorporation Act of
1981, without any changes to its aims
or objectives and with minimal
changes to its aims or objectives only
as required by the Corporate Affairs
Office.

(m A Klein nem con)

8 Election of Office Bearers
No further nominations were received
other than those notified with the
notice of meeting. The President then
declared the following elections:-
Prof A Thomas President, Professor R
Crompton Vice President, Dr R Leckey
Registrar, Dr R Fleming Treasurer, Dr
J Riley Secretary.

9 Other Business
There was no other business.

10 Closure
The meeting closed at 8.25pm.

TAS

Tasmanian Branch
Report to Council
February 1992

Branch membership remains at around
60, with activity centred around
Hobart.
The Tasmanian branch has seen very
limited activity over the past year due
to the small active membership and the
deferral of two planned speakers to
1992. As a result there were only two
visiting speakers. The first was Prof.
Donald Ivey of the University of
Toronto. His topic was “The
Sophisticated Scientist -Curmudgeonly
Ruminations of a Physics Teacher”.
Prof. Ivey discussed the teaching of
Physics to tertiary students and to the
wider community and questioned how
successful we have been in teaching
those aspects of physics that are not
easily assessed, such as an appropriate
physics ‘accent’. The second visiting
speaker was Prof. Roy Chisholm of the
University of Kent, who discussed
‘Number, Space and Time’,
emphasizing the geometrical concepts
underlying measurement processes and
the role reference frames give to the
meaning of coordinates. This led to a
description of new ideas for a theory
of elementary particles in curved space
from which the standard electro-weak
scheme emerges and which predicts
the mass of the top quark to be about
130 GeV.

Other branch activities included a two
day Professional Development Seminar
for year 11 and 12 physics
teachers attended by 35 people. This
represents most of the State’s physics
teachers at year 11/12 level. The
meeting covered a range of topics from
the Tasmanian Certificate of Education
and education techniques to pure and
applied research in Tasmania. The
meeting was acclaimed as a
resounding success.

Finally, the branch considered and
made some constructive criticisms of
the first draft of the Strategic Plan for
Physics.

Marc Duldig
Past President

PROFESSIONAL
DEVELOPMENT SEMINAR
Building the Physics Community

The Tasmanian Branch of the
Australian Institute of Physics
sponsored a professional development
seminar for grade 11-12 physics
teachers in colleges and independent
schools. The 35 participants included
most of the State’s physics teachers.
Several chemistry teachers also came
because the new Tasmanian Certificate
of Education course in Physical
Sciences at year 11/12 is a
combination of physics and chemistry.

The seminar was held on 9 and 10
December 1991, in the Physics
Department at the University of
Tasmania in Hobart. Within the theme,
Building the Physics Community, the
seminar had three aspects: to provide
input from physicists active in
fundamental research or applying
physics in the community; to provide
an opportunity for teachers to share
and develop their own excellence; and
to look at how the Physical Sciences
course may fit into the larger scheme
of education.

On the first morning three speakers
linked physics with the wider
community in Australia. Dr Paddy D-
Lynch, of the University Centre of Education, argued cogently that students' perceptions and understanding of physical reality are often very different from the perceptions which scientists have found and which we now accept. Hence students will not learn from us unless we recognise their starting point.

Dr Stuart Godfrey, from CSIRO Oceanography, discussed the measurement of sea surface temperatures and their relevance to our climate. Participants were impressed with the data he quoted showing how sea surface temperatures in spring can forecast Australian agricultural export earnings six months ahead.

Dr Barbara Shields, physicist with the state Health Department, described the history and significance of the recently revised radiation protection standards. Her description provided very useful background for teachers of the new Physical Sciences course which not only deals with the physics of the nuclear process, but also with the related ethical and community issues.

On the second morning the seminar heard illustrated lectures on two leading areas of research. Professor Bob Delbourgo presented a superbly illustrated account of chaos theory. Using computer-generated graphs of the successor value plotted against the antecedent, he showed the distinctions between randomness (as from a roulette wheel), linear deterministic laws, and chaotic behaviour of a non-linear although deterministic system.

Dr Ian Newman showed how ion conductance properties and behaviour of a single protein molecule, forming an ion channel in a membrane, can be studied. He showed his own data obtained at a current-voltage curve for a protein found in plant cells that conducts CI ions. Some such channels may be altered by stretching the cell membrane containing them and, this is a possible mechanism for the hair cells in our inner ear to detect the 10^-9 m amplitude of faint sounds.

The teachers showed their own enthusiasm (most have been teaching for 10-20 years) in sharing examples of teaching strategies. From their wide educational experience, they raised a number of significant educational issues. These included: the question of where the next generation of physics teachers will come from; the University of Tasmania's admission rules and how they affect students of physics; and what approach to physics and its teaching is helpful for non-academic students.

All agreed that the seminar had been worth while and that one with a similar format should be held in 1992, perhaps in conjunction with the chemistry teachers and the Royal Australian Chemical Institute.

Ian Newman

Invited Lecture at the Tasmanian Branch Annual General Meeting

Immediately prior to the Annual General Meeting, Professor Roy Chisholm of the University of Kent at Canterbury delivered a lecture on "Number, Space and Time". In his talk he emphasised geometric ideas underlying the measurement process and the role of the reference frames in giving meaning to coordinates. He ranged over various concepts in quantum field theory and general relativity and he finally presented his own ideas (in collaboration with Ruth Farwell) for a theory of elementary particles in curved space; he did this by invoking a frame field which plays a similar role to the vierbein in general relativity. By extending the dimensions of that field he was able to sketch out a model in which the top quark mass is predicted to have a value of about 150 GeV.

The first meeting of the SA Branch for 1992 was on the evening of January 22nd and was attended by about forty people who were taken on "A Physicist's Tour of Mawson Base" by Dr. Penne Greet of the Australian Antarctic Division's Aural and Space Physics Group. Dr. Greet was in Adelaide, as the guest of the SA Branch, to participate in the annual Physics Summer School, run each January by the University of Adelaide for intending Year 12 Physics students.

The Mawson Base is one of four Antarctic bases operated by the Australian Antarctic Division and with its complex and varied scientific program, is perhaps the most interesting from a scientist's point of view. To introduce her audience to the base Dr. Greet took them, with the aid of a large number of her own photographs, on an illustrated "walking tour" of the various experimental sites.

From the physical and electromagnetic isolation (15 minute walk in good weather) of a CSIRO experiment studying the magnetosphere via micropulsations of the earth's magnetic field, the audience were taken past the dog lines, a subject of much topical debate to the University of Tasmania's cosmic ray laboratory. Here the University of Tasmania would seem to have established the ideal experiment for a harsh environment. Their equipment, which monitors the flux of cosmic-ray neutrons and muons, runs largely unattended, returning the majority of its data directly to Hobart for analysis. On leaving the cosmic-ray laboratory we headed towards the aeronomy building which housed the equipment Dr. Greet was most familiar with.

In the early 1980's the University of Adelaide's Mawson Institute for Antarctic Research, under the direction of Dr. Fred Jacka, designed, constructed and installed at Mawson Base a Fabry-Perot interferometer for studying the dynamics of the upper atmosphere. Early work with the interferometer concentrated on oxygen emissions, originating at an altitude of about 250 km, which provided data on the winds and temperatures in that region of the thermosphere, for comparison with model predictions. Dr. Greet's interest has been in using the interferometer to study sodium emissions which contain information on the winds and temperatures at an altitude of about 90 km. In particular she has been concerned with the hyperfine structure of the sodium doublet, as the relative intensities of the hyperfine lines provide a measure of the temperature in the emission region.

Having successfully expounded the theory behind the measurements, Dr. Greet gave the audience an appreciation of the problems associated with turning theory into practice. The initial phases of her work produced unexpected results for the ratio of the intensities of the hyperfine lines. Problems were located with the calibration of the equipment and the model used to interpret the data, problems not unfamiliar, in different contexts, to many of her audience. With these two problems now understood Dr. Greet is currently concentrating on modelling them correctly and preparing for her next interpretation of the sodium data.

From the aeronomy building the tour proceeded onto two separate
experiments which have been designed to monitor the exceptionally pure air of
Antarctica. The CSIRO has a
laboratory to monitor the number of
aerosols present in the lower
atmosphere as a function of their size
while the University of Miami
monitors the elemental composition
and CO₂ level. The tour concluded at
the “wombat” building which houses
equipment to monitor and predict the
behaviour of the ionosphere.
No visit to a place such as Mawson
would be complete without some
comment on its unique environment.
Thus in the course of our tour we were
also able to see emperor penguins,
elephant seals, huskies and the like.
Experience, somewhat vicariously,
days without night and nights without
day, and attend mid-winter mess
parties.
The evening concluded with a vote of
thanks from Dr. Fred Jacka, former
director of the Mawson Institute for
Antarctic Research.
David Liebing

OF INTEREST

ASB-91
XVth Annual Scientific Meeting of
the Australian Society for Biophysics

The School of Biological Sciences,
Macquarie University, was the venue
for the fifteenth annual get-together of
Australia’s biophysicists on the 6th-8th
December. With more than 60
registrants, approximately half of the
society’s membership, and 50 or more
attending all of the sessions, the
meeting continued the relaxed and
friendly atmosphere that has been the
norm for these conferences.
The highlight of the meeting was a
lecture presented in the memory of
John Raison, who had passed away
earlier in the year. The John Raison
Memorial Lecture was given by Ted
McMurchie of CSIRO Human
Nutrition who had worked under
John’s supervision for CSIRO Food
Research at Macquarie University
some twenty years ago. It would be
difficult to imagine a more fitting
memorial lecture. Ted described his
mentor’s contribution to plant science
through the unraveling and
characterisation of chilling sensitivity
in plants. This work received
international acclaim and earned John
Raison several awards. Dr McMurchie
also spoke of John Raison as the family
man, the inspiring supervisor, the
dedicated scientist and the anti-
bureaucratic achiever. We were
fortunate to have several of John’s
family in attendance and, at the
conclusion of the lecture, his wife
Marie was presented with a bouquet of
flowers and a bound collection of
John’s scientific papers by Glenda Orr
who had worked with John in his
recent years at the CSIRO Division of
Food Processing.
The ASB-91 scientific program
consisted of sessions in Biomolecular
Interaction, Membrane Structure,
Biophysical Techniques and
Macromolecular Structure
determination, with two sessions on
each of Bioenergetics and Membrane
Transport. Overview lectures on each
of these topics preceded the session and were presented by Keith
Williams, Leann Tilley, Paul Curmi,
Christa Critchley and Phil Kuchel
(biophysical techniques being the odd
man out). These were supplemented by
a further 25 papers and an elegant
discourse, “NMR Studies of the Water
Permeability of Red Blood Cell
Membranes”, by Professor Cheorge
Benga from the University of Medicine
and Pharmacy, Cluj-Napoca, Romania.
A new feature of the program was a
poster session at which five minute
oral presentations were given to
supplement and highlight the poster
details. Frances Sepasovic did a great
job in "Chairing" this session and the
clear and conciseness of these
presentations was admirable. Because
of the informal atmosphere and the
diverse interests of the conference,
the ASB has always prided itself that it
provides an ideal venue for students to
get experience of speaking. The
formula certainly worked this year. We
had a bumper crop of students and
student presenters, and very high
standard contributions. Reggie
Waldeck (Sydney Uni. Biochem.) was
awarded the $100 prize and certificate
for the best student presentation with
his talk on an NMR study of membrane
transport, and Anna Kypridis (LaTrobe
Biochem.) and Karin Ahling (ANU
Chemistry) earned commendation for
their work on an immunological
biosensor and photosystem II
modelling respectively.
A further feature of the meeting was
the “coming of age” of NMR in a
biophysics context (not before time
some of us would grumble). The
discussions this year concentrated on
NMR as a powerful tool for delineating
the physics of biological systems as
opposed to a succession of wiggly
curves on which some minor
perturbation was attributed to the
yawning and stretching of a methyl
group in sympathy with the audience.
Jan Gebicki, as the Macquarie “mine
host”, ensured that all ran smoothly
and Geoff Francis was a trusty “Man
Friday” with the slides etc. It was a
pleasure to work on the scientific
program of the meeting, the reward
being good talks, animated and
friendly discussions, and the sort of
people who make you look forward to
next year’s meeting.
Tony Collings
CSIRO Division of Applied Physics

QLD

The first meeting of the AIP Queens-
land branch committee was held at
Griffiths University in February. The
following Office Bearers were elected:

Chairman
Evan Gray, Griffith University

Vice Chairman
Trevor Lewis, Queensland University
of Technology

Secretary
John Dobson, Griffith University

Treasurer
John Vaccaro, Griffith University

Committee
Ewan Toombes, Richland State High
School; Hugh Avey, University of
Southern Queensland; Brian Dalton,
University of Queensland; Ian Edmonds,
Queensland University of Technology

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PO Box 2434
Brisbane, QLD, 4001
**Product News**

**Tsunami: Ultrashort Pulse Ti:Sapphire Laser**

The Tsunami, a regeneratively mode-locked Ti:Sapphire laser from Spectra-Physics lasers, is the most stable and dependable method of generating tuneable picosecond and femtosecond optical pulses in the near infrared.

Now, with the release of a range of new accessories for the laser, it's benefits are available over a wider set of linewidths and wavelengths. The new accessories include:

- **Model 3980-1 Frequency Doubler** for wavelength coverage from 360 to 540nm
- **Model 3980-2 Pulse Selector** to enable single-shot, or low repetition rate output to be selected from Tsunami's standard 82MHz pulse train
- **Model 3970 Fibre Prism Pulse Compressor** generates sub-90 femto-second pulses from the 130fs output of the femtosecond configuration of Tsunami
- **Broad Pulse Option** generates broad pulses (10ps to 60ps) with narrow linewidths from the picosecond version Tsunami

Tsunami's regenerative mode-locking technique, in which an active mode-locking element derives its timing signal from the cavity itself, ensures unmatched long-term stability and true hands off performance.

For further details contact Simon Miles at Spectra-Physics.

**New Compact High-Energy Pulsed Nd:YAG Lasers from Quanta-Ray**

Spectra-Physics Laser have released a new family of GCR Series pulsed Nd:YAG lasers.

A range of output energies, from 320ml/pulse to 850ml/pulse, are offered, in a small footprint package, which includes a power supply which fits under an optical table.

No external cooling water is required and power requirements are single-phase, making these lasers ideal for installation in remote or challenging environments.

These oscillator-only laser systems build on the Quanta-Ray design philosophy of simplicity and reliability. The linear optical cavity simplifies alignment and minimises the number of optical elements in the resonator. Further, advances in optical fabrication techniques at Quanta-Ray, have allowed these lasers to be offered with a choice of 90% or 70% fit-to-Gaussian beam spatial profiles. No other manufacturer is able to offer this, testimony to the superior optical characteristics of the Quanta-Ray design.

The four new systems (GCR-12,14,16 & 18) differ only in the number of optical rods and pump chambers employed. Models can be upgraded to higher powers or smoother beam profiles in the future as required.

The systems may all be injection seeded, and a full range of accessories including frequency doubling, tripling and quadrupling, dye lasers and wavelength extenders are available.

The Quanta-Ray family of Nd:YAG lasers from Spectra-Physics now comprise the most reliable systems with the highest output powers (up to 1.8 Joules per pulse) and the smoothest beam profiles commercially available.

For further details contact Simon Miles at Spectra-Physics

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**Martock Design Model MD103 3 Axis Linear Module**
BOOK REVIEWS

Prompt Critical

Another Look at Chernobyl

How many died? 31 (official) or 7000+ (Chernousenko)? In war, the death toll is the first casualty and one soon learns that the real situation lies somewhere between the lies. Same here. The above fatality figures almost certainly bracket the true, but where can we find it?

Ever since Vladimir Chernousenko appeared in a Thames television documentary I have been anxious to read his book Chernobyl: Insight from the Inside. Dr. Chernousenko, a theoretical physicist by training, was invited by the Ukrainian Academy of Science to act as scientific director of their task force at Chernobyl. From May 1986, shortly after the disaster, he worked in the Special Zone within 10 km of the destroyed power reactor, and played a major role in conceiving and directing the clean-up operation. He is now dedicated to establishing an international research centre at Chernobyl to draw some benefit from the suffering and misery it has caused the people of the region.

Dr. Chernousenko has written his book to tell the world the truth about the disaster and its legacy. He is a whistle-blower, and with good reason. The Soviet system reacted to the disaster by suppressing the truth, even to the extent of leaving their people exposed to the worst of the fallout by pretending nothing serious had happened. There was totally inadequate radiation and medical monitoring of the Chernobyl workers, let alone the general population.

Now that the truth is out, the psychological trauma is extreme and, together with widespread malnutrition, has magnified the effects of radiation exposure on the general population. When I was in Kiev in 1990 the loss of confidence in the Soviet government was widespread. I would suggest that the dramatic collapse of the Soviet Union was as much due to Chernobyl as it was to Gorbachev. This book reinforces that view.

However, as its author concedes, Chernobyl: Insight from the Inside is written emotionally. He does not make a very convincing case for the figure of 7000 deaths from the disaster. A death list of the 'rectifiers', who absorbed lifetime dose allowances in handling extremely radioactive debris, includes, for example, three deaths from car accidents. Subtracting them, and those already in the official list, leaves about 40. Bad enough. But it is difficult to make the figure up to 7000 because in five years the natural deaths among a group of 600,000 middle-aged men, the 'rectifiers', would be of that order. But whatever the truth, there will be those who will, for their own reasons, keep repeating the 7000 figure regardless.

Dr. Chernousenko seeks to dispel the myths of Chernobyl. Here his book is very enlightening. The most startling revelation is that the operators were completely unaware that their reactor could go into a runaway state. The operational limits were suddenly revised in 1986 - after the accident. The operators were not to blame for the disaster: they were the scapegoats. Blame belongs to central administration, who did not pass on information from the designers to the operators. (Was Challenger not a management disaster also?) Anyway, Ukraine is now bringing criminal charges against 16 politicians and administrators ultimately responsible for the reactor.

Chernobyl: Insight from the Inside is published by Springer-Verlag in hardcovers for DM 68. It should be in all technical libraries and read by everyone wanting to get a better picture of the world's worst reactor accident. Despite his physical and mental ordeal, Dr. Chernousenko still favours nuclear power to reduce global pollution, designing that the 15 remaining RBMK reactors be phased out and replaced by safe western designs.

Colin Keay
Book Reviews Editor

The distribution of papers in this volume may help us see what a great mind finds fascinating in this subject. Sixty percent of the research papers in this volume are written on various aspects of the perturbations and stability of the gravitational fields of Schwarzschild and Kerr. This work has many other potential applications, such as in the study of the accretion phenomena and other observable properties of black holes. The study of the normal modes for perturbations is an essential part of black hole radiation theory.

Seventeen percent of the papers are on the collision of plane gravitational waves. Most of these are joint works with V. Ferrari and the late B. Xanthopoulos, who wrote the introduction for the present volume. A further twenty percent of the papers pertain to finding various exact solutions of the gravitational equations. Even such well-known space-times as Weyl's static solutions reveal new secrets under his scrutiny. Chandra was the first to provide an algorithm for constructing a stationary axisymmetric vacuum space-time from a given static axisymmetric Einstein-Maxwell field.

Two papers deal with the phenomena that occur on Cauchy horizons in general relativity. His 1982 results with J. Hartle proving that the flux of radiation received by an observer crossing the Cauchy horizon is singular is the precursor of Hawking's recent conjecture of the absence of closed time-like loops. The significance of this line of research is that it provides an argument for the absence of vicious causality violation in nature, preventing self-collisions of the kind proposed by Thorne and his collaborators.

The handy list of Chandra's publications at the end of this volume is both useful and impressive. He is the author of nine monographs and several hundred papers. The exact number is perhaps less important than the suggestive shape of the curve which you get when you plot the year versus the number of papers. Yes, it is the elephant curve from the "Little Prince".

Most of the papers of this volume were written after the year, 1983, that Chandra's book on black holes appeared, which makes it a useful companion to the former volume. I have only noted a few minor flaws in the preparation, such as Schwarzschild's name incorrectly set in the title.

Selected Papers Vol. 6
S. Chandrasekhar

This is the final volume of Chandrasekhar's collected papers, devoted entirely to his works in General Relativity. A living legend, and the sole Nobel prize winner for the theory of Relativity, he returned to the subject some forty years after having found his renowned limit for collapsed solar masses. Clearly, Chandra could never escape the intellectual challenges of the field.

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Laser Ultrasonics
Techniques and Applications
C B Scruby and L E Drain
Adam Hilger, Bristol 1990
xiii + 447pp. UK £50 (hardcover)

As is well known, high frequency ultrasound is widely used for the characterization of solid and liquid materials in scientific and industrial applications. One of the limitations of conventional ultrasonic measurement techniques in some important applications is the necessity of making physical contact with the material being investigated in order to provide a coupling path for the ultrasound into and out of the material. Coupling between the ultrasonic transducer(s) and the liquid or solid material can be achieved either by direct contact or via a liquid or solid coupling medium. Gases, such as air, cannot be used for two reasons: firstly, there is a large acoustic impedance mismatch between the transducer and the gas, and between the gas and the material of interest, so very little ultrasonic energy is transmitted through these interfaces, and secondly, the absorption of ultrasound by gases at megahertz frequencies is very large.

Coupling problems can be avoided if the ultrasound can be generated within the material of interest. Electromagnetic acoustic transducers (EMATs) produce ultrasound in metals by inducing high frequency eddy currents near the surface in the presence of a static magnetic field. This technique is useful in some cases, as contact with the surface is not required, but has low sensitivity and the requirement for the transducer to be close (∼1 mm) to the surface limits its application.

Techniques by which laser light can be used both to generate and detect ultrasound in solids are of great interest for applications that require not only non-contact but also remote detection methods. In very simple terms, when a high power laser pulse is absorbed near the surface of a solid, it can result in a high frequency, broadband strain that can propagate into the material. There are two dominant mechanisms responsible for this strain, and both are a result of the local heating produced by absorption of the laser pulse: they are localised thermal expansion, and material ablation from the surface. An ultrasonic displacement at the surface of a solid can be detected by an optical interferometer. Displacements as small as 0.01 mm (1) at frequencies up to at least 10-15 MHz can be detected, depending on the optical conditions of the surface. Areas of potential application for these techniques include inspection of very hot materials, inspection of large areas over which optical beams can be readily scanned, inspection of materials that might be degraded by liquid contact, inspection in cases where surface topology and/or surface motion might make direct contact difficult.

Research into the use of laser ultrasonic techniques has been going on for some years in a small number of laboratories around the world. The techniques are now coming to the stage where commercial or industrial applications are approaching feasibility. It is therefore timely that the book "Laser Ultrasonics" by Scruby and Drain should be published now. The authors have been closely involved with the development of laser ultrasonic techniques at the UKAEA Harwell Laboratories (now AEA Technology) for over ten years. They therefore write with an authority that very few others could match.

By targeting a relatively narrow field, the book succeeds admirably in the dual role of basic text and reference. The authors clearly recognize that the subject matter of the book is likely to appeal to readers from the somewhat diverse backgrounds of laser applications and the interactions of laser light with solids, and of ultrasonic propagation and non-destructive inspection, so they have included a short introductory chapter that outlines some general principles in both areas. This is a brave undertaking, the results of which will always be open to criticism of omission and superficiality, but in my opinion they have succeeded in producing a useful few pages to jog the memory where necessary, and with enough references to enable the beginner to dig deeper as required.

The next three chapters, some 186 pages, are concerned primarily with the use of laser interferometry to detect and measure ultrasonic waves. Chapter 2 gives a brief review of the acousto-optic effect, which is essentially the effect on an optical beam of the refractive index variations produced in a material by the pressure fluctuations of sound waves. In a sense this chapter has a dual purpose: it covers the underlying physics and the use of acousto-optical devices (Bragg cells) in various optical applications, and it leads into the detection of surface acoustic waves by an optical beam.

Chapter 3 is a thorough and well-written account of the principles of laser interferometry as it is applied to the measurement of surface motion. A number of different types of interferometer are discussed in some detail, including both reference beam and multiple reflection interferometers, interferometers that measure changes of optical phase, and therefore surface displacement, and those that measure frequency changes and hence surface velocity, interferometers for measuring small and large vibration amplitudes. The most widely used Michelson and confocal Fabry-Perot configurations are discussed and compared. Important factors such as the effects of rough surfaces and low frequency background vibration are considered in detail.

Chapter 4 is the heart of the discussion of the optical detection of ultrasound, which is completed by a summary of the applications of laser interferometry to ultrasonic field measurement in Chapter 5. This summary concludes with a sensitivity comparison with other ultrasonic detection techniques which, while useful and necessary, is academic in the sense that, because of its cost and complexity, one only chooses to use laser interferometric detection in circumstances in which its other advantages made it the only feasible technique.

The remainder of the book is devoted to laser generation of ultrasound (Chapter 6) and its applications (Chapter 7), with an interesting concluding chapter (7) that considers the future prospects for laser techniques in ultrasonics. Laser generation of ultrasound is a more mature technology than laser interferometric detection, but it has nevertheless not yet reached the stage of being widely used industrially.

Chapter 5 is the longest chapter in the book (102 pages). It describes the processes that result in ultrasound generation, from the absorption of high frequency optical radiation by the solid to the ultrasonic radiation patterns that result, and the ultrasonic bulk and guided waveforms produced in plates. The chapter concludes with a discussion of the possible lasers that might be chosen for ultrasound

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**BOOK REVIEWS**

generation and a summary of the characteristics of laser-generated ultrasound. Techniques for producing focussed and/or steered beams, and narrow band ultrasound, are still very much in their infancy, so there are likely to be significant further developments in this area in the future.

The applications of laser generated ultrasound discussed in Chapter 6 include flaw detection, material property measurement, transducer calibration and wave propagation. However, as with interferometric detection, laser generation would normally only be used in circumstances such that the specific features of the technique (remote noncontact, high spatial resolution, broad bandwidth) make it the only feasible approach.

This book is well written by authoritative authors, and it provides an excellent description of the relevant background and of the current state of the technology of laser ultrasonics. It is well produced and contains remarkably few typographical or other errors. It should be of interest to people concerned with applications of laser interferometry and also to those interested in interactions of laser light with solids.

While confined mainly to research laboratories at present, it is certain that applications of laser ultrasonic technology will become more widespread in the near future. Because the technology is relatively immature there are bound to be significant advances, particularly in the area of interferometric measurement of ultrasound. However, because of its emphasis throughout on the underlying principles involved, I believe that this book will remain a useful reference and review volume for many years. I therefore recommend it highly to anyone presently working in this or related areas. For anyone considering entering the field of laser-based ultrasonics it is absolutely essential reading.

D C Price

Division of Applied Physics

CSIRO Lindfield

Uncertainty, Calibration and Probability - The Statistics of Scientific and Industrial Measurement

2nd Ed. C. F. Dietrich

Adam Hilger, Bristol, Philadelpia and New York, 1991

xvi + 435pp, £90.00 (hardcover)

This second edition of Dietrich is the result of a conscientious revision throughout with additions and rearrangements but is essentially the same work as its 1973 predecessor. Background material on "A General Theory of Uncertainty" Chapter 7 has been added as well as an appendix giving computer computational methods and there are additions to the already extensive tables.

That it hasn't made the leap to present theoretical and numerical approaches, or extensions to topical subjects, can be judged by the fact that the most recent bibliographic reference is dated 1970 - R A Fisher's "Statistical Methods for Research Workers".

Does the work have value and an audience at this time? The answer is most definitely, yes. Firstly because it states the foundations of the subject with clarity and secondly because it contains a wealth of detail on fundamental topics, such as distribution theory. Where else will you find a 38 page dissertation on rectangular distributions? There is, however, a major difficulty with the "longhand" approach that is so characteristic of the book - the treatment of least squares runs to 85 pages, for example.

What place then has "Uncertainty, Calibration and Probability" in the literature of the subject? It is a unique work that the physics practitioner and measurement scientist needs to know about and use. It is consulted for detail not found in other places. For students, it offers alternative treatments which may be more understandable than mathematically economic texts.

A comment of special local interest related to traceable calibration services is included at 1.02 in both editions:

"The need for action at the national level was realised some fifty years ago (thirty in the 1973 edition) by Australia with its National Association of Testing Authorities (NATA). In Great Britain the British Calibration Service (BCS) was set up in 1960...."

Eric G Thwaites

Division of Applied Physics

CSIRO Lindfield

The Charm of Physics

Sheldon L. Glashow

American Institute of Physics, New York, 1991

xiii+ 307 pp, US $24.95 (hardcover)

This is a captivating and entertaining book. It has an unusual structure and consists of 29 short essays, articles already published in popular magazines and newspapers, and several components of the teaching material of a Harvard Core Curriculum Course in Physics: the titles are all on theoretical concepts in elementary particles or extensions beyond the purely scientific topics. Examples of the latter are: Antinuclitros and Geology; and SSC Machine for the Nineties.

Sheldon Glashow shared the Nobel Prize for Physics in 1979 for developing the electroweak theory with Salam and Weinberg. The two fields of electromagnetic theory and the weak interaction controlling radioactivity were assembled under one theory and Glashow introduced the quark bearing the property that is now called charm.

The articles are arranged under five sections, but the titles reveal ideas that spill over between the sections, and at any rate the articles are not in chronological order, even within sections. So there are several points of repetition. Despite this, the pleasure in reading the book is such that conventional arrangements under headings do not help a lot. What we want, as physicists, in reading a Nobel laureate is to try to listen to him talking about new ideas. If we are not experts, then we want straightforward prose explaining the new ideas and learn how a good scientist thinks. All this is found admirably in Glashow's book.

Some of the essays reveal earlier stages of the physics but they are worth reading if only to see the physics evolve.

Glashow's text is never bland in its popular character and he is plain and direct in his criticisms of some of the physical ideas (and of some of the physicists). It is worth quoting a few of his comments:

"Physics was international in the nineteenth century and so it is today. We treasure our international fellowships very much and we rarely try to say 'This was done in America, this was done in Europe, this was done in Russia'. It was done by us, working together" (p 22).

"Not nearly as mathematically inclined as Kepler, Galileo was never to accept his colleague's notion of ellipses" (p33).

"The whole ensemble of the periodic table is subject to the laws of quantum mechanics, which date to the year 1926. Since then, the table is no longer a mystery, but useful to our chemist friends who invent charming new products like silly putty. Chemistry is no longer as much of a forefront, fundamental science as it was a century ago" (p 114).

"There are two approaches to.....the possession of a theory which is on the D
BOOK REVIEWS

one hand too successful but on the other clearly incomplete. There is the pedestrian and the grandiose: the upwards path from mere experiment to theory, and the downwards path of pure positive thinking; the way of Bohr and the way of Einstein. I think there is a lesson to be learned from the past. Bohr’s route has proven itself to be successful beyond any reasonable expectation. Einstein’s path—search for a complete and unified theory now—has proven to be a dismal failure” (p 190).

Einstein made another critical omission. He never completely accepted the quantum theory for which he was partly responsible. God does not play dice, said Einstein. But we are now convinced that He does” (p240).

We see here and in other positions in the book that Glashow is not sympathetic to the idea of a “grand unified theory” and would, if pressed, probably expect physics to keep going, and therefore physicists to continue enjoying their researches. Similar thoughts were raised in me by some of Dirac’s obituaries, in which it was stated that Dirac liked to explore the mathematics of the physics that interested him. Will this ever be enough?

There is much in Glashow’s book for a wide range of interests in physics. His writings for undergraduate courses could be used as they stand, even if, like Feynman’s “Lectures”, only the best students would gain everything from them. And as for more experienced physicists, Glashow offers the kind of writing that makes so many of us regret that we are working on less fundamental physics and wish that we could get back to the “real physics”.

Bert Bolton
Department of Physics
Monash University

Useful Optics

Walter T Welford
University of Chicago Press, 1991
ix + 140pp., US$12.95 (paperback)

This little book lives up to its name. It is a summary of optics, aimed at the graduate student who has had little optics in his course, because of the other needs in a modern physics degree, but now needs to set up optical equipment for his research project. Few proofs are given, only references with comments on them. Welford assumes that a physics course has covered some fields and does not follow the detail of most textbooks: the book is refreshingly free of the historic rubbish of the sign conventions of geometrical optics, stating only “according to the usual conventions of coordinate geometry”.

Traditional fields such as geometrical optics and optical design, prisms, materials, and radiometry are covered simply and clearly. Modern aspects that are not so often in textbooks are treated in a little more detail: Fourier optics, gaussian beams, thin films, detectors and sources, image scanning, interferometry and holography. An amazing amount is condensed into 140 small pages, even a chapter on setting up optical systems. Although the proofs were corrected after Professor Welford’s death, I found only two minor misprints.

The book will interest more than the graduate student for whom it was written. Without proofs, it is not suitable as a textbook but, as supplementary reading, it can provide relevance to any optics course. For those experienced in optics it is well worth owning, both as a convenient summary and for new ideas.

W. H. Steel
School of Mathematics, Physics,
Computing and Electronics
Macquarie University

Superconductivity and its Applications

Y-H Kuo, P. Coppens and
H-S Kwok (Eds)
American Institute of Physics
xi + 713pp., UK£59 (hardcover)

This book is a collection of papers presented at the Fourth Annual Conference on Superconductivity and Applications organized by the New York State on Superconductivity in September 1990. The meeting attracted many eminent scientists from Japan, China, USSR, Germany and other countries to highlight the important progress, development and applications of high temperature superconducting ceramics.

The book contains a total of 75 papers which are distributed into four sections. The first section contains 5 authoritative and comprehensive reviews written by recognized experts in the field of crystallography and crystal chemistry of high $T_c$ superconductors as well as modelling of superconductivity. The second section consists of 26 papers covering a wide range of fundamental properties which include electrical conduction, thermal conductivity as well as the magnetic field and temperature dependence of critical current.

Physicals and Nuclear Arms Today

David Hafemeister (Ed)
American Institute of Physics, New York, 1991
ix + 390 pp., UK £31.25 (paperback)

This book of contemporary readings, selected from “Physics Today” magazine, and originally published between 1976-89, covers a very broad range of topics, from the history of the development of nuclear weapons and their physical and environmental effects, to their modes of delivery and defence against these modes. There are also valuable discussions on the needs for current testing, proliferation and the relationship of nuclear weapons to other aspects of the nuclear fuel cycle such as research reactors, breeders and waste disposal.

Of particular value are the debates on controversial arms control measures such as a comprehensive test ban, civil and strategic defence, and strategic arms limitation where one’s “side” is dictated by political views as much as by the underlying scientific and technical facts. The broad range of contributor’s mostly lucid and plain writing physicists but also including defence analysts and “Physics Today” editor’s link the physics to the technological, economic and political aspects of nuclear weapons developments within the superpowers.

There are some significant gaps of course, for little is said on the national and global economic effects of the nuclear arms race, or about the significance of microminiaturisation, stealth technologies and third generation weapons developments including the neutron bomb; and about the reconnaissance, communications, command and control support systems which link Australia to nuclear weapons. Nor will Australian readers find much discussion of the equally fascinating and relevant developments of British, French and Chinese nuclear weapons and systems.

However with its breadth of material and its comprehensive references to further reading this book will be of great value to all those physicists, teachers and students who have an interest in the interaction between science and society. Although the price (>£70) will put it out of the range of many students they should be given access to it in any good library.

D.R. Hutton
Department of Physics
Monash University

Australian & New Zealand Physicist Volume 29, Number 3, March 1992
densities. A massive 38 papers are covered in the third section which deals with the transport phenomena, electron tunnelling and characteristics of thin films. A number of innovative and exotic techniques for thin film synthesis were described. The fashionable sol-gel method is surprisingly not described. The slow pace of commercialisation and market potential of high $T_c$ superconductors is reflected by the small number of papers (5) covered in the final section on the applications of these materials. Interestingly, all the six papers were presented by the commercial companies and/or government research organizations.

In general, all the papers are very technical, specialized and are thus not easy for those not directly involved in the mainstream to obtain a reliable assessment of scientific and technological progress. The book describes no new or higher temperature superconductors. However, papers by Sheng and Cava et al. are highly optimistic of finding new and higher $T_c$ superconductors in the near future. The former has derived a novel illuminating chemical formulation for the search of these elusive materials. Some new findings on the fundamental properties are also elegantly presented.

On balance, the book contains a few papers with unacceptable printing quality. A few figures were unprofessionally drawn. In addition, a number of papers were written in a very casual and non-technical format.

This book is a valuable resource for researchers, engineers and students wanting to keep abreast of important advances made in the rapidly growing field of high $T_c$ superconductors as of September 1990.

L.M. Low
Department of Applied Physics
Curtin University of Technology

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**Theory of Magnetic and Electric Susceptibilities for Optical Frequencies**

P. K. Anastasovski
Nova Science Publishers
New York, 1990
xvi + 237 pp., US $85 (hardcover)

It was once a real mystery how light travelled through space. Times change, and now we worry about how light finds its way through matter. The standard approach is to imagine the electric field of the incident lightwave as affecting the distribution of the charges. In effect vibrating charge patterns radiate a fresh lightwave and the process is set to repeat. This primitive but useful description is not far removed from that used by Newton in his Opticks (Book II, Prop. XIV), and can be easily modified to account for non-linear effects.

Along comes Anastasovski with a simple but unsettling question. "What happened to the magnetism in the electromagnetic wave?" You may well object that a magnetic field fluctuating at optical frequency has negligible effect on charge motion. Anastasovski replies that "Even if it is true that light waves interact effectively with atoms only by their electrical fields, causing a disturbance in the electronic symmetry of the atoms, it is rather difficult to accept physically that all this could happen without also affecting the magnetic properties of the atoms and molecules." You may try to object further that if the low frequency magnetic permeability is close to unity then we can ignore magnetic effects. But, says Anastasovski, if we do not expect the dielectric function to be constant with frequency why should we expect constancy of magnetic permeability.

Like it or not he forces us to contemplate magnetic parameters at optical frequencies. What we would really like now is one of those clarifying demonstrations of fundamentals by Professor Opat. In the meantime Anastasovski attacks the problem by manipulating mixtures of transparent liquids. He compares the measured refractive index with that calculated from applying the Clausius-Mossotti, Lorenz-Lorentz, and Langevin-Debye equations.

Are you still with me? I hope by now you have gathered the impression that this is a book for interesting questions rather than standard and definitive answers. Indeed this treatise could pose a threat to teachers of electromagnetic theory if it fell into the hands of the wrong students.

Sadly quite a few misprints remain in the text, although two glaring examples were fixed by the publishers at the last moment with white-out. Some of those that remain involve fractured words which one expects these days to be caught by the word processor. There are also what appear to be mistranslations, like "isolators" for "insulators" and "molar" for "molecular".

Gavan Rosman
Photonics Section
Telecom Research Laboratories

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**Book Notice**

**KDP-Family Single Crystals**

L.N. Rashkovitch
Adam Hilger, Bristol 1991
ix + 202 pp., UK £45 (hardcover)

This highly technical volume is so narrowly specialised that only someone interested in working on new ferro-electric materials would find it useful. Of course, to such a person it could be very useful indeed, especially with the current surge of interest in novel quantum electronic devices. Surface physicists may find some of the examples interesting.

Like all of the Hilger series on Optics and Optoelectronics it is beautifully produced and well illustrated. Written by the Head of the Crystal-growth Laboratory of the Physics Department of Moscow State University, it summarises the physico-chemical data and state of knowledge of these crystal systems up to 1990.

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**New Books**

**Structures in Dynamics, Studies in Mathematical Physics, Vol 2**

H.W. Broer, F. Dumortier
S.J. Van Strien and F. Takens
North Holland Publ., Amsterdam 1991
xi + 309 pp., US $56.50 (paperback)

**Non-linear Optics**

R.W. Boyd
xiii + 439 pp., US $59.95 (hardcover)

**The Electron: New Theory and Experiment**

D. Hestenes and A. Weingartshofer (Eds.)
Kluwer Academic Publishers,
Dordrecht 1991
xi + 399 pp., Dfl 160 (hardcover)

**Knots and Physics**

L.H. Kauffman
World Scientific, Singapore 1991
xi + 538 pp., US $28 (paperback)

**Gaseous Electronics and its Applications**

R.W. Crompton, M. Hayashi,
D.E. Boyd and T. Makabe (Eds.)
Kluwer Academic Publ.,
Dordrecht 1991
xiv + 364 pp., US $124 (hardcover)

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<th>Date</th>
<th>Event</th>
<th>Details</th>
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<tbody>
<tr>
<td>May 25 - 29</td>
<td>ICPE Conference on Physics Education for Reforming the Fundamental Physics Teaching</td>
<td>Nanjing, China. Prof. Geoffrey I. Opat, School of Physics, The University of Melbourne, Parkville, Victoria. Phone (03) 3445121, fax (03) 347 4783</td>
</tr>
<tr>
<td>May 26 - 29</td>
<td>National Institute of Standards and Technology, USA</td>
<td>Accuracy in Powder Diffraction II. For further information and for Young-Scientist-Grant application forms contact: E.Prince, Reactor Radiation Division, National Institute of Standards and Technology, Gaithersburg, MD 20899, U.S.A. (E-mail: prince@nbsenl or <a href="mailto:prince@enl.nist.gov">prince@enl.nist.gov</a>)</td>
</tr>
<tr>
<td>July 6 - 10</td>
<td>Fifth International Conference on Thinking - Exploring Human Potential</td>
<td>James Cook University of North Queensland, Townsville, Australia. John Edwards, Conference Convenor, Department of Pedagogics, James Cook University, Townsville QLD 4811, Australia. Fax (07) 251 690 (within Australia) or 61 77 231 090 (overseas)</td>
</tr>
<tr>
<td>August 17 - 20</td>
<td>The 14th Triennial URSI International Symposium on Electromagnetic Theory, Sydney,</td>
<td>Australia. Dr G. L. James, Chairman of the Organising Committee, CSIRO Division of Radiophysics, Phone (02) 868 0222 or (02) 868 0290, fax (02) 868-0400</td>
</tr>
<tr>
<td>August 26 - 28</td>
<td>Fifth New Zealand National Physics Conference, University of Auckland</td>
<td>Dr. G. D. Patti, Department of Physics, University of Auckland. Private Bag 92019, Auckland, NZ. Phone NZ (09) 373 7999/X48828, fax NZ (09) 373 7445</td>
</tr>
<tr>
<td>Sept 8 - 11</td>
<td>ASPEN Symposium - Introductory Physics Education in University, Japan</td>
<td>As Prof. Yasuiko Tsuruoka, Dept. of Physics, Tokai University, 1117 Kitakaname Hiratsuka City, Kanagawa 259-12, Japan. Phone 81-463-58-1211, fax 81-463-58-812</td>
</tr>
<tr>
<td>November 25 - 27</td>
<td>Australian Acoustical Society Annual Conference 1992, Ballarat, Victoria</td>
<td>John Upton (Convenor), Phone (03) 370 7666 or (03) 370 7166, fax (03) 370 0332, Geoff Barnes, Phone (03) 720 1266, fax (03) 720 6952</td>
</tr>
<tr>
<td>December 1 - 5</td>
<td>ICPE Conference on Physics Education for Development, Philippines</td>
<td>Prof. Geoffrey I. Opat, School of Physics, The University of Melbourne, Parkville, Victoria, 3052, Australia. Phone (03) 344 5121, fax (03) 347 4783</td>
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1993

| May 31 - June 2 | ICAM '93 International Conference for Applied Mineralogy, Perth, WA                     | Secretary, ICAM '93, Congress West, PO Box 1248, West Perth, WA 6005. International Ph (619) 322 6906, fax (619) 322 1734, Technical Enquiries only, Jim Graham, Phone (619) 387 0971 |
| August          | International Conference on Ion Sources, Beijing                                         | Conference Secretary, Prof. Zhao Weijiang, Institute of Heavy Ion Physics, Peking University, Beijing 100871, P.R. China, fax x86-1-2564095 |
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- Lead Salt Lasers
- Mixed-Gas Ion Lasers
- Nitrogen Lasers
- Neodymium:Glass Lasers
- Neodymium:YAG Lasers
- Neodymium:YLF Lasers
- Ruby Lasers
- Titanium:Sapphire Lasers
- Xenon-Helium Lasers

- Ion Laser & Dye Laser from Coherent (top left)
- Nd:YAG Lasers & Dye Laser from Continuum (top right)
- Ultrafast Ti:Sapphire Laser from Coherent (bottom left)
- Excimer Laser from Lambda Physik (bottom right)

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